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École Doctorale : **SIReNa - SCIENCE ET INGÉNIERIE DES RESSOURCES NATURELLES**

Soutenue publiquement le 19 décembre 2019, par :
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# The contribution of virtual crisis simulations to the study of crisis management situations: the case of iCrisis crisis simulation approach

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# Acronyms glossary

**ORSEC :** *« Organisation de la réponse de sécurité civile »* - French Civil Security Structuration

**PCS :** *« Plan communal de sauvegarde »* - Municipality crisis response plan

**PPMS :** *« Plan particulier de mise en sûreté »* - School crisis response plan

**PCA :** *« Plan de continuité d'activité »* - Business continuity plan

**SDIS :** *« Service Départemental d'Incendie et de Secours »* - Fire and Rescue services

**SAMU :** *« Service d'Aide Médicale d'Urgence »* - Emergency Medical Assistance Service

**COGIC :** *« Centre Opérationnel de Gestion Interministérielle des Crises »* - Operational Centre for Interministerial Crisis Management

**ERCC :** European Emergency Response Coordination Centre

**EU :** European Union

**INHESJ :** *« Institut National des Hautes Études de la Sécurité et de la Justice »* - French National Institute of Higher Studies in Security and Justice

**IRA :** *« Institut Régional d'Administration »* - Regional Institute of Administration

**INSA :** *« Institut National des Sciences Appliquées »* - National Institute of Applied Sciences

**UL :** *« Université de Lorraine »* - University of Lorraine

**IUT :** *« Institut Universitaire de Technologie »* - University Institute of Technology

**SPPPI :** *« Secrétariat Permanent pour la Prévention des Pollutions Industrielles »* - Permanent Secretariat for the Prevention of Industrial Pollution

**NASA-TLX :** National Aeronautics and Space Administration Task Load Index

**TWLQ :** Team Workload Questionnaire

**IWL :** Individual Workload

**CWL :** Collective Workload

# GENERAL INTRODUCTION -
## *INTRODUCTION GÉNÉRALE*

The world is becoming more and more complex. The increasing density of assets and their interconnections make the world more complex, exposing these assets to equally complex risks. The occurrence of an unwanted event in this context can be just as complex and require a rapid and appropriate response from the affected organization immersing it in what could be identified as a crisis.

One of the elements often associated with the complexity of a situation are the interdependencies that cause cascading effects in the event of failure. The FP7 European project CascEff, which ran from 2014 to 2017 aimed to improve the emergency response in incidents that involve cascading effects. The main objective for the 14 members of the consortium was to develop a tool to model the cascading effects that could help the decision makers in each phase of the risk management cycle (planning phase, response phase, recovery phase).

This work has been conducted in the framework of the CascEff project and more precisely to help addressing issues linked to the response phase. Initially, the iCrisis simulation approach has been chosen to test the final cascading effects modelling tool.

The iCrisis simulation approach developed and used at the University of Lorraine enables to conduct crisis simulations to raise awareness of crisis managers at the strategic level. By its flexibility, this approach offers the an adequate environment to make experimentations. The interest of crisis simulation for the CascEff project was the opportunity to start a whole reflection on crisis simulation and its intrinsic capacities.

Let us return to the fact that our world is complex, so it can be witnessed the occurrence of complex and uncertain situations that have the potential to immerse organizations in crisis situations that disrupt their functioning or even threaten their future. These situations of a unique nature require an appropriate response in order to limit their negative consequences. To do this, crisis managers must be experienced. However, gaining experience in managing a complex, uncertain or even unknown situation is a complicated task. Of course, living these situations increases the crisis manager's experience, however, these situations are not common and in order to manage them well, it is more interesting to have the knowledge and skills before the crisis occurs. Crisis simulation offers the possibility to control elements of the situation to be experienced such as the environment and the scenario, which theoretically allows to recreate any kind of situation if the means are available. The interest in developing and promoting crisis simulation is therefore relevant. If crisis simulation is considered as an approach to train or sensitize crisis managers, then it is essential to ensure that it has a real ability to simulate crises. Today, although the number of crisis simulation approaches is significant (there are as many as there are companies offering this solution), their ability to generate a crisis is based only on the declarations of the experts who developed them. In the context of scientific research, it seems relevant to try to propose a verification approach to ensure that the selected simulation approach is indeed reliable. In effect, beyond the resources spent by organizations

wishing to take advantage of a crisis simulation, the objective of improving skills, knowledge and more generally experience is important enough to be certain that the simulated situation is truly a crisis.

In this context, we propose the following question. To what extent iCrisis simulation approach can attest its ability to simulate crisis at a strategic level? Beside this scientific problematic, there is a double objective: justify the use of iCrisis crisis simulation approach in a pedagogical context and extend its use to scientific purposes and take the opportunity to study the crisis.

To answer this question, we propose to develop 5 chapters. Each of these chapters aims to answer an element of the general problem.

Chapter 1, entitled «From emergency management to crisis», aims to point out that the concept of crisis as used in everyday life is largely derived from the world of emergency management and has the attributes of a situation with serious consequences and for which an urgent response is needed. In this chapter, a significant part is therefore devoted to the structuring of emergency management (with a focus on France). Then, we present how organizations are structured to face the crisis.

Chapter 2, entitled «Position of the research regarding the concept of crisis», attempts to return to the basics for understanding where the concept of crisis comes from and how it can be characterized, beyond the many textual definitions provided by the literature. Because in reality, the framework of the world of the known and the procedures provided by emergency management seems simplistic to apprehend a situation in which some of its characteristics are the unknown and the collapse of the references...

Chapter 3 discusses crisis simulation with a synthesis of what they are. A second important part is devoted to the presentation of the iCrisis crisis simulation approach which focuses on its theoretical premises until the concrete approach developed during the PhD period.

The chapter 4 coming after is the presentation of the empirical study to observe the crisis characteristics in the framework of crisis simulations. Basically, in this chapter, the characteristics of the crisis proposed in chapter 2 are put in parallel with the iCrisis simulation approach with the objective to verify that they can be observed during an iCrisis crisis simulation.

Eventually, the chapter 5 takes the opportunity that in the framework of iCrisis simulations, crisis characteristics are observed in order to conduct two case studies. The first case study tends to assess the how does the mental workload of crisis managers evolves during a crisis. The second focuses on the consideration of cascading effects by crisis managers during a crisis.

This research is an exploratory research which tends to identify characteristics of complex situations, develop hypotheses and conduct a study based on ideas (Post and Andrew 1982). This work proposes a new approach and focuses on the capability of the crisis simulation approach to recreate the crisis. The presented case studies aim to illustrate the iCrisis crisis simulation approach can be used to study the crisis. However, there was no objective to conduct precise analyses on observed situations which would be a future perspective.

This research has been conducted in a team, in the framework of ongoing projects. Even though the entire work presented in this manuscript is personal, several persons have contributed and helped to realized it (supervisors, interns, colleagues etc.). In this context, colleagues have often been associated and for this reason, “we” (as a team) has been used several times.

*Notre monde devient de plus en plus complexe. La densité croissante des enjeux et leurs interconnexions rendent le monde plus complexe, exposant ces enjeux à des risques tout aussi complexes. La survenue d'un événement indésirable dans ce contexte peut être tout aussi complexe et exiger une intervention rapide et appropriée de la part de l'organisation touchée, ce qui peut avoir pour conséquence de l'immerger dans ce qui pourrait être identifié comme une crise.*

*L'un des éléments souvent associés à la complexité d'une situation est l'interdépendance qui provoque des effets cascade en cas de défaillance dans un réseau de systèmes. Le projet européen FP7 CascEff, qui s'est déroulé de 2014 à 2017, visait à améliorer l'intervention d'urgence lors d'incidents impliquant des effets en cascade. L'objectif principal pour les 14 membres du consortium était de développer un outil de modélisation des effets cascade qui pourrait aider les décideurs dans chaque phase du cycle de gestion des risques (phase de planification, phase de réponse, phase de rétablissement).*

*Ces travaux de thèse ont été menés dans le cadre du projet CascEff et plus précisément pour aider à aborder les questions liées à la phase de réponse. Dans un premier temps, l'approche de simulation iCrisis a été choisie pour tester l'outil final de modélisation des effets en cascade.*

*L'approche de simulation iCrisis développée et utilisée à l'Université de Lorraine permet de réaliser des simulations de crise pour sensibiliser les gestionnaires de crise au niveau stratégique. Par sa flexibilité, cette approche offre un environnement adéquat pour envisager des expérimentations. L'intérêt de la simulation de crise pour le projet CascEff a été l'occasion de lancer une réflexion complète sur la simulation de crise et ses capacités intrinsèques.*

*Revenons au fait que notre monde est complexe, nous pouvons donc être témoin de situations complexes et incertaines qui ont le potentiel d'immerger les organisations dans des situations de crise qui perturbent leur fonctionnement ou même menacent leur avenir. Ces situations, de nature unique, exigent une réponse appropriée afin d'en limiter les conséquences négatives. Pour ce faire, les gestionnaires de crise doivent avoir de l'expérience. Cependant, acquérir de l'expérience dans la gestion d'une situation complexe, incertaine ou même inconnue est une tâche complexe. Bien sûr, vivre ces situations augmente l'expérience du gestionnaire de crise, mais ces situations ne sont pas courantes et pour bien les gérer, il est plus intéressant d'avoir les connaissances et les compétences avant que la crise ne survienne. La simulation de crise offre la possibilité de contrôler des éléments de la situation à vivre tels que l'environnement et le scénario, ce qui permet théoriquement de recréer tout type de situation si les moyens sont disponibles. L'intérêt de développer et de promouvoir la simulation de crise est donc pertinent. Si la simulation de crise est considérée comme une approche de formation ou de sensibilisation des gestionnaires de crise, il est essentiel de s'assurer qu'elle a une réelle capacité à simuler la crise. Aujourd'hui, bien que le nombre d'approches de simulation de crise soit important (il y en a autant qu'il y a d'entreprises offrant cette solution), leur capacité à générer une crise est basée uniquement sur les déclarations des experts qui les ont développées. Dans le contexte de la recherche scientifique, il semble pertinent d'essayer de proposer une approche de vérification pour s'assurer que l'approche de simulation choisie est effectivement fiable. En effet, au-delà des ressources dépensées par les organisations désireuses de tirer profit d'une simulation de crise, l'objectif d'amélioration des compétences, des connaissances et plus généralement de l'expérience est suffisamment important pour être certain que la situation simulée est véritablement une crise.*

*Dans ce contexte, nous proposons la question suivante. Dans quelle mesure l'approche de simulation d'iCrisis peut-elle témoigner de sa capacité à simuler une crise à un niveau stratégique ? Au-delà de cette problématique scientifique, l'objectif est double : justifier l'utilisation de la démarche de simulation de crise iCrisis dans un contexte pédagogique et étendre son utilisation à des fins scientifiques et profiter de cette opportunité pour étudier la crise.*

*Pour répondre à cette question, nous proposons de développer 5 chapitres. Chacun de ces chapitres vise à répondre à un élément de la problématique générale.*

*Le chapitre 1, intitulé «De la gestion des situations d'urgence à la gestion des crises», vise à souligner que le concept de crise tel qu'il est utilisé dans la vie quotidienne est largement dérivé du monde de la gestion des situations d'urgence et présente les caractéristiques d'une situation aux conséquences graves, pour laquelle une réponse urgente est nécessaire. Dans ce chapitre, une part importante est donc consacrée à la structuration de la gestion des urgences (en particulier en France), généralement pris en main par la sécurité civile. Ensuite, nous présentons comment les organisations sont structurées pour faire face à la crise.*

*Le chapitre 2, intitulé «Position de la recherche sur le concept de crise», tente de revenir aux fondamentaux pour comprendre d'où vient le concept de crise et comment il peut être caractérisé, au-delà des nombreuses définitions textuelles fournies par la littérature. Parce qu'en réalité, le cadre du monde du connu et les procédures fournies par la gestion de l'urgence (emergency management) semblent réducteurs pour appréhender une situation dans laquelle certaines de ses caractéristiques sont l'inconnu et la chute des références....*

*Le chapitre 3 traite de la simulation de crise avec une synthèse de ce que sont ces approches de simulation de crise. Une deuxième partie importante est consacrée à la présentation de l'approche de simulation de crise iCrisis depuis ses prémisses théoriques jusqu'à l'approche concrète développée pendant la période doctorale.*

*Le chapitre 4 qui suit est la présentation de l'étude empirique visant à observer les caractéristiques de la crise dans le cadre des simulations de crise. Globalement, dans ce chapitre, les caractéristiques de la crise proposées dans le chapitre 2 sont mises en parallèle avec l'approche de simulation iCrisis dans le but de vérifier qu'elles peuvent être observées pendant une simulation de crise iCrisis.*

*Enfin, le chapitre 5 se penche sur le fait que dans le cadre des simulations iCrisis, les caractéristiques des crises sont observées afin de mener deux études de cas. La première étude de cas tend à évaluer l'évolution de la charge de travail mental des gestionnaires de crise pendant une crise. La deuxième porte sur la prise en compte des effets en cascade par les gestionnaires de crise lors d'une crise.*

*Cette recherche est une recherche exploratoire qui tend à identifier les caractéristiques de situations complexes, à développer des hypothèses et à mener une étude basée sur des idées (Post et Andrew 1982). Ce travail propose une nouvelle approche et se concentre sur la capacité de l'approche de simulation de crise à recréer la crise. Les études de cas présentées visent à illustrer que l'approche de simulation de crise iCrisis peut être utilisée pour étudier la crise. Cependant, il n'y avait pas d'objectif de mener des analyses précises sur les situations observées ce qui seraient une perspective d'avenir.*

*Cette recherche a été menée en équipe, dans le cadre de projets en cours. Bien que l'ensemble du travail présenté dans ce manuscrit soit personnel, plusieurs personnes y ont contribué et aidé à le réaliser (superviseurs, stagiaires, collègues, etc.). Dans ce contexte, les collègues ont souvent été associés et pour cette raison, le terme « nous » (en tant qu'équipe) a été utilisé à plusieurs reprises.*

# CHAPTER 1: FROM EMERGENCY MANAGEMENT TO CRISIS

## Introduction

The crises linked to major «incidental» events often lead to associate the notion of crisis with the process of response to these events requiring urgent and rapid interventions. This positioning tends to systematically introduce the concept of crisis into the well-known cycle of risk management inside the emergency management phase. It is interesting to note that crisis units and crisis management plans are in fact tools for managing a critical situation requiring the empowering of technical and human resources. However, do we really manage a crisis? What is a crisis in the end? Moreover, within this response phase, we find in the meantime the persons involved, the victims and the actors making the number of involved people important numerously but also regarding their role. Thus, one can ask the question: the crisis for whom? These questions must be asked because the crisis management systems are presented as tools to control the situation in order not to be exceeded. «Managing», «non-exceedance» can be terms associated with the notion of crisis? A word whose etymology makes it find its roots in the Greek term *Krisis*[1] which is defined as a turning point.

In France, the modernization of civil security in 2004 has emphasized, through the ORSEC system (civil security structuration), the fact that «everyone is an actor». This enables to go beyond the scope of SEVESO-type industrial installations which must identify and manage their major risks (external and internal intervention plans). This new paradigm, associated with the occurrence of large-scale natural events and a security context enameled by terrorist acts, gave an unprecedented place to «crisis management» illustrated by the establishment of intervention plans in a large number of public bodies:

- the *«Plan Communal de Sauvegarde»* (municipality crisis plan) in municipalities in 2005[2];
- the *«Plan Particulier de Mise en Sûreté»* (school crisis plan) in schools (although established in 2002[3] following the storm of 1999 and AZF industrial disaster in 2001) that were updated in 2015[4] following the attacks (7-9 January 2015) in France and were then widely spread;
- the *«Plan de Continuité d'Activité»* (Business Continuity Plan), which offers an important position to crisis management, in other types of organizations (not only public) which are strongly recommended[5] even though they are not mandatory.

[1] Henry George Liddell, Robert Scott, *A Greek-English Lexicon*
[2] Décret no 2005-1156 du 13 septembre 2005 relatif au plan communal de sauvegarde et pris pour application de l'article 13 de la loi no 2004-811 du 13 août 2004 de modernisation de la sécurité civile
[3] B.O. hors-série n°3 du 30 mai 2002 - https://www.education.gouv.fr/bo/2002/hs3/default.htm
[4] circulaire n° 2015-205 du 25-11-2015 - https://www.education.gouv.fr/pid285/bulletin_officiel.html?cid_bo=95837
[5] Guide pour réaliser un plan de continuité d'activité - https://www.economie.gouv.fr/files/hfds-guide-pca-plan-continuite-activite-_sgdsn.pdf

These few examples show the important presence of crisis management in organizational systems of organizations whose objective is not to fall into an unmanageable situation to ward off the risk of activity shutdown.

Indeed, it seems clear from the perspective of these plans that they aim to manage critical situations that require an empowerment to avoid being overwhelmed (exceeded). It is really about doing the best to avoid the crisis, this disruptive situation. As a matter of fact, in society, the crisis units have as objectives to avoid the appearance of the crisis which explains the proximity between the concept of crisis and emergency management. By the way, some emergency management professionals even speak of «crisis avoidance room»[6] (*SDIS 54* - Fire and rescue services of the Meurthe-et-Moselle department in France) depicting a benefit to separate both concepts.

In this first chapter we propose to present the relations between the concept of crisis and the emergency management and to explain this positioning. The first part will present the organization of civil security with a focus on France which has been a study case within the framework of the European project CascEff. Moreover, it allows to propose to the English speakers a precise presentation of the French system that is not very well spread out of France. In a second part, we will present the often found «crisis» operational structuration in organizations which allows to understand and to note the influence of the professionals of the emergency management on the organizations' crisis organization. Finally, we will discuss the relationship between the concepts of emergency and crisis in order to position the crisis as a concept in its own. In this last part, a few definition of words making part of the sphere of both concepts are proposed in order to bring clarity and understand why there could be confusion.

## 1. Emergency management for preventing crisis

Because of the fact that in society, there is a need of being with the back to the wall in order to evolve, the occurrence of major events contributed to organizational changes such as Seveso (1976), 9-11 (2001) or Fukushima (2010) for example. In order to mitigate the risks, one of the possible actions, among others, is to reduce the consequences with a better capability to respond. The «crisis» is associated with the response phase, a phase normally overseen by the emergency management.

The domain of emergency management has considerably inspired «incidental» crisis management, since the urgent nature of the response is one of the most visible parameters of the crisis situation. For this reason, major disasters have often induced changes in the consideration of crisis management. As said before, the law of modernization of the civil security in France had a lot of influence in the organization of the response to unwanted events but also in the general management of the risk.

[6] http://www.sdis54.fr/faire-le-18/l-organisation-operationnelle

This organization in France is called ORSEC *«organisation de la réponse de sécurité civile»* (Civil Security Response Organization).

In the following section we present the structuration as it exists in France in order to provide a precise overview of the functioning of the response in the country. We will then see that the European context is interesting regarding the fact that these organizations rely on each State without any standardization whereas the geographical situation of Europe makes emergency services often working together on cross-border events. The fact is that in Europe there are two main types of organizations depending on whether countries are centralized (as in France) or decentralized.

This first part of the chapter concludes with a discussion on the positioning of the crisis concept in the risk management cycle.

## 1.1. Emergency management in France

The 2004 French law on the modernization of the civil security (August, 13th 2004) resulted in a revised system for emergency preparedness. The ORSEC system has been designed to mobilize and coordinate the civil security response under a single authority who is either the Prefect of “département” (French word for the county territory level) or the Mayor of the municipality depending on the nature and on the intensity of the event. The authority has the objective to help the coordination between the emergency services such as, Fire and Rescue services, ambulances and security forces but also in relation with all the adequate stakeholders who are needed to be involved. In this context of general commitment, this organization prepares everyone who is able, with its own skills, to participate in the protection of the population. Every public or private person identified by ORSEC is able to permanently ensure the missions assigned by the Prefect and prepares an own emergency management functioning plan[7]. Within the ORSEC system, not only professionals are actors but also each citizen carrying the idea that everyone contributes to the civil security by its own behavior[8].

ORSEC encourages each organization to prepare itself against identified risks by developing plans and procedures to mitigate the impact of an event by improving its coping response. Because the ORSEC gathers in a unique system response tools for different types of events affecting different types of organizations, it enables an alignment and the sharing of same standards between everyone.

[7] Loi n° 2004-811 du 13 août 2004 de modernisation de la sécurité civile - Article 1

[8] Loi n° 2004-811 du 13 août 2004 de modernisation de la sécurité civile - Article 4

### 1.1.1. ORSEC: an operational system aiming to be effective in emergency situations

As a non-stop operating system, ORSEC is not triggered, but the director of operations takes the lead and initiates the suitable applications. Basically it is designed to fit the «daily» response and to surge capacity when it is needed by providing adequate resources illustrated by the fact that the emergency response is gradual, from a permanent standby state to the general mobilization.

ORSEC relies on a simple structure constituted by five main elements:

- a director who is able to mobilize all the resources, public or private, that are necessary;
- a network: Emergency Medical Assistance Service («SAMU»); security forces *(«police», «gendarmerie»*); Fire and Rescue Services («SDIS»); Municipality; *«département»* Council; Network Managers (road, electricity, gas etc.); Companies etc. The common preparedness facilitates the development of a shared operational culture;
- a risk identification in order to have a unique directory of foreseeable risks. This directory enables to share a common risk culture and helps the cohesion with the risk prevention policy;
- the conduction of exercises to implement the ORSEC system;
- the management of real events;
- feedbacks of training sessions and real events to assess and improve the ORSEC organization.

The ORSEC operation system aims to be modular with a set of procedures and operational tools that can be used according to the type of incident. It is a progressive operation because the response is gradual regarding the magnitude of the event which means that the stakeholders will be more and more involved from the daily usual response to the major event. It also aims to be suitable for identified foreseeable risks, and adjustable to any other situation given that it is not possible to plan every situation that could generate a risk hazard, this is why the operational response plan is very flexible.

The acronym «ORSEC» is associated with functions (evacuation, supplying, etc.) which are identified as general provisions and the type of the incident (flood, blast, etc.) to cope with or the aftermaths to manage (mass casualties, etc.) which are depicted by specific provisions. These provisions provide the basis of the response encouraging reflex actions.

### 1.1.2. The general provisions

The general provisions shape the structure on which the management of the crisis must rely on. Four missions represent the basis of the general provisions. The first consist in identifying all actors, public or private, somehow involved in the protection of the population, in order to make a database that remains updated. The second is the lead of the operations by setting up the *«département»* operational center, where the crisis unit manages major events. The third mission involves a constant observation of the situation during the standby period. Last but not least, the fourth is raising the warning alert. These missions are the foundation of action modes that are activated to manage the encountered situation. Examples of this action modes are: provide assistance to the victims; arrange the evacuation of the population; provide shelters for the victims, supplying food; protect goods, environment and cultural heritage; cope with networks problems (electricity, gas, water...). The general provisions form a common knowledge for operational professions.

### 1.1.3. The specific provisions

In France, a risk analysis is carried out by the prefecture of each department to identify the main risks specific to the territory. Based on that, local practitioners and all other potential involved stakeholders work together to develop the most adequate procedures to cope with the considered risk which will be a specific provision.

These provisions especially cover natural hazards (flooding, earthquake...), local technological hazards (SEVESO plant, nuclear plant, hydraulic dam...) and the other technological hazards (transport of dangerous goods, airplane crash, etc.).

ORSEC aims to anticipate events based on observation monitoring. The prefecture of the department is constantly linked with national organizations such as French weather centre (*«Météo-France»*) and national expert on inland waterways and river transport (*«Voies Navigables de France»*). For instance two national reports about the weather situation are sent every day by *«Météo-France»* to the prefecture of each department. From this information, ORSEC enables the preventive deployment of resources regarding the specific provisions of the identified risk.

Therefore, the main features of the identified risks are given by the specific provisions. They include a risk analysis which is divided into two parts: a study of the hazard (potential scenarios; impacted areas; effects; etc.) and a study of the assets (concerned municipality; population identification; assets identification; vulnerability assessment). Furthermore, it contains information about population protection (how to alert the population, where to secure the population, etc.) and strategies of intervention. The number of involved stakeholders can be very important, for this reason the document depicts the specific assignments of the actors (plus conventions with associations such as the Red Cross for instance). And finally, for each specific

provision there is an updated contact directory of stakeholders who are likely to be involved.

The elaboration of specific provisions aims to train stakeholders in order to make strategic decisions regarding the event. Thus, even if an identified risk does not occur accordingly with the considered scenarios, actors may have gained experience and technical skills to adapt themselves to the new situation.

The specific provision design approach can be considered as a real-life emergency situation with the following questions to answer:

- Development of the scenario
    - What type of events can we be facing?
    - What are the involved assets?
- Development of the strategy
    - Based on the scenario, what is the most appropriate strategy to implement?
- Objectives
    - What are the objectives regarding the event and the strategy to implement?
- Action plan
    - What are the actions to be carried out in order to achieve the objectives?
    - Who is in charge of the actions?

This approach allows to overcome the time constraint induced by the urgency and the need for immediate decision-making. It gives the opportunity to engage and involve most of actors and experts on a common working issue, who are not easily available during an event. And eventually, it permits to consider every possible solution, even inappropriate or unrealistic ones. In the development phase, the error is possible and of no consequence.

Specific provisions show the complex nature of an emergency situation that could lead to a crisis situation since it contains on one hand as much as possible exhaustive information about a specific risk and in another hand the needed flexibility and awareness to deal with a situation that do not fit the predefined standards.

### 1.1.4. ORSEC structuration

According to the severity of the incident, the crisis response which involves many stakeholders is organized in four levels: municipal, *«département»* level, defense area level and the national level (table 1). In addition, the European level permits to coordinate actions with other EU countries mostly to facilitate the allocation of means from one country to another.

At the municipal level, the Mayor is responsible for the security of the municipality inhabitants and He/She is the knowledgeable person about local issues. This makes the Mayor an essential actor of the ORSEC system. Until a certain level of severity, when an event occurs the Mayor becomes the director of the operations. The Mayor is in charge to make the municipal response plan (Plan Communal de Sauvegarde) which contains knowledge about local risks, alert instructions, a list of municipal resources to cope efficiently with disaster.

The department level is represented by the Prefect, who is the representative of the authority of the State. The Prefect is responsible for the public order and thus to prepare and execute the means to ensure the security and the protection of the population. When a disaster occurs, the Prefect triggers the *«département»* crisis center (*«Centre Opérationnel Départemental»*) and becomes the director of operations. In this situation, He/She can have access and use all of the needed resources either public or private. No matter how the situation evolves, the Prefect remains the director of operations if it is not the Mayor.

France is divided into seven defense areas which encompass several regions. At this level, cooperation with the army can be made if needed. The defense area level provides support and reinforces when *«département»* means are not sufficient to manage a major event.

When several sectors represented by different ministries, are affected, an interministerial crisis unit is set up at the national level in order to coordinate the response of the various ministries involved. To manage these crisis situations, the government and the Minister of the Interior trigger the Operational Centre for Interministeryial Crisis Management (COGIC : *«Centre Opérationnel de Gestion Interministérielle des Crises»*). From accidental events to crises, the COGIC's daily mission is to collect and analyze information relating to the safeguarding of the population, the goods and the environment.

The European Emergency Response Coordination Centre (ERCC) supports a coordinated and quicker response to disasters both inside and outside Europe using resources from the countries participating in the EU Civil Protection Mechanism. The ERCC is a coordination hub which facilitates a coherent European response during emergencies. It completes a task of collecting and analyzing information on disasters, hazards, emergency plans to improve planning and the preparation.

The response is scaled according to the severity of the events (table 1). Daily incidents are managed by practitioners but as soon as an incident affects the normal functioning of the society then a director of operations takes the leadership. There are two levels of operations directors. For a local response, the operations director must be local. This is the reason why the Mayor manages the response for ordinary incidents. When the event exceeds the response capacity (human, technical and spatial) of the municipality, the Prefect becomes the leader.

Thus, all these actors are organized under the responsibility and the coordination of the operations director in order to cope with the incident or crisis situations all together to protect citizens, property and the environment. However, the nomination of the operation director remains subjective and linked to the sensitivity of the Prefect and his/her decision.

*Table 1. Examples of the organization of the operations leading*

| CASE | CHARACTERISTICS | STAKEHOLDERS | OPERATIONS DIRECTOR |
|---|---|---|---|
| Car crash<br>Limited incident | Localized<br>Short duration<br>Immediate consequences | Emergency services (usual response) | Head of the involved service (called here Operations commander |
| Car crash<br>Important incident | Localized<br>Few hours duration<br>Immediate consequences | Emergency services (with support of specific means) | Mayor |
| Car crash with many victims<br>Transport of hazardous substances accident<br>Fire in specific areas (tunnel, industry etc.) | Localized<br>Few hours duration<br>Immediate consequences | Emergency services (with support of specific means) | Prefect |
| Industrial incident<br>Contamination (e.g. oil spill)<br>Flood | Part of the *«département»* affected<br>Few days duration<br>Progressive consequences | Emergency services (with support of specific means) | Prefect |
| Severe storm<br>Pandemic<br>Major flood<br>Nuclear incident | *«département»* partly or entirely affected<br>Few days or weeks duration<br>Progressive consequences | General mobilization of services<br>Involvement of Ministries | Prefect |

#### 1.1.5. Synthesis

The ORSEC system, supported by the French emergency services and run by the prefecture of each department, aims to be a system enabling the best possible response to an event so that it remains manageable. This begins with the identification of risks, then continues with the elaboration of intervention plans, training, non-stop monitoring and observation and then a structuration in case of need of empowerment through crisis units. The master word is the mastery!

## 1.2. Emergency management in Europe

Although the European Union adopted in 2001 the Community Mechanism for Civil Protection which helps to facilitate cooperation at major events, it remains basically in the form of logistical support and intervenes when a State makes a request. Therefore, the EU does not bring a common picture for emergency management. However, the European Commission presented in 2018 proposals for strengthening the European Civil Protection Mechanism[9], in response to the many devastating natural disasters that have affected Europe in the past years.

European countries crisis management systems can be divided into two families (Amraoui 2009):

- The centralized countries — such as France, Sweden and Belgium — that are organized vertically adapt the level of response to the scale of the crisis from the local to the national, giving priority to collective actions. With an operations director representing the State, it shows the strong involvement of the State level in the crisis management. The means are allocated by the State for the different levels. The strong administrative part of this system gives the ability to manage the crisis by relying on the support, if necessary, of the higher level (experts' assistance, material assistance, etc.).

- The decentralized countries — such as Spain, Italy, Germany and the United Kingdom — that are organized horizontally, allow local regional or municipal organizations to coordinate the crisis. When a crisis occurs, it is managed locally by municipalities in the United Kingdom and Italy, the German Länder or the autonomous communities in Spain. The role of these entities is fully recognized by the Constitution and has never really been challenged as the population is committed to grant a large degree of autonomy to local authorities. When the crisis is important, local officials apply the principle of subsidiarity and their proximity to the inhabitants enables a large mobilization of volunteers.

[9] European Commission press release - Commission Work Programme 2018: An agenda for a more united, stronger and more democratic Europe - Strasbourg, 24 October 2017. http://europa.eu/rapid/press-release_IP-17-4002_en.htm (Read 25/09/2019)

Although two categories of emergency management can be drawn in Europe, a common element is shared by all organizations: a large range of stakeholders are involved from the civilian, to public and private organizations as well as emergency services. This involvement of multiple actors with different experience and skills in an emergency or crisis situation may have consequences due to the fact that by definition people do not react in the same way because they do not perceive the situation in the same way.

Another element that can be highlighted is the use of the word «crisis» to determine the severe nature a situation as if it was a «big emergency». However, in the emergency management organizations, crisis centers are mentioned as places where managers at a strategic level gather to cope with a rather severe situation (which is not a routine response). Thus it seems clear that there is a difference between emergency and crisis but no clear definition has been set.

## 1.3. The position of crisis within the risk and emergency cycle

The risk management includes a large range of activities, programs and measures which can be undertaken with regard to the possible occurrence of an event:

- Before an event: risk prevention and protection but also preparedness (planning, learning and training);
- During an event: the operational response and,
- After an event: feedbacks to assess the situation.

The objective is to avoid a disaster, reduce the  impact of such event or recover from its losses. The three stages represent a cycle (Figure 1).

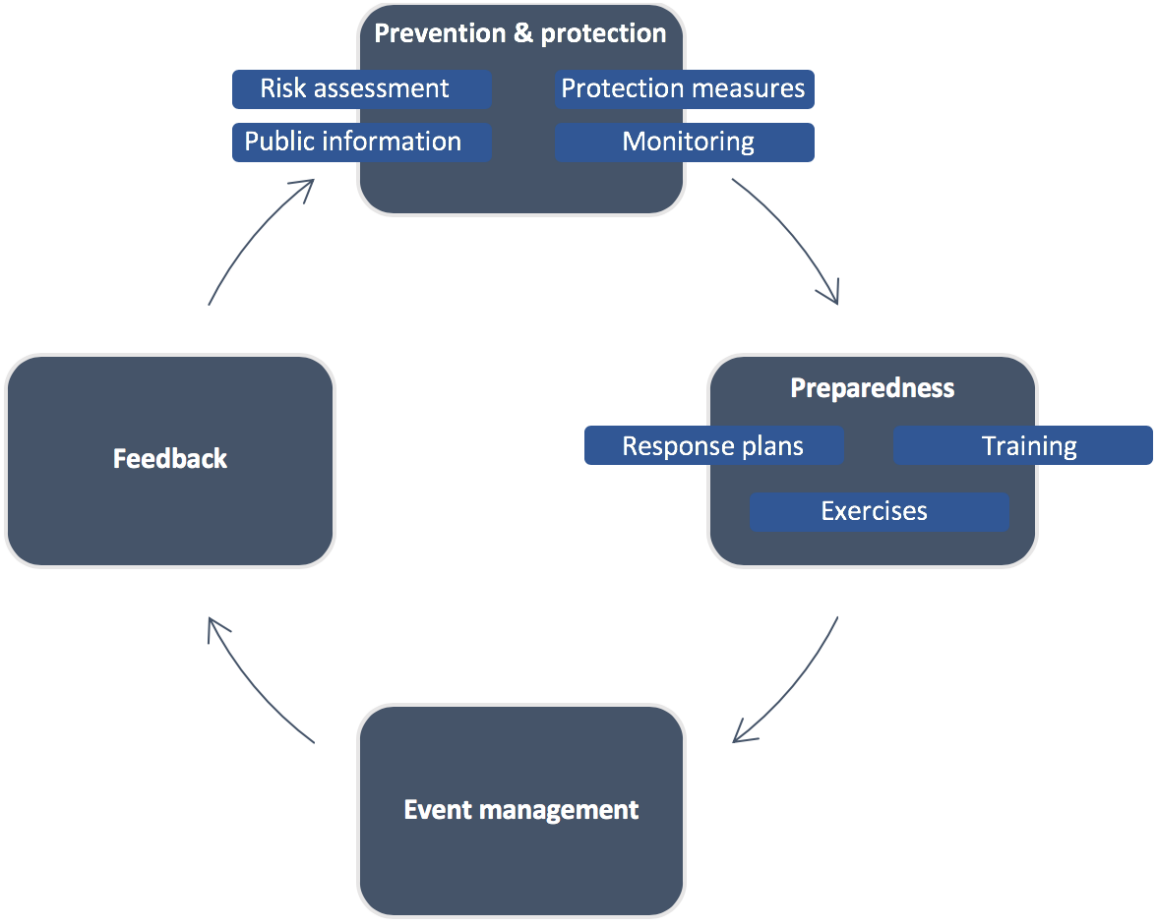



*Figure 1. Risk management cycle*

During the period before an event, activities are undertaken by organizations to analyze and assess the risk. The results given by these studies, incident and undesirable events scenarios are developed in order to design the mitigation measures to protect human and property losses and thus prevent from the identified risk. For example, carrying out awareness campaigns, strengthening the existing weak structures. Before coping with an undesirable event, the phase of preparedness is the period when, based on the risk analyses, organizations design the adequate human and material resources which meet previously established scenarios; determine means of communication; and define a list of structures to support the coordination of actors. A whole set of plans, for each involved organization, is made to help decision-makers when the time of coping with the undesirable event comes. Within these plans, many documents are included such as different scenarios, the procedures, the updated phonebook of the different actors, the composition of the crisis units, the roles and objectives of each, etc. The preparedness phase is also the right period to take the opportunity to prepare organizations, exercises and training techniques, in order to make sure that procedures are well known.

During an undesirable event, actions undertaken are called emergency response activities. They deal basically with the implementation, in a real case, of the different plans already elaborated. They are different according to the type of event, its duration and the severity of the aftermaths as it was presented within the section introducing the ORSEC system. Within this phase, mismatches can be highlighted between the plans and the reality which makes adaption crucial.

After each event, feedbacks are made to identify dysfunctions and measures to rectify; and bring knowledge to teach and train in order to become more efficient (Wybo et al. 2003).

The concept of crisis is associated with the event that is occurring. Crisis management is an operational mode activated to cope with a more or less important event. A clarification in the used terminology is presented later (part 3 of chapter 1). However, what is clear is that the crisis makes part of risk management cycle inside the «event management» phase.

## 2. Organizations coping with «crisis»

The concept of crisis is often defined as complex. Authors studying the causes of crises (Pauchant and Mitroff 1990; Perrow 1999) reveal that the sociotechnical nature of organizations contributes to increase the complex nature of situations which tends to increase vulnerability to crises. To emphasize the importance of the sociological dimension, it is interesting to focus on the main causes of failures in complex technical systems. According to authors (Shrivastava 1995), they can be due to:

- human factor (lack of communication between actors, negligence, etc.);
- technical design of the system (process design, equipment, etc.);
- organizational system (no reporting of incidents, organizational rigidity, procedures, etc.); and
- socio-cultural factors (managerial negligence, environmental operators and suppliers, etc.). In each of these causes the responsibility of Human can be attested.

Organizations have a central position concerning the crisis since it can be the cause, the target and the place where means are gathered to manage the situation. However, socio-technical organizations are complex (Dautun et al. 2007) because of the great diversity of the actors who are there but also the diversity of activities and objectives that can sometimes be difficult to combine.

In this second part we first present the structuration of organizations regarding the management of «crisis», then we introduce the main roles during a «crisis» with a focus made on the strategic and tactical levels. Eventually, a presentation of what is crisis unit is made.

## 2.1. Structuration of organizations

First of all, as a system dealing with people, an organization is defined by sociologists as an articulation of different parts which perform various functions (Ogburn and Nimkoff 1947). According to Weick (1993) a sociologist who focused his research on crisis situation, an organization can be defined as a group of people seeking to make sense of what is occurring around. During a crisis, involved individuals fulfil different functions, in different frameworks such as activities or jurisdictions interact all together sharing common interests (Weick 1993) in order to achieve a common goal which is to cope with the crisis whereas as a sudden and unexpected event threatens to disrupt an organization's operations (Coombs 2007).

In the context of crisis, organizations that are submerged, operate and structure differently from everyday operations, because the situation they face is not normal. The responses of the organizations rely on their experience of coping with crises (Lalonde 2003) but also on factors related to the initiating event and the structuration (Dautun 2007).

Organizations structure themselves depending on the nature and the severity of the event. Even though models of structuring are predefined within the preparedness phase, the complex nature of situation requests adjustment during the emergency phase in order to meet the adequate needs. One of the characteristics of crisis situations is the presence of a large number of stakeholders, who work on behalf of different organizations, to deal with the complexity of the situation. However, many differences between organizations such as their missions, responsibilities, structural configurations and skills make challenging to work together and set a coordination strategy to effectively cope with the event (Dautun 2007).

Given the fact that the experience of individuals within an organization has an influence on the capability to cope more or less efficiently with a crisis, it is then important to recall that there are different types of organizations with different experiences and by extension different skills. However, every organization whether it is an emergency service, a company or a public organization is vulnerable to a breakdown of its structure which would represent a considerable loss that could be a crisis. To face this

critical situation, predefined plans bring tools based on individuals' roles that permit to cope with the crisis at a strategic, tactical and operational levels to finally surpass it.

## 2.2. Roles during «crisis»

In France the organization of civil security suggests that everyone is an actor during a crisis, from the civilian to practitioners and decision makers. However, during a crisis, the critical actors are the members of the crisis unit, the response management team, and the field-based response units that form a strategic-tactical-operational system. It consists of a flexible and scalable organization of operations represented by human and technical resources whose purpose is to effectively direct operations. As presented before, the incident management system is designed to be implemented in all cases, regardless of the type and scale of the event, from the alert to the end of the crisis (Wybo and Kowalski 1998) with a capability to empower itself if the situation needs it.

*Table 2. Scope of actions for strategic, tactical and operational levels in crisis management (Tena-Chollet 2012)*

| **Actions / Decisions** | **Strategic level** | **Tactical level** | **Operational level** |
|---|---|---|---|
| **Scale** | In connection with the overall environment | Management of the onfield operations | Operating the deployed means |
| **Time** | Long term | Medium term | Short term |
| **Effect** | Durable | Brief | Very brief |
| **Reversibility** | Null | Weak | Strong |
| **Procedures** | Not programmable | Mid-programmable | Programmable |
| **Information** | Uncertain and exogenous | Almost complete and endogenous | Complete and endogenous |

Tena-Chollet (2012) discussed the constraints as well as the criteria that are specific to each of these three levels and showed how different the spheres of action and decision-making are. The table 2 summarizes the domains, horizons, effects, reversibility factors, procedures and characteristics of the information available, for each of the three levels of crisis management (Tena-Chollet 2012). This table makes

it possible to realize that the involvement of a strategic crisis unit in the management of an event is crucial, but also to become aware of the complex nature of the context, of the connections of levels that must be established.

Single agencies or countries such as United Kingdom and the United States of America often refer to the operational - tactical - strategic levels of actions as Gold, Silver and Bronze (Bram et al. 2016).

### 2.2.1. The strategic-tactical pair at the center of crisis management

Quarantelli (1988) reminds that in the army, the military makes a distinction between strategy and tactics. Strategy deals with the overall approach to a problem or objective, whereas tactics concern the actions undertaken to attain a specific goal.

Within the above mentioned classic 3-dimensions model, the strategic-tactical pair that is at the center of crisis management makes it possible to clearly disseminate the objectives (strategy) that will be illustrated through tactical actions that are depicted by the definition of technical and human means to be implemented. Practically speaking, the director of operations (at the strategic level) is characterized by the question of «WHAT?», whereas the command of operations is mainly asking the question of «HOW?» (Montchamp and Bizet 2016). Experience shows that this scheme cannot be so simplistic because the operations manager cannot exclude the operational consequences on site and in parallel the commander of operations is expected to make proposals in order to solve the situation. This pair is constantly connected and indispensable to the management of the critical situation. With the purpose of giving a good quality answer to these two questions («What?» and «How?»), theoretically, a differentiation between the strategic and tactical levels is needed. However how is the reality?

### 2.2.2. The pair strategic-tactical: geographical differentiation

The institutional chain of command in crisis management creates a geographical differentiation. The strategic authority is located in the capital for example, either in the headquarters of the organization or in the regional authority. Regarding the tactical level it is expressed within the operational centers of the local Fire and Rescue Service or Police for example. Eventually, the operational level is represented by Command Post on site. This functional division is not fixed, and evolves according to:

- the personality of the actors (that can make a hyper-directive director come on the scene for example);

- the lack of organization and means (often encountered in organizations not used and not prepared to cope with crisis situations) or;
- because of an operational necessity (support to victims and/or support to operational services and/or stakeholders on site).

For these reasons, strategist can get involved in the field of operations which is depicted in cindynics (Kervern and Boulenger 2007) as a dilution of responsibilities.

### *2.2.3. The strategic-tactical pair: temporal differentiation*

A temporal gap is inherent in these different levels. The strategist works by anticipation to avoid surprises and prevent damage, and to plan and prepare the way for future actions (Lagadec 1991). The pace of the tactical level is closely related to the kinetics of the event as well as the time scale of stakeholders involved. For example, the higher the temporal dynamics of the crisis are, the more uncertain and unpredictable the duration and consequences are and the less the difference between the strategic and tactical rhythm is important.

Firefighters often claim that the tactical level, by applying the reflex measures at the beginning of the event, saves time at the strategic level in order to design the appropriate response strategy. On the other hand, the quality of this developed strategy will save time for operational engagement tactics in a second step. However, the modern crisis can be now characterized by the involvement of a very large number of stakeholders either private or public and from any time of activities. The lack of knowledge regarding the involved actors and the nature of their operations combined with social and media pressure can weaken the work at the tactical level, that is at the forefront on the field, enforcing to only applicate defensive measures and stay in the reflex phase without letting time for reasoning and anticipation.

The pair represented by the director of operations and the practitioner (Fire and Rescue Services, Police, Medicals, Networks managers etc.) can also be distinguished by a difference of status. The skills and the knowledge of the director of operations about a large panel of disciplines such as politics, economy, social sciences enable him/her to have a global vision during a crisis that is most of time multifactorial. Practitioners, based on specific knowledge and competences, are able to make in a specific domain a tactical and operational transcription of strategic objectives. This association of knowledge and different experiences constitute the privileged interface of response system to an event, ensuring coherence between the strategic level and the tactical / operational level.

## 2.3. Crisis unit

The crisis unit is the place where the strategic steering process is made. In general, it is located in the headquarters of the involved organization, it is composed with a decision maker surrounded by a supporting team. In relation, the tactical command post is located on the scene. The crisis unit aims to :

- develop a strategy, set objectives,
- determine success criteria, the planning of the necessary means, and
- coordinate all the actions needed to complete the management of the situation in order to minimize its consequences. It is also in connection with other stakeholders involved within the situation.

It is in the crisis unit where, to a large extent, the crisis steering process can be a success or not (Lagadec 1995). It is well defined and prepared in advance to know the reflexes and techniques to manage the situation. Practically speaking, the primary objective of a crisis unit is, first and foremost, to be put in place as soon as the first signals referring to a critical situation are perceived in order to avoid the crisis. For example, the crisis unit among French firefighters is often called a «crisis avoidance unit».

The Coordination Committee is a multidisciplinary team which assists the competent authority. The team in charge of the strategy is composed of (minimal composition): a director who has the power of decision and a representative of each involved in rescue and safety disciplines. Experts and representatives from organizations who are considered as valuable for the management of the situation can be invited to participate by the competent authority.

Basically, there are two cases that can lead to the formation of the crisis unit. The decision to gather the members of the crisis unit can be made based on the appearance of predefined criteria or based on the will of the director or an advisor.

### *2.3.1. Missions of the crisis unit*

An organization is coping with a crisis because its intrinsic missions are threatened. For this reason and from a general perspective, the crisis unit tends to maintain the vital functions of the organization which can be illustrated by three stages: face, regulate and surpass the situation (Hansen-Glize 2008). It is, first and foremost, to fight against the massive disorganization induced by the crisis situation. But, above all, the first objective of the crisis unit is to try to interrupt the chain of aggravations that these

disorders engender, and already start thinking for a fruitful reconstruction. By facing, Hansen-Glize (2008) means the fight that the crisis unit must undertake against all time lags such as simultaneities, successions, durations that can be unpredictable and conflicting. Then, beyond the more or less serious incidents identified during a crisis, slippages of all types must above all be taken into account by the crisis unit in order to regularize the situation to return to normal operation with as much control as possible... Eventually, in this situation, which involves disintegration, destruction, dilution, destabilization, loss of benchmarks, discrediting, each authority, directly or secondarily involved, is called upon to surpass the consequences of the risky choices that had to be made.

From a practical point of view, the mission of a crisis unit is to carry out a strategic steering process that can be depicted by the following actions (Lagade 1995):

- support the scene (where the incident happens) if necessary;
- ensure overall consistency of the response across the entire organization;
- draw substantive answers to the technical and political issues raised by the event;
- ensure quality links with all the networks in which the organization is involved (internal and external actors, administrations, etc.);
- ensure a national (at the organization outreach scale) communication (internal and external).

These missions naturally are broad to stick with the expectations during a crisis situation. However, they must be adapted to each organization according to its functions and its capacities. As a practical example, Dautun (2007) recalls the priority missions to be assumed by the crisis unit of a prefecture (in France) during the operational phase of the management of the crisis, according to the circular of 26 March 1993[10]:

- protection of populations (alert, information, rescue);
- continuity of government actions (security of public buildings, sensitive points, transmissions and communications);
- conservation of internal security and the control of public order problems;

[10] Circulaire du 26 mars 1993 Relative à la gestion des risques et des crises Organisation des services interministériels de défense et de protection civile (S.I.D.P.C.) Bulletin officiel du ministère de l'intérieur et de l'aménagement du territoire n°1 premier trimestre 1993

- guarantee and the protection of the functions essential to the national life (refueling, transport, energy production, telecommunication);
- communication to the public and the press.

To fulfill the determined missions, the crisis unit organizes itself and identifies the roles that are needed and by extension its composition.

#### 2.3.2. Roles and composition of the crisis unit

A prepared organization anticipates crisis management by constituting a crisis unit composed of a limited number of representatives, previously identified according to their skills and experience in psychological and sociological skills (Crocq et al. 2009). Once identified, each member of the crisis unit is specially trained in the various crisis management tasks identified by the organization (Lagadec 2001). The difficulty for the majority of organizations dealing with activities different than risk and crisis management is depicted by the fact that members of the crisis units are not professionally profiled to complete this mission. For example, the crisis unit of a company is often formed by the members of the board of directors who are experts in domains in relation with the activities of the company whereas during a crisis situation, the functioning of the organization is by definition disturbed. Therefore, it is important to dissociate the roles within the crisis unit from the professional functions of the representatives.

In a crisis unit of an organization, the number of members is limited to help maintaining a certain cohesion and efficiency. A work based on the document about crisis units proposed by Lagadec (1995), discussions with practitioners (Fire and rescue services and “Préfectures” in France), and own thinking lead to highlight seven main roles within a crisis unit (table 3). These roles are prepared in advance in relation with the emergency / crisis plans developed by the organization.

*Table 3. Main roles present in a crisis unit*

| Roles | Actions (with regard to the event) | Comment |
|---|---|---|
| Crisis steering (director of operations)<br>Can be represented by:<br>The director of the involved organization or a representative | Before:<br>Triggers the crisis unit<br>During:<br>- Sets a strategy and objectives of avoiding and exiting the crisis<br>- Coordinates the actions of the different involved means<br>- Decides the communication in relation with the communication manager<br>After:<br>Organizes a debriefing to depict feedbacks and improvements | The director of operations forms the team that works on commandment and coordination of involved teams to make strategic decisions<br>Needed means:<br>Secretary support to write a handrail plus receive and filter incoming communications |
| Intelligence / information gathering<br>Can be represented by:<br>General services manager or Health and security service manager or Intelligence service manager | Before:<br>Prepares plans, phonebooks and identify sources of information<br>During:<br>Seeks, validates and proposes information<br>After:<br>Participates to the debriefing, presents feedbacks and proposes improvements | This team seeks for all the information needed for the management of the situation: provides the other teams with information; makes research to find information requested<br>Needed means:<br>- Updated phonebooks<br>- Updated plans and procedures directory<br>- Access to social media, news channels TV<br>- Etc. |
| Connection with tactical and operational services<br>Representative of involved services (networks, emergency services etc.) | Before:<br>Meetings and working groups to know each other, management procedures/plans and their respective tasks<br>During:<br>This team:<br>- Gathers decisions made and transmits orders<br>- Gathers information from the scene<br>- Brings expertise in the domain of operations<br>After:<br>Participates to the debriefing, presents feedbacks and proposes improvements | These representatives are the privileged link between strategic and tactical levels. They transmit the strategic order that enable the establishment of the tactics. |
| Logistics<br>Can be represented by:<br>-Financial service manager<br>-Technical service manager<br>-Legal service manager<br>-Human resources manager | Before:<br>Prepares documents listing adequate information:<br>- Inventory of technical resources (number and location…)<br>- List of employees (name, function, contacts, external contact…)<br>- Emergency accommodation facilities details<br>- Emergency supplying details (water, food…)<br>- Insurance details and emergency billing process details<br>- Emergency laws and legal details<br>During:<br>Deals with:<br>- Material Logistics<br>- Human Logistics<br>- Accounting and Financial Logistics<br>- Legal Logistics<br>After:<br>Participates to the debriefing, presents feedbacks and proposes improvements | The purpose of a logistics unit is to provide the resources and means needed to make decisions and for the actions undertaken.<br>During a critical situation the use of specific means can induce extra charges for the organization that need to be taken into consideration. Moreover, the legal unit supports by taking all measures to ensure the legality of actions and prepares possible actions (e.g. appeals) |
| Communication<br>Can be represented by:<br>-Communication manager<br>-Expert journalist in contract with the organization | Before:<br>- Prepare the communication process in relation with emergency plans<br>- Set the communication means<br>- Social Network page<br>- Special toll-free hotline<br>During :<br>Prepares the communication based on decisions made by the director of operations toward adequate stakeholders and/or the public:<br>- Other communication services of involved organizations<br>- The media<br>- Social networks<br>- Etc.<br>After:<br>Participates to the debriefing, presents feedbacks and proposes improvements | This team is in charge of the communication toward the different receivers. Be careful to not be mistaken with the intelligence team.<br>This team makes the official communication.<br>This role is important regarding the image of the organization |
| Expertise<br>Can be represented by:<br>Experts with the specific knowledge of the danger that the organization is facing | Before:<br>List of experts pre-identified in relation with pre-identified risks<br>During:<br>This team:<br>-is at disposal of decision makers and other roles<br>-proposes ideas<br>-does not decide<br>After:<br>Participates to the debriefing, presents feedbacks and proposes improvements | This team is formed with one or several experts to help the decision making process. It is important to pre-identify the list of experts in order to help them getting used to the functioning of the crisis unit (know other members, aware to the type of reasoning) |
| Anticipation<br>Can be represented by:<br>Expert in the science of danger (cindynics) or crisis situation | Before:<br>Identifies external experts or trained employees.<br>During:<br>This team is formed by experts that do not deal with specific situation in order to evaluate the situation (course of events, management…) and gives advices to prevent dysfunctions.<br>After:<br>Participates to the debriefing, presents feedbacks and proposes improvements | This unit brings together a group of people who, permanently, have the same information as others and use risk analysis methodologies such as cindynics to devise strategies to avoid any failure of the actions undertaken.<br>In case of failure,the actors lose valuable time to rethink or even realize failure. An external actor can help the director of operations in this process. This is the purpose and function of this team. |

As a comparison with general crisis units, the roles that constitute the crisis unit of a French prefecture are defined in the design guide of the operational centers of the prefectures as follows[11]:

- the command unit that provides an overview of information from other units, makes decisions and coordinates the actions of various means;
- the rescue and care unit that defines and coordinates rescuing and securing strategies;
- the emergency accommodation unit is responsible for the management of emergency shelters and accommodations for affected people;
- the public order unit is in charge of the law enforcement, the management of the roads, etc. This unit also identifies clues for judicial investigations and coordinates police actions the scene;
- the expertise-evaluation unit that is formed by experts according to the nature of the event occurring (weather, industry, e.g.);
- the critical networks unit participates in the maintenance of electricity, internet and other vital networks for the population but also for crisis management;
- the operational services transmission unit is in constant relation with the operations at the scene in order to get information and transmits strategic instructions made at the crisis center;
- the secretary unit holds a handrail and receives and filters phone calls.

This typology is scalable depending on the Prefect management style. For more information, a precise presentation of the French operational centers design have been made by Dautun (2007). The structuration presented here follows in most points the proposition made (Table 3). Missions such as Intelligence are not clearly identified here, however this type of missions are undertaken by sub groups of experts. The interesting conclusion here is that any organization must adapt its structuration regarding its own missions, objectives, resources and its way of functioning. The proposed missions can then be held in a way or in another.

## 2.4. Synthesis

This part presented the organizations coping with «crisis». In this work, the word organization has been chosen because it enables to consider either private companies

[11] Guide d'aménagement des centres opérationnels des préfectures du 8 août 2002

and public bodies. Behind this notion, there are organizations with primary missions that must be fulfilled to avoid the risk of disruption or death, where decisions are made. All these organizations are prone to have a structuration to cope with «crisis».

The pair strategic-tactical is in the meantime very complementary but quite different in terms of level of thinking and types of actions. Basically, the strategic level gives objectives and make decisions while the tactical level think about the actions to undertake in order to reach the objectives. The crisis unit is at the strategic level and this is how it is considered within this work.

The point about the crisis unit depicts its classic functioning that can be found in important (in term of size and means) organizations. They are widely inspired from the structuration developed and used by professional emergency services (e.g. Fire and rescue services, Prefecture).

## 3. Crisis and emergency: one complementarity and several differences

This part aims to depict that «crisis» is different than emergency even though it is clear that each other's domains are shared. Previously, it was seen that the crisis can be positioned in the response phase of the risk management cycle when an adverse event occurs. However, a crisis is not an emergency. In this third part of the chapter, we discuss the relations between both concepts and try to understand why they can be confused whereas they are different. Then, we propose to focus on the perception of crisis to introduce the fact that behind the notion of crisis, as an undesirable event, there are human feelings. Eventually, we explain that the crisis is more complex than just the occurrence of an undesirable event, by talking about its anatomy.

### 3.1. Emergency versus crisis

The concept of «crisis» is often misunderstood in the context of risk management and during the management of uncomfortable situations for organizations. It is quite obvious that «Crisis management» is used in any out-of-the-ordinary situation regulation, requiring emergency treatment, and calling for «risky» decisions (Hansen-Glize 2008). The phenomenon is depicted by all the so-called «crisis management plans» that refer to an organization to handle an emergency situation with critical consequences. It seems that there are confusions when it comes to talk about crisis management, emergency response, crisis communication, incident management, and event management for example. All these processes are important but the management of a crisis situation remains upon them aiming to develop the strategy and the tactics in order to retrieve the normal functioning of an organization whose life

is threatened. It is important not to take it as an emergency situation because the process of solving/response is different and this misunderstood, as a consequence, will result in confusions regarding roles to be involved and actions to be undertaken. Therefore, clearly identify the situation represents the first step of a critical event management.

To try to understand why does this amalgam comes from, Lagadec (1995) recalls that until the 80-90's, the society was more habituated to thinking in terms of accidents and limited failures: good relief services, good emergency plans and some specialists could be enough to fill in relatively small gaps. The disturbance for one did not mean that the others were automatically endangered. During the 80s the French public authorities worked on the need to «manage the crisis»[12] to respond to the security and safety emergency developed in the civil society. These events that are identified as serious post-accident crises or accidents were classified as «natural», «technological» or «societal» type. If we take into account the number of causes, stakeholders, territories, and learn from the catastrophes that occurred in France, or elsewhere in the world, it highlights the need for «good coordination» between institutional and emerging actors. In addition, the «complexification» of the environment has brought new actors involved within the process of crisis coping because of the added value they can bring. Hence, by empowering those who were not already responsible such as insurers, for example, the hope of optimal management of the crisis allowed to think and let say: «Never again!» (Hansen-Glize 2008).

However, the world changed in complexity by rendering more connected critical infrastructures raising the issue of interdependencies and cascading effects. Then, the world is now confronted with powerful dynamics of destabilization. This context illustrated with major disasters have considerably altered the current view of the crisis and, consequently, the representations constructed in the public discourse.

The necessity to clarify terms that are used to qualify situations faced by organizations is important in order to prepare the adequate response. Indeed, each organization is vulnerable and must to identify risks and plan its response accordingly. Although they involve the notion of urgency and serious consequences, the management of these risks is considered part of the normal functioning of an organization. On the other hand, differentiation is necessary if it is a situation that fits the criteria of a crisis situation such as «for any management structure, unique events that do not fit with an organization's history, policy or procedures if they did, it would not be a crisis» (Borodzicz and Van Haperen 2002). Although the crisis is caused by a known risk, its strategic management cannot deal with it as an emergency.

[12] loi n° 87-565 du 22 juillet 1987 relative à l'organisation de la sécurité civile, à la protection de la forêt contre l'incendie et à la prévention des risques majeurs

### 3.1.1. Numerous terminologies

Incident, major accident, disaster and crisis are terms of the same semantic family that causes confusion for managers. As pointed out by Denis (1993), the action of qualifying or defining the event that an organization is facing is the first moment in the management of a disaster. With the objective of studying further into details crisis situations, a clarification of these concepts is needed. The literature proposes to clarify them according to a gradation of the gravity of the phenomenon. However, we will see that it cannot be as easy as it seems to be.

From a global perspective, according to the Oxford Advanced Learner's Dictionary (Oxford Dictionary), an incident is an instance of something happening, an event or occurrence. More precisely, the literature gives some definitions that include the dimensions of consequences and the undesirable nature of the event. The incident is commonly used in the industry to define unwanted events that have only a low material impact or have nearly caused an accident (Dautun 2007). According to Perrow (1999), an incident is a disruption of a component or unit of a system that does not directly threaten the entire system. Drupsteen and Guldenmund (2014) add to these definitions the unexpected nature of the event affecting the safety within the organization. Koornneef (2000) calls incidents «operational surprises», meaning undesirable conditions that have the potential for damage or other losses.

An accident is defined as a known event, indexed, easily isolatable and dimensioned within conventional assumptions (Lagadec et al. 2000). The accident situation will be described as major when the consequences are significant. From an operational point of view, the management of a (major or not) accident is part of the «routine» type. The actors apply, without apparent difficulty, contingency plans defined upstream (Lagadec 1991).

No definition of disaster is accepted universally (Turner and Pidgeon 1978). Shaluf et al. (2003) explain this because the definition of disaster depends on the discipline using the term.

A disaster can be likened to an event that has serious consequences for humans and suddenly arises in our daily lives without having been foreseen (Denis 1993). Conventionally, a disaster is defined according to its origin, its consequences, its course and its level of risk (Dautun 2007). Disasters of natural origin are opposed to man-made disasters. Whether the disaster is related to «God's deed» (NeSmith 2006) or «man-made» physical origin, (Quarantelli 1990) do not make a categorization according to its origin, since they focus mainly on consequences on the society and community responses. A situation is described as a disaster depending on the severity and duration of the consequences, the society, and tensions in the community sociologists (Denis 2002). Damage scales have been developed to quantify, a posteriori, the event. Dauphiné and Provitolo (2013) describe situations of accident, disaster, major disaster or super-catastrophe according to a gradation of the number of victims, financial losses and losses of biomass. As another example of description

methodology, the European scale of accidents characterizes a posteriori the effects and consequences of a situation on six levels ranging from 1 (not serious) to 6 (very serious).

In its technical report Union Carbide referred to Bhopal as an «incident», the government of India, in its report, called it an «accident», the injured victims called it a «disaster» and the social activities called it a «tragedy», «massacre» and even «industrial genocide» (Shrivastava 1992).

Regarding the notion of crisis (that will be widely developed in Ch. 2) the state of art gives an insight on the difficulty to find a common definition. To confirm this feeling, MacMullan (1997) in her review of the meaning of crisis since 1972 came to a conclusion that a universally accepted definition of what a crisis consists in has not yet been developed. This opinion is shared with Mittrof et al. (1996). For both this definition is also unlikely to emerge in the near future. In 2018, more than twenty years after this finding, the position remains the same. However, authors agree to say that both crisis and disaster refer to a severe situation. However, Turner and Pidgeon (1997) see a different management process since during a disaster, management procedures must be maintained and management problems coped with under conditions of major technical emergency involving threats of injury and loss of life whereas Shaluf et al. (2003) recalls that the meaning of «crisis» is a situation in which important decisions have to be made in a short time claiming the need to go beyond the scope of procedures.

### *3.1.2. Differences and interferences*

To depict the similarities and the differences between crisis and emergency, we propose to have an insight on Borodzicz's doctoral thesis (Borodzicz 1997), in which the author tries to make a clear distinction by providing definitions. «Emergency» is defined as a «situation requiring a rapid and highly structured response where the risks for critical decision makers can to a relative degree be defined». Hence, this situation can be managed by emergency services applying their prepared plans and routine responses. A «crisis» is defined as a «situation requiring a rapid response, although in contrast, the risks for critical decision makers are difficult to define owing to ill-structure». The need of a rapid response is probably one of the reason why a crisis is easily misconceived as an emergency (Kim and Lee 2011) because time available for decision making is constricted (Lalonde and Roux-Dufort 2013). The emergency response is generally based on known and formalized responses although the unique nature of a crisis situation implies the need to innovate.

Another difference that creates confusion between terms is one of the criteria that characterizes the crisis: the relativeness. The crisis is relative and its perception and representation of what is a crisis is different (Miller and Iscoe 1963). For example, the same situation may be a crisis at one time but not at another (Shaluf et al. 2003) or a

crisis for an organization would be an emergency for another. In fact, the phenomenon of crisis can be considered as irregular. It is relative to the context of the affected environment. A crisis may perturb individuals, groups, organizations or maybe nations. This particularity makes that in the literature, there is no consensus about how this term should defined. This is probably why we frequently find the term crisis to discuss about an emergency, a disaster or a catastrophe too (Dombrowsky 1995).

Although a disaster is different from a crisis in number of ways, there is also some similarities between these two types of situation. Because of its intensity and because of the fact that it impacts the entirety of a system, the disaster is known as a crisis-related phenomenon (Shaluf et al. 2003). However, the cause and effect relationship is not clear since it has been argued (Davies and Walters 1998) that the crisis, if not attended, may develop into a disaster.

## 3.2. The perception of ”crisis”

Although crises are common, little is known about how a situation can be perceived and then defined as a crisis. The perception of the crisis is important because if a situation is defined as such, the primary crisis management activities are affected (Penrose 2000).

Determining if a situation is a crisis is an important issue that is studied since the 70’s with Hermann (1972) who was a pioneer in proposing such ideas. His model relies on three elements that are:

- the threat that is a possible barrier in the process of achieving a certain goal and the author introduces the hierarchical level which is involved since the threat is likely to be recognized by the decision makers;
- the decision time that is short when the situation will be altered anyhow in the next coming future, after which the decision can be made only under less favorable circumstances or even no decision can be made;
- and the surprise that deals with a lack of awareness by the decision makers that the crisis situation is likely to occur

The model presented by Hermann in 1972 has not remained unchallenged. Consecutive studies such as the one completed by Brady (1974) proposed that among the three elements of Herman’s model the threat is the most important to determine when a «problem» becomes a crisis because for Brady, time pressure and surprise are necessary constituents of a crisis. Billings et al. (1980), on the other hand, state that the first step in the process of defining a situation as a crisis involves perceiving an event in the environment which triggers the crisis. This situation generates the perception of a gap between the current state (perceived reality) and the desired state

(illustrated by goals or objectives). Once perceived, Billings et al. suggest to attend, evaluate and compare the triggering event against some standard or measure of how things should be, in order for a problem to be sensed. The first step in making a decision is recognizing or sensing the problem. To realize this assessment Billings recommends to focus on the possible loss (value and probability) and time pressure. It is clear then that it is not easy to define a situation as a crisis even though its identification is crucial to design the management of the event.

## 3.3. The anatomy of the crisis

The work undergone on the perception of crisis lead authors to describe its complex «anatomy» by defining several stages. Fink (Fink 1986) for example studied how a crisis manifests itself in an organization and proposes four stages:

- The prodromal crisis stage: considered at this stage, the critical situation will be most easily treated. Fink compares this stage to sailors spotting a storm, they cannot change the storm but they can prepare themselves for coping with it. At this moment the crisis is still a threat, the objective is to prevent that the critical situation turns into a crisis.
- The acute crisis stage: described as the point of no return. At this stage, the crisis has hit and the objective for the organization is to limit damage. This stage of the crisis is characterized by the speed and intensity which things happen with.
- The chronic crisis stage: also called the «clean-up» or «post-mortem» phase of the crisis is when investigations and self-analysis are undertaken as well as the start of healing.
- The crisis resolution stage: reached when initial objectives are achieved.

From the global anatomy of the perceived crisis, two visions, based on the paradox that the occurrence of a crisis is unexpected but can also be predictable, may emerge: the event type vision and the crisis process vision (Dautun 2007).

According to the event-type vision, the state of crisis would be triggered by a single or multiple event, unpredictable, contingent and of low probability of occurrence (Shrivastava 1995). The impact of this phenomenon is brutal, destructive, unexpected, provoking a state of shock, surprise (Lagadec, 1991). This approach tends to confuse triggering event and crisis. The crisis would therefore occurs at the peak of a disaster. However, considering the crisis only as an event does not help to anticipate crises and, above all, does not prevent them. According to Roux-Dufort (2003), the event approach encompasses a sum of events and situations that are very varied, which makes the power of precision and discernment lose its power. The focus is indeed on

the effects that the crisis produces. We must wait until it is triggered to identify it and be able to act, which does not recognize the crisis upstream in order to avoid it.

The second vision constructs crisis as the result of a process of maturation within organizations. This approach leads to consider the crisis in a broader dimension of time and space (Forgues 1996). Turner (1978) was one of the first to assume that disasters and crises could also result from the action or inaction of organizations. According to him, these situations are caused both by a discharge of energy in the environment - the physical intensity of the phenomenon and the severity of the consequences - and an inappropriate treatment of the situation by the organizations. Based on Turner's work as well as several past crises cases in the late 90s-early 2000s (Pearson et al. 1997; Faulkner 2001), the anatomy of crises is defined according to 7 successive stages listed by Dautun (2007). This approach helps to realize that it is possible to take measures to mitigate or to avoid the occurrence of a crisis. Shrivastava (1993) explains that the crisis is not an event but a process that extends in time and space.

Figure 2 presents both visions illustrating that crisis process vision and trigger event vision are two distinct interconnected situations. These two visions are not opposed but rather complementary, one focusing on the events generating crisis, the other looking for the organizational flaws that create fertile ground for the development of crises. Although they do not consider the cause as being of the same nature, the two approaches qualify the situation according to the same characteristics. Thus, regardless of the vision, the perception of the crisis will be identical for the individual or the organization that faces it.

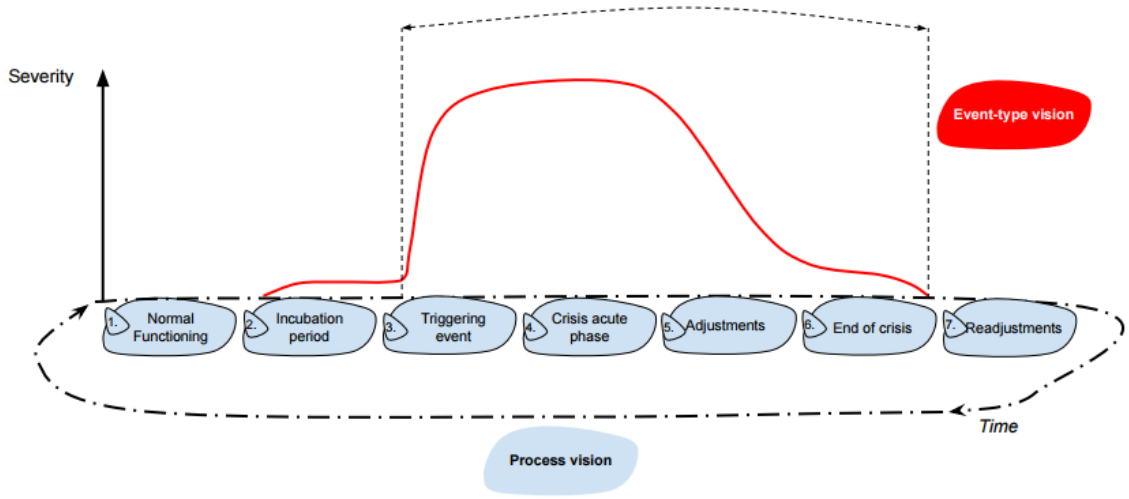



*Figure 2. Representation of the anatomy of the crisis according to the event-type and process visions. Adapted from Dautun (2007)*

## Conclusion

The notion of crisis is widely used on a daily basis in many contexts: economic, political, health, «incidental», etc. In this first chapter we emphasized that we are focusing on the crisis linked to the occurrence of an unexpected and disturbing event of «incidental» nature. These crises can be associated with disasters or accidents. We have found that in the field of managing «incidental» events from the scale of an accident to the disaster, emergency management professionals are primary stakeholders and serve as model. The crisis is never desirable, when the occurrence of an undesired event either known, manageable or unknown for which it is necessary to innovate, the management of direct consequences is essential. In this context, emergency management services apply their operational protocols, which makes them key actors. The presentation of the civil security organization is therefore important to consider our study on the «incidental» crisis.

During the 2000s, the awareness of the need to get prepared to cope with crises following extreme natural, industrial, and malicious events has led to make «crisis management» integrates many organizations of any types of activity. Therefore based on recent events and motivated by national politics, the organizations have structured their management of these undesirable events.

We have seen that the crisis goes beyond the event and the situation it generates. However, since crisis goes beyond the nature of the event, it is persistent to consider it as a concept in its own, despite the close relationship it has with the world of emergency management. This concept involves the perception that is necessarily relative in different individuals.

The ambiguity between the emergency and the crisis was noted and it was important to show the differences between these two concepts because there is an interest to identify that the situation is a crisis or not in order to adapt the functioning of the crisis unit. Even though, it is really important that an organization focuses on its capability to respond to every events it is able to foresee, there is still a need to keep a certain capability to adapt whether the situation exceeds the actual response procedures. We found in this first chapter that the word «crisis» is also difficult to define. As part of this research, we have studied a number of definitions in order to choose one on which to base the study. The result is that it is very complicated to choose one. Indeed, when reading all suggested definitions, it appears that they include differences but also seem complementary. For this reason, we focused on the characteristics given by the authors to illustrate their definitions. In the following chapter, a positioning of our research regarding the concept of crisis will be proposed. After presenting how the crisis was apprehended in a general way, this positioning will allow us to return in more detail on what we mean by «crisis» then we present the characterization that we make of it.

# CHAPTER 2: POSITION OF THE RESEARCH REGARDING THE CONCEPT OF CRISIS

## Introduction

We have found that there is a very rich terminology to define the seriousness of a situation. Words such as incident, accident, disaster and crisis are denominations for which the definitions correspond to the first moment where critical event started to be managed (Denis 1993). In fact, the disruption of an environment by a triggering event can lead to several types of reactions and behaviors that can impact entities as diverse as an organization, a structure, or a territory (Heiderich 2010). We saw in the previous chapter that a crisis could not be managed in the same way as an accidental critical situation because it is unique in nature and exceeds the known benchmarks of those who suffer from it (Lagadec 1991) and consequently the plans and procedures. Therefore, even though the concept of crisis is linked with the vocabulary of the emergency it is different.

In this chapter we will return to fundamentals: where does the word «crisis» come from? Some etymological reminders will help to understand how this term is apprehended today.

Although we often associate the word «crisis» with the nature of an event, in fact we can see that in reality the crisis can be considered on its own. Indeed, in the analysis of crisis situations, whether technical, natural or operating, for example, the same characteristics are given to illustrate the situation itself as well as the feelings of those who live it and who tries to manage it.

One can illustrate this by taking the example of an organization undergoing a phenomenon that could interrupt its main activity. In this situation, the body is likely to suffer so much that its survival is in danger. This configuration can generate a crisis within the organization.

In this research, based on the previous elements, it seemed difficult to stop at a simple definition of crisis. For this reason, a characterization of the crisis is proposed to provide cross-cutting indicators that can be applied to any type of crisis.

The chapter is composed by four parts that tend to draw the position of this research work regarding «crisis». In the first part, beyond the difficulties of perception discussed in the previous chapter, we focus on the official definitions of the crisis starting from its etymology to the main definitions found in the scientific literature. The second section deals with the categorization often given to crises and the will to go beyond this scope to consider the crisis above all. Our reflection finally led us not to focus on a specific definition of the crisis but rather on a list of characteristics because each proposed definition brings an added value for a better understanding.

# 1. Crisis: from etymological sense to scientific use

The concept of «crisis» is ubiquitous in society. Despite this omnipresence, it remains imprecise and unspecified. In fact the crisis is one of the concepts whose theory is the most underdeveloped (Hay 1999). In this context, it is interesting to imagine that it would be likely that the omnipresence of the term paradoxically comes from its vagueness.

Over the centuries, the word crisis has had different meanings depending on the field of use as well as the evolution of research. Generally, «crisis» is often used to announce the consequences and describe the causes of a negative situation (Laulusa 2009).

Crisis finds its root of the ancient Greek word *krisis*, which means the decision, in the context of a judgment. The term was first used in medicine to designate the time from which the doctor had to decide on the treatment of the patient because he was in a serious phase of a disease.

Historically in the French language (Le Robert) this term is then firstly confined to the field of medicine «the decisive phase of a disease» and by extension it was transposed into a broad variety of domains such as the economy (economic crisis), society/politics (political crisis), or the environment (geological, biological crisis).

In the English language, the term also first had a medical character «the turning point of a disease» before giving the general meaning of «decisive point» in the 17th century. The modern definition keeps the notion of «turning point when an important decision must be made» even if the first definition corresponds to «a time of intense difficulty or danger» (Oxford dictionary).

In Chinese the word crisis (*weiji*) goes further than the Greek vision by describing a moment or a critical situation, but the threat is combined with the idea of opportunity. The word *«weiji»* is indeed formed of two opposite terms, the danger (wei) and the opportunity (ji). The crisis is then seen under two contradictory visions: on the one hand the harmful situation, the critical moment, the state of emergency expressed by the character wei; and, on the other hand, and simultaneously, the opportunity, the luck, all included in the term ji.

It is interesting that when going through the literature authors mostly focus on the Greek vision - Morin (1993) states in the early 90's that most of the authors tend to avoid the positive side of the crisis - since crises are considered to be threats to the survival and the goals of an organization (Hermann 1963; Fink et al. 1971; Nystrom and Starbuck 1984; Smart and Vertinsky 1984; Shrivastava et al. 1988; Pauchant and Mitroff 1992; Kovoor-Misra 1995; Ulmer et al. 2013). Although Milburn et al. (1983) bring in their vision the Chinese openness by saying that they can also serve as opportunities for organizations. Another paradox can be found regarding the expectedness of the crisis with authors characterizing it as surprising (Hermann 1969;

Pearson and Mitroff 1993) and others as predictable (Milburn et al. 1983). In this work, we consider that the notions of opportunism and unpredictability are inherent to a crisis of course but they find their place within the risk management cycle at different stages compared to the crisis situation. The crisis situation, collapsing an entire system, offers the possibility of «rebuilding» in a better way. However, this reflection comes with the feedback and mitigation phases when the organization, which has faced the crisis, identifies and takes advantage from the opportunity offered by the lived experienced to mitigate the risk now known.

As far as predictability is concerned, this characteristic occurs before the onset of the crisis, probably during the identification and risk prevention phases, when the awareness of the non-ability to deal with all situations is increased, as well as when gaps in risk prevention are uncovered.

Beyond this paradoxical characteristics, authors go deeper in the characterization by adding that a crisis is a special situation with its own characteristics defined by uncertainties, a quick onset, temporal constraints, significant short-term losses (human and economic), a lack of controllability and a high level of stress (Flin 1996; Sniezek et al. 2001).

The general definitions found in the literature (Table 4) show, in a practical way, the difficulties of finding a common sense for the concept of crisis since for each author, a definition emerges. There is no consensus to have a universal definition (Mitroff et al. 1996). Although they are different, it is difficult to find a false one because they all make it possible to highlight features that seem to be peculiar to the crisis.

Despite these sometimes diverging definitions, the definition of Pauchant and Douville (1993) should be acceptable to most authors. This definition is interesting because it remains vague in order to fit to all domains and emphasizes the peculiarity of the crisis, namely the need, in the context of emergency, to question assumptions and procedures of the impacted organization due to a disruptive situation induced by a new risk.

This part put in evidence that in the same time the elements associated with the concept of crisis can be heterogeneous and complementary. For this reason, it seems interesting to propose a precise study on how to obtain a certain completeness of the elements that aims to characterize the crisis. Before that, we will gain enough height to understand that the crisis can be of any kind and that it can affect any type of organization as said before.

*Table 4. Definitions of the concept of crisis found in the literature (adapted from Lalonde and Roux-Dufort 2013)*

| Authors | Definition |
|---|---|
| (Hermann 1972, p. 13) | A crisis is a situation that threatens the high priority goals of the organization, restricts the amount of time available for response, and surprises decision makers by its occurrence. |
| (Milburn et al. 1983, p. 1144) | An organizational crisis can be defined as: (a) an opportunity for the organization to attain its current goals; or (b) a demand of or threat against the organization which either prevents the organization from attaining its goals or actually removes or reduces an organization's ability to attain its goals, that the organization seeks to resolve because the outcomes at stake are important and the resolution strategy is uncertain. |
| (Rosenthal et al. 1989, p. 10) | A crisis represents a serious threat to the basic structures or the fundamental values and norms of a system, which under time pressure and highly uncertain circumstances necessitates making vital decisions. |
| (Pauchant and Douville 1993, p. 45) | Crises are disruptive situations affecting an organization or a given system as a whole and challenging previously held basic assumptions; they often require urgent and novel decisions and actions, leading potentially to a later restructuring of both the affected system and the basic assumptions made by the system's members. |
| (Keown-McMullan 1997, p. 8) | Three elements characterize a crisis: (1) a triggering event causing significant change or having the potential to cause significant change; (2) the inability to cope with the change which has taken place; (3) a trigger so significant that it to pose a threat to the survival of the organization. |
| (Pearson and Clair 1998, p. 60) | An organizational crisis is a situation of low-probability and high-impact perceived by critical stakeholders as potentially threatening the viability of the organization and subjectively experienced by these individuals as being personally and socially threatened. The ambiguity of the causes, effects and ways of resolving the organizational crisis will lead to disillusionment or loss of psychic and shared meaning, as well as to the destruction of individuals beliefs and values and individual postulates. |
| (Seeger et al. 1998, p. 233) | Organizational crises are specific, unexpected and non-routine events that create high levels of uncertainty and threaten or are perceived to threaten an organization's high priority goals. |

## 2. The crisis as a concept above its nature

In this second part we review what the literature teaches us about the nature of crises. We discuss this point by trying to explain that in our study we consider the crisis as a situation and a state that exceeds any classification. As a situation immersing

managers into a state of crisis this can easily be detached from the nature of the crisis. This situation can occur in all types of organizations from the moment when its survival is in danger.

## 2.1. Different types of crises

Based on the literature, a crisis can be of multiple forms and various typologies exist (Pauchant and Mitroff 1988; Quarantelli 1988; Lagadec 1991; Kovoor-Misra 1995; Hwang and Lichtenthal 2000; Gundel 2005) which have been well presented in the literature (Shaluf 2003; Dautun 2007). Situations are classified according to three main elements: their triggering event, their causes or their similarities. The categorization of the situation is a process that reassures the decision maker of the type of situation that the impacted organization must manage.

It is then of great value (Gundel 2005) to define the type of crisis because there is a need to understand into more details the crisis situation to keep on improving its coping by managers. The need to be able to name and analyze the situation is vital for the organization. Therefore, classifying crises is the first step to keep them under control (Gundel 2005). This vision enables to go deeper into the details of the good technical skills to improve the management of the situation or even more avoid it. However, this conceptualization tends to consider that a crisis is a situation that can be kept under control.

Typologies have been made based on the origin of the source of the hazard (internal or external) and the primary factors (human or technical causes) (Mitroff and Pauchant 1988; Pauchant and Mitroff 1995; Kovoor-Misra 1995). From these studies come several major types of crises such as technical crises, human crises, political crises, legal crises, ethical crises, cultural crises, economic crises, information crises, technological crises, environmental crises, and crises due to natural disasters.

Gundel (2005) focuses on organizational response and classifies situations according to the predictability of the crisis and the influencing capacity of the affected organization before and during the crisis. Four types of crises emerge:

- conventional crises that are predictable and for which organizations have considerable influence;
- unexpected crises that are rare and unexpected for which organizations have a weak influencing capacity;
- intractable crises can be anticipated but, because of a failure, the influencing capacity is weak;
- and fundamental crises that are unpredictable and uncontrollable due to a lack of knowledge about the response to be provided.

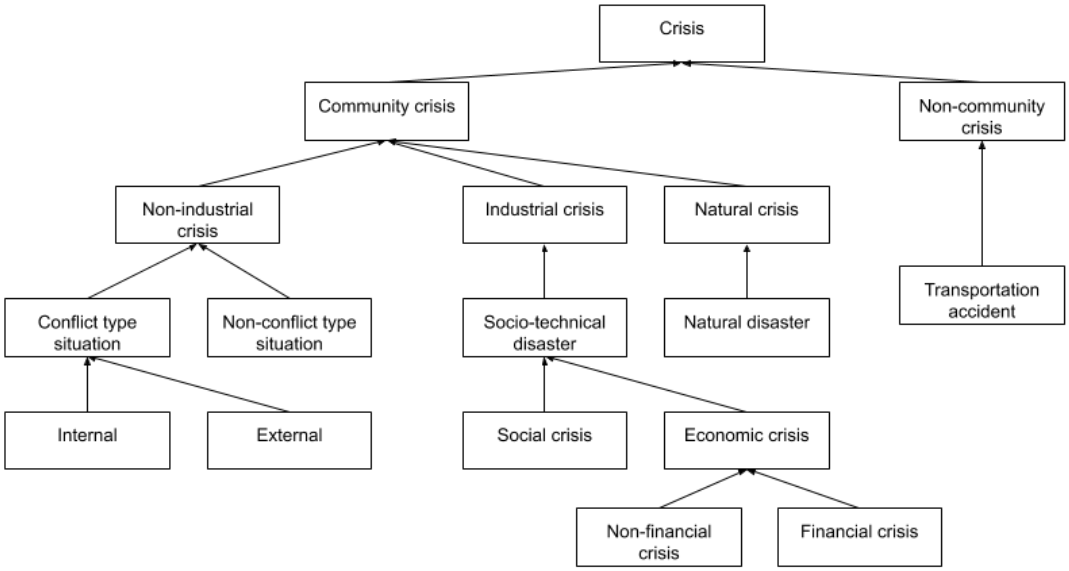



*Figure 3. Typology of crisis proposed by Shaluf and al. (2003)*

While considering the crisis through its different types, it is necessary to have an expert position in the field in which it occurs while the general concept of crisis remains the convergence point of all. Shaluf et al. propose a typology (figure 3) based on arguments developed in 2003 that may be discussed. However, the interesting element in this figure is the convergence point toward the case «CRISIS» which is above all. Indeed, determining the type of crisis influence some characteristics of the crisis or its perception but it does not influence the number of them. If so, it would not be a crisis anymore. The characteristics that defines the crisis are intended to go beyond the scope of the type of crisis and should be observed in any of them.

Therefore, classifying crisis is a process which is part of the objective that aims to prevent the crisis itself. In this research, the focus is made on the statement that anyhow, a crisis will occur and the managers will be confronted to its characteristics. Categorizing is a way to keep the critical situation in the domain of what is known and predictable.

It is difficult to identified a situation as a crisis and being capable to know when the managers are immersed and consequently when it ends. A clarification regarding the timeframe is that a crisis is of short period and if it would continue for an extended time, it would not be a crisis anymore but rather a « general problem « (Carley 1991). The influence of the triggering event can still be perceived which implies an acute focus on it but there is a moment when the managers understand the situation and they start managing the general problem.

### 2.2. Global concept based on the non-capability to fulfill intrinsic missions

Each organization exists because it has primary missions that make it live. If one or more of its missions are threatened then the survival of the body is at stake.

Indeed, if we take the example of an industrial company, we can identify the following missions:

- to produce;
- to make a figure;
- to protect employees;
- to satisfy the client;
- to sell; etc.

If one of these missions is not maintained then very quickly the company will be in great difficulty because it will lose its customers, the productivity of its employees or amount of money which is essential to its operation.

This situation can clearly put an organization in crisis because if it has arrived at this stage it can be the result of plans and procedures that could not respond positively. The organization is therefore facing the need to innovate in order to find a solution in a context of absolute urgency (formula borrowed from medical emergencies).

There are several situations in which these missions could be impacted:

- when one of its missions is directly affected and;
- when an event occurs impacting the organization and which implies that one of the primary missions stops.

These two cases are different because in the first, all means are focused on how to retrieve the capability to fulfill the primary missions again. In the other situation, where the organization focuses naturally on the problem that has arisen, the danger of not taking into account sufficiently the return to service of the primary missions may become major.

In the following parts, a review of the literature is analyzed to present the characteristics into both categories. Each characteristic is explained through a text that presents how elements from published definitions are sorted to end up with two lists of categories.

## 3. Characterization of the crisis

At first glance, the diversity of definitions found in the literature for the concept of crisis seems confusing. This can be explained by two elements: the need to define this key

concept when working on it and the fact that it is used in a large variety of domains (from disaster management to politics and healthcare etc.). When reading the broad array of definitions in the literature, although they seem to provide different meanings and bring confusion, the features proposed by authors to characterize the crisis in their definition look very relevant. To manage this issue of understanding as well as the issue of consistency regarding previous work, despite proposing a new definition of the concept of crisis, we based ourselves on the characteristics given by the literature. Once gathered, it looked clear that they converge on two aspects when describing the concept of crisis. Therefore, we came up with two categories of characteristics which define a crisis at the level of the crisis unit strategic manager:

- The characteristics of a crisis situation;
- The characteristics of the reaction of managers who are immersed into a crisis situation.

## 3.1. Crisis situation characteristics

Regarding the crisis situation, authors characterize it using a large panel of vocabulary. However, it is common that different words actually mean the same characteristic and for this reason, we propose nine characteristics (table 5) and we explain each of them regarding the literature.

*Table 5. Characteristics of a crisis situation*

| Characteristics | References |
|---|---|
| Chaos | Wiener and Kahn 1962; Lagadec, 1993; Zhang, Jia, and Gu 2012; Lalonde and Roux-Dufort 2013 |
| Unexpectedness | Rosenthal, Boin, and Comfort 2001; Bundy and Pfarrer 2015; Herman 1972, Farazamand, 2001 |
| Important consequences | Pearson and Clair 1998; Farazmand 2001; Sniezek, Wilkins, and Wadlington 2001; Carmeli and Schaubroeck 2008; Bundy and Pfarrer 2015 |
| Uncertainty | Wiener and Kahn 1962; Lagadec 1991; Gredler 1992; Farazmand 2001; Rosenthal, Boin, and Comfort 2001; Sniezek, Wilkins, and Wadlington 2001; Boin 2004; Bundy and Pfarrer 2015 |
| Evolving nature of the problem | Lagadec 1991; Farazmand 2001; Zhang, Jia and Gu 2012 |
| Irregular rhythm | Lagadec 1991 |
| Numerous stakeholders | Lagadec 1991; Pearson and Mitroff 1993 |
| Information management issues | Wiener and Kahn 1962; Milburn 1972; Jannis and Mann 1977; Billings, Milburn, and Schaalman 1980; Gredler 1992; Pearson and Clair 1998; Boin 2004; Carmeli and Schaubroeck 2008 |
| Media involvement | Lagadec 1991; Reid 2000; Bundy and Pfarrer 2015 |

#### 3.1.1. Chaos

The term chaos is often used to describe a crisis (Lagadec 1993; Zhang et al. 2012), but other descriptions suggest similar or associated characteristics, such as a «new and unknown situation» (Wiener and Kahn 1962) and «unique and exceptional» (Lalonde and Roux-Dufort 2013). As a confusing situation of disorder leading to disorderly behavior (Zhang et al. 2012), chaos can describe many new situations; it is therefore unique when it happens, in contrast to a known situation in which previous experience tends to prevent chaos.

#### 3.1.2. Unexpectedness

The literature often defines a crisis as a consequence of an event or situation that is unexpected (Hermann 1972; Rosenthal et al. 2001; Bundy and Pfarrer 2015) or difficult to predict (Farazmand 2001).

#### 3.1.3. Uncertainty

Crises are often associated with uncertainty (Gredler 1992; Bundy and Pfarrer 2015). In his description of crisis as a situation that involves «more than uncertainties: the unknown», Lagadec (1991) noted that uncertainty can arise from the unknowable nature of an event's cause, extent or duration (Sniezek et al. 2001), as well as its evolution, since «no one seems to be able to predict the chain of events or the possible outcomes» (Farazmand 2001). In addition, during a crisis, communication can help lowering the uncertainties regarding the nature of the event. However, one person's idea of clear information may not match someone else's; this can impart additional uncertainty. All of these uncertainties make assessing the situation difficult (Wiener and Kahn 1962).

#### 3.1.4. Important consequences

Crisis situations have impacts that are large (Pearson and Clair 1998; Carmeli and Schaubroeck 2008) and widespread (Bundy and Pfarrer, 2015), leading to severe losses (Farazmand 2001; Sniezek et al. 2001).

#### 3.1.5. Evolving nature of the problem

A crisis does not remain stable; otherwise, it would end. What makes a crisis situation to persist is the fact that it evolves (Lagadec 1991) both dramatically and rapidly (Farazmand 2001).

#### 3.1.6. Irregular rhythm

The temporal rhythm of a crisis situation is not fixed. Periods of inaction alternate randomly with periods of rapid change (Lagadec 1991).

#### 3.1.7. Numerous stakeholders

The increasing number of stakeholders involved in crisis management means that a large variety of actors participate, and these people can ease or complicate the process of coping with a crisis (Lagadec 1991; Pearson and Mitroff 1993).

#### 3.1.8. Information management issues

Crises often have multiple explanations, ambiguity regarding responsibility and potential damages, and several feasible solutions (Billings et al. 1980; Pearson and Clair 1998). This ambiguity is shared between numerous stakeholders. The large number of actors sending information can result in information overload (Milburn 1972) for crisis managers. In addition to the high volume of information being transmitted, messages can be inadequate (Gredler 1992) if the information was not transmitted to the right person or is incomprehensible because of its technical vocabulary. Paradoxically, despite the large amount of information present, the most critical one may not be available (Wiener and Kahn 1962) because information is often incomplete or conflicting (Carmeli and Schaubroeck 2008). Consistent information management is the process through which relevant information is provided to the correct decision makers (Anand et al. 1998) during a crisis.

#### 3.1.9. Media involvement

A crisis usually involves the media. They scrutinize the situation (Reid 2000) and may enhance the large-scale impact of information or rumors (Lagadec 1991), making the crisis situation a collectively perceived event (Bundy and Pfarrer 2015). The media can be both aggressive and tenacious if they believe that there is a story to tell (Reid 2000).

### 3.2. Characteristics of the managers' perception and reaction to a crisis situation

In this part, we tend to present the characteristics of the crisis unit strategic managers' reaction to a crisis that they are coping with. This second category of 5 characteristics has received less attention in the literature based on the number of relevant studies (table 6). While defining the crisis, authors focus on the situation. However, due to the

fact that this situation needs to be managed anyhow, some authors characterized the situation with the pitfalls that it carries.

*Table 6. Characteristics of the crisis managers' reaction in the context of a crisis situation*

| Characteristics | References |
|---|---|
| Astonishment | Hermann 1963; Hermann 1969; Hermann 1972; Pearson and Mitroff 1993; Zhang, Jia, and Gu 2012 |
| Time pressure | Wiener and Kahn 1962; Hermann 1972; Billings, Milburn, and Schaalman 1980; Quarantelli 1988; Rosenthal, Charles, and Hart 1989; Lagadec 1991; Gredler 1992; Pauchant and Douville 1993; Farazmand 2001; Rosenthal, Boin, and Comfort 2001; Sniezek, Wilkins, and Wadlington 2001; Boin 2004; Zhang, Jia, and Gu 2012 |
| Relative nature of the crisis | Miller 1963; Lagadec 1991; Kovoor-Misra et al. 2001 |
| Anxiety | Wiener and Kahn 1962, Miller and Iscoe 1963; Flin 1996; Sniezek, Wilkins, and Wadlington 2001; Perry 2007; Perghel and Psychogios 2013 |
| Changes in relationship | Wiener and Kahn 1962; Miller and Iscoe 1963; Milburn 1972; Gredler 1992; Ramboatiana and Roux-Dufort 2006 |

#### 3.2.1. Astonishment

This characteristic results from the aspect of unexpectedness previously described. It is logical that the human reaction to a unexpected event is astonishment and surprise. Zhang et al. (2012) proposed this causal link in the definition of a crisis by saying that it results in people being astonished or in other terms surprised (Hermann 1963, 1969; Pearson and Mitroff 1993).

#### 3.2.2. Time pressure

Descriptions of time pressure are common in the literature, reflecting the perception of decision makers in crisis situations. The severity of a crisis situation requires an immediate reaction (Hermann 1972) and urgent decisions (Pauchant and Douville 1993). In addition to decisions, feedback is urgently needed (Billings et al. 1980), although there is little time to respond (Quarantelli 1988). These factors result in time pressure (Gredler 1992; Rosenthal et al. 1989) on the people coping with the situation. The word urgency (Wiener and Kahn 1962; Lagadec 1991; Farazmand 2001; Rosenthal et al. 2001; Sniezek et al. 2001; Boin 2004; Zhang et al. 2012) illustrates the need to quickly solve the problems inducing time pressure for crisis managers.

#### 3.2.3. Relative nature of the crisis perception

Crisis represents the breakdown of individual frames of reference (Lagadec 1991). Each individual has his own frame of reference, formed by his experience, knowledge and emotional state. Therefore, people experience crises differently (Kovoor-Misra et al. 2001) and crisis states are relative: a crisis for one person may not be a crisis for another (Miller and Iscoe 1963).

#### 3.2.4. Anxiety

Crises cause anxiety (Miller and Iscoe, 1963; Wiener and Kahn, 1962) that can equate to a high level of stress (Flin, 1996; Sniezek et al. 2001). Perghel and Psychogios (2013) suggest that a crisis is a time of acute stress that should not be confused with chronic stress.

The concepts of stress and anxiety are often used in an equivalent manner. Although the two concepts are related, they differ biologically; they are difficult to differentiate and thus to measure.

Stress is a behavioral, emotional, cognitive and physiological response to a stressor (Lazarus and Folkman 1984). First described by Selye (1956), it involves a physiological reaction that allows the body to face external aggression. This reaction is characterized by three phases: the alarm phase, during which the body mobilizes its defenses; the resistance phase, during which adaptation to the stressor occurs; and finally the exhaustion phase, which occurs if the stressor is too strong or goes on for too long, meaning that the body cannot cope with it. Both the alarm and resistance phases are considered to be beneficial and positive because they allow a person to adapt and control the effects of the stressor. However, the exhaustion phase is considered to be negative because it involves a failure to adapt to assault.

In contrast, anxiety describes an unpleasant emotional state that is usually temporary (Spielberger 1983). This state exists at a given time and at one level of intensity; it is characterized by tension, apprehension and nervousness. Therefore, the definition of anxiety focuses on the state of the participant, while the definition of stress focuses on the relationship of the participant with their environment.

#### 3.2.5. Changes in relationship

Crisis situations create tension between the people that experience it (Gredler 1992; Miller and Iscoe 1963; Wiener and Kahn 1962), as well as internal conflicts (Milburn 1972) that can lead to changes in relationship (Wiener and Kahn 1962). Crisis situations often trigger excessive emotional and affective demonstrations (Ramboatiana and Roux-Dufort 2006) such as arguing or scapegoating someone.

## Conclusion

The crisis is a difficult concept to apprehend because of its omnipresence associated with its vague character. It has been seen that, depending on the culture, its etymological meaning is divided between a Greek vision concentrating above all the notion of decision in the context of a judgment and a Chinese vision that wants to translate the association between the danger and the opportunity. The word crisis used as such in French or in English first made sense in the field of medicine to evoke a decisive phase in a disease requiring a decision.

The crisis can be considered as a global concept that applies to all types of configurations because it is the endangering of an organization induced by an undesired and unexpected event that can generate chaos. Some crises are experienced with consequences being not too terrible for the general population opinion. However, for an organization which loses everything, this is a break in the framework for managers. The relativity indicator is of great importance in understanding this point.

We have seen that the notion of crisis is vague which can be explained by one of its characteristics which is relativity. Indeed, a critical situation can be perceived as a crisis for some individuals and not as such for others with different experience and sensitivity. The vagueness of the concept associated with its current considerable use of fashion effects makes its apprehension and understanding complex. We saw in the previous chapter that in everyday language as well as in professional practices, crisis management often corresponds to the management of a critical event of an urgent nature. The scientific literature which has dealt with this topic since the 1970s exhibit as many definitions as authors. Nonetheless, although there are many different definitions, it is interesting to note that they all incorporate relevant elements regarding the concept of crisis. These elements of illustration and/or qualification are in fact characteristics of the crisis (e.g. urgency, ambiguity, etc.).

In order to improve the understanding of the crisis, a list of characteristics given by the literature of the crisis was constructed. Two categories of characteristics arise from this list: those defining the situation; and those specific to the reaction of managers in crisis. Actually the crisis situation is often presented as an event, nevertheless it is undeniable that it is also and above all the feeling and the reaction of the individual coping with it. For this reason we take the position to make two dimensions of features. Nine characteristics enables to assess whether a situation can be designated as a crisis and five other ones help checking if a person is experiencing a crisis.

We will see later that working with parameters such as the characteristics of the crisis, enables to consider checking their emergence in order to assess whether a situation can be considered as a crisis or not.

The next chapter will deal with the methodology of the research that aims to develop a crisis simulation approach. There will be a review of what is a crisis simulation, then a focus one existing that will be used.

# CHAPTER 3: CRISIS SIMULATION APPROACH, THE RESEARCH MATERIAL

## Introduction

The complexity of crises makes very important to anticipate them in order to better prepare to cope with them, to better recognize them but also to better understand them. Crisis simulation is almost exclusively used for pedagogical objectives. indeed, it is clear for a long time that for a better capacity of response it is necessary in particular of the experiment. To gain experience, you have to live situations either real or simulated. The simulated situation has several advantages, that of not really suffering the disastrous consequences of such a situation. Another advantage is that simulation, because of its flexibility, can be used to precisely create a particular situation. Crisis simulation fulfill this pedagogical objective quite well in regards with the amount of organized exercises in structures in which it is mandatory or not. However, due to its complex nature it should be persistent to better understand crisis situations as well as the behaviors of people immersed.

To study the crisis, many researches, such as those proposing definitions (cf. chapter 2), rely on the study of prior events defined as crises. The feedbacks obtained from many events are of course very rich and they enabled to define as precisely as possible the crisis. Thanks to these definitions, we were able, in this research work, to design our vision of the crisis based on characteristics. Therefore, the study of past events provides indispensable elements for the construction of the vision of the crisis. Observing real events is difficult because, first of all, they are unexpected and we do not know yet whether the situation occurring can be considered as a crisis, thus not everything cannot be observed at the good time. However, we think that to study crises it could be also interesting to work on simulated situations like it is often done in other domains (climatology, finance etc.). The advantage is that there is a better mastering of elements to be simulated and also a better capability to make observations and investigations.

The iCrisis tool developed at Mines Nancy in 2010 seems to be an adequate solution. Its flexibility and its development principles based on the concept of crisis make this tool a key solution to try to reach the objective of making scientific observations.

In this chapter, we present crisis simulations since the basis, with the history of the simulation to the various crisis simulation platforms that can be found nowadays and finally a discussion of their advantages and disadvantages. A second part will focus on iCrisis with a spotlight on its evolution from the beginnings to the current version. Following by, the iCrisis simulation approach is introduced which allows to understand that the simulation goes beyond the simulator by helping to reach the goals.

## 1. What is a crisis simulation?

Simulation is a process that is widely used. A simulation is supposed to recreate as accurately as possible a realistic situation to let the user imagine any type of situations.

Simulations are mainly used for two types of purposes: Scientific for prediction, in climatology or finance for example and Pedagogical for preparation in surgery or emergency management for instance.

As a disruptive and unknown situation affecting an organization or a given system as a whole, a crisis situation often requires urgent and novel decisions and actions. Crisis management is based on knowledge and reflexes that replace the normal functioning of an organization. This implies the need for managers of crisis situations to have gained some experience in a practical or theoretical way. Crisis simulations appear to be a pedagogical solution for this experience gaining issue.

## 1.1. History of the simulation: a heritage of wargames

Today, simulations are widely used in various crisis management contexts. The history of simulation started with war games and can be traced back to 500 B.C., when the general Sun Tzu is reported to have said ‘‘the general who wins a battle makes many calculations in his temple ere the battle is fought’’ (Walker et al. 2011). At the end of the eighteenth and beginning of the nineteenth century, war games developed for conflict modelling and training purposes were used by Prussians and Napoleonic army (Schuurman 2017). Conflicts with Napoleon intensified the desire in Prussian forces to train. For this reason the Prussian army introduced in 1798, the Neues Kriegsspiel[13], a war game based on chess-like mechanics whose objective is to conquer the adversary fortress, with the different forces of the army: infantry, cavalry and artillery. According to Kleiboer (1997), the game of chess originally was a type of simulation to train military commanders. In addition to testing actions, these games also allowed to study reactions of players (Kleiboer 1997) which shows that beyond the pedagogical goal of mastering a tactic, there was a scientific interest in improving the knowledge behind these simulations. After the World War II military realized the importance of the link between the combats and the political dimension, the scope of simulation methodology was then widened toward the crisis management (Kleiboer 1997). During the 1950s and ‘60s, researchers got computers which lead to a large use of computers to develop man-machines simulations. Geisler and Ginsberg (1965) and Shubik and Brewer (1972) discussed in their work the techniques that were used as well as the situations that were considered. Computers, networking, and tele-communications highly improved in the last years, allowing to use simulation and gaming for improving crisis management (Walker et al. 2011). These advances improved the degree of realism in simulated situations providing the sensation of a real emergency situations.

[13] Developed by the military theorician Johann Georg Julius Venturini

## 1.2. Different platforms of crisis simulations

There are a wide variety of devices to meet the crisis simulation goals. These tools have major differences. It should be noted that some of these tools are based on artificial intelligence engines that calculate the behavior of entities and the propagation of physical phenomena, while others correspond to environments created by experts acting situations. Also regarding the scale of the simulation it can be found approaches dealing only with one or a few participants whiles others deal with hundreds of participants at several levels of the chain of response to an undesirable event.

In the following presentation, a particular concentration is focused on the devices encountered and tested during the period of this thesis work.

- On field full scale simulation

This type of simulations consist in reproducing the physical environment as precise as it is possible. The process of preparing these simulations is very complex because it must take into consideration all the physical elements to imitate the reality of the expected situation such as places, equipments, teams, etc. They are regularly carried out and usually take the form of a catastrophic accident of great magnitude, sudden onset, requiring the mobilization of large means. Most of the time, it involves the establishment of a Crisis Response Plan, and therefore the participation of several levels of intervention. For companies, such field exercises are regularly organized. They are regulated, even controlled, sometimes audited, for example, in the framework of the ISO 14001[14] certification related to environment management in which emergency preparedness and response are tested through exercises (ISO 14001, Clause 4.4.7). These simulations require a long work upstream and the mobilization of several partners. Therefore, they are highly costly. Two examples experienced during the PhD period are presented below.

  - Campus Vesta

Campus Vesta, located in Ranst (Belgium) is a former Military Domain of 50-hectare transformed into a Multifunctional Training Site (figure 4). It belongs to the Province of Antwerp hence members of local emergency services are trained there. On this site a very large variety of situations can be simulated in many type of environments. It offers numerous accommodations[15] to carry out any type of scenario such as a 2 x2 lanes highway, a village, a hospital for example.

[14] https://www.iso.org/fr/standard/60857.html (12/10/2019)
[15] https://www.campusvesta.be/over-ons/infrastructuur.html (12/10/2019)



*Figure 4. Aerial view of Campus Vesta training site. Source: www.campusvesta.be*



*Figure 5. Pictures of the simulation carried out in Campus Vesta on 2016/05/28. Top left: a car in fire; Top right: intervention of emergency services; Bottom left: a simulated body burned in a car; Bottom right: a crisis unit.*

This facility is interesting regarding its capabilities to reproduce a very large panel of scenarios at full scale. The simulation attended (figure 5) dealt with the fall of aircraft debris on a town. Many different facilities such as a hospital, a school, an industrial plant and houses were impacted. The three levels of emergency management were involved from operational to tactical and strategic.

This type of simulation is important since it enables to involve all actors of a crisis from the stakeholders to the victims. It is a real opportunity to live the situation in its entirety while other types of simulation focus on specific elements such as the functioning of the crisis or the procedure to manage phenomenon.

- French «Exercise cadre» (crisis management general plan exercise)

In France, the major organizations, with policing responsibility as prefectures and town councils regularly organize on field full scale simulations to test the general plans and the coordinated response between every stakeholders (police, fire and rescue services, ambulances, etc.).




*Figure 6. Pictures of the simulation carried out in Nancy (France) by the Préfecture on 2016/03/16*

The first simulation attended was organized by the Préfecture of Meurthe-et-Moselle département and dealt with a terror attack in a sport hall of Nancy. To reach a good level of realism, actors played the roles of victims and others, the terrorists. One of the objectives of the simulation was to check the capability of involvement. Then, once the

information of a terror attack happening was given to the police, the whole chain of response was called and started to send means. Quickly the parking of the sports hall became full of emergency resources (figure 6). The entire chain of response was tested since the local crisis units were activated, the judicial actors were involved for the first elements of the investigation, actors played victims arriving in locals hospitals and clinics by themselves.

The second simulation was organized by the team of Professor Verdel. To manage this simulated situation, we set in parallel 4 municipalities (figure 7) of the Nancy urban area: Essey-lès-Nancy; Pulnoy; Saulxures; Seichamps. The three main objectives were: (i) to activate their municipal crisis plan (PCS); (ii) to activate their on field municipal teams; and (iii) to work intermunicipal relations. This simulation linked 4 municipal crisis units but also resources on the ground.



*Figure 7. Pictures of the simulation carried out in Nancy (France) by 4 municipalities of the Nancy urban area on 2016/11/08*

This type of simulation is interesting because due to the fact that it is organized by the prefecture, which is the head of emergency response locally, the stakeholders mobilize themselves. In addition, in regards with the means allocated to organize such simulation, the stakeholders, who are very busy with their daily activities, make the effort to involve themselves since everyone knows that it is a rare opportunity to test the interservice response.

- Scale-model simulation
  - XVR

The XVR Simulation Platform is a simulation tool mainly designed to support Incident Command training of various levels, to most known as bronze, silver and gold levels. XVR is an computer tool that offers simulation functionalities in the fields of immersive 3D virtual reality environments, 2D maps and fictive communication and media flows. The 3D virtual reality module can be used at several levels, from a unique computer until 360° plane simulators for example. This powerful tool is associated with several simulation approaches: the classroom setup used for triggering a group discussion

about a virtual scenario in the system; the individual setup to immerse participant in a virtual situation while an evaluator assesses the skills; and the team setup that allows to train multiple participants in mono- or multidisciplinary situations.

This type of tool brings the visual information that enables to increase the capability of immersion. The objective of presenting to the participant a realistic 3D scenario is to allow to obtain situational awareness of the scene. The realistic view provides elements of the incident, gives the level of aftermaths to people and infrastructure. By using the visual injects in combination with other information sources, the objective is to help the participants obtain a good understanding of the situation.

By simulating a situation at different scales and levels, the tools makes possible to address the same situation but at several levels. As shown in the pictures below (figure 8), the simulator can be used from an operational level to a tactical or strategic level.




*Figure 8. Pictures presenting different uses and view perspectives extracted from XVR simulations*

- Virtual full scale simulation

Full-scale virtual simulations are usually simulations performed in one or more rooms whose purpose is to operate crisis cells. Indeed, we focus here on the strategic level of the response. It puts actors in situation to test themselves or raise their awareness. The implementation of such simulations takes different forms depending on whether they come from public training institutes, companies, or consulting firms. In this case, it is no longer obligatory to focus on the origin of the crisis, which is no longer necessarily an accident, but which may be of a commercial, financial or social nature.

These simulations allow for easy adaptation to participant profiles by adapting the scenario to expectations.

- The crisis management platform of Alès School of Mine Engineering

This crisis management platform is located at the Alès School of Mine Engineering in the Laboratory of Industrial Environment and Risk Engineering. Built in 2011, this training platform for crisis management aims to immerse participants in crisis by isolating them in a room reconstituting a real crisis cell (figure 9). It is organized around 4 rooms:

- Two rooms for participants. It is therefore possible to separate learners into two groups and train them in parallel on the same scenario. One can also consider forming two different crisis cells and implement a self-powered scenario.
- An animation room which is at the heart of the simulation platform allowing the animators to play the scenario
- A control room which is the technical room of the simulation platform.




*Figure 9. Inside the room for participants of the crisis management platform of Alès School of Mine Engineering*

- INHESJ

Since 2007, the «Institut National des Hautes Études de la Sécurité et de la Justice» (French National Institute of Higher Studies in Security and Justice) has had a specific center for training in crisis management. Its approach aims to reconstruct a crisis situation in an organization at the strategic level. Thirty participants can be welcomed. These crisis rooms are equipped with technical means as close as possible to reality (figure 10).

This immersive approach allows participants to live in complex crisis situations where decision making is subject to multiple constraints specific to the crisis. The animation is done by experts.

The interface between the players and the animators of these simulations is provided by a specific software (PIXCIS ©). It allows to play scenarios developed for each organization that solicits.

The simulation approach used is based on flexibility and therefore allows to adapt the scenarios but also to adapt to the participants

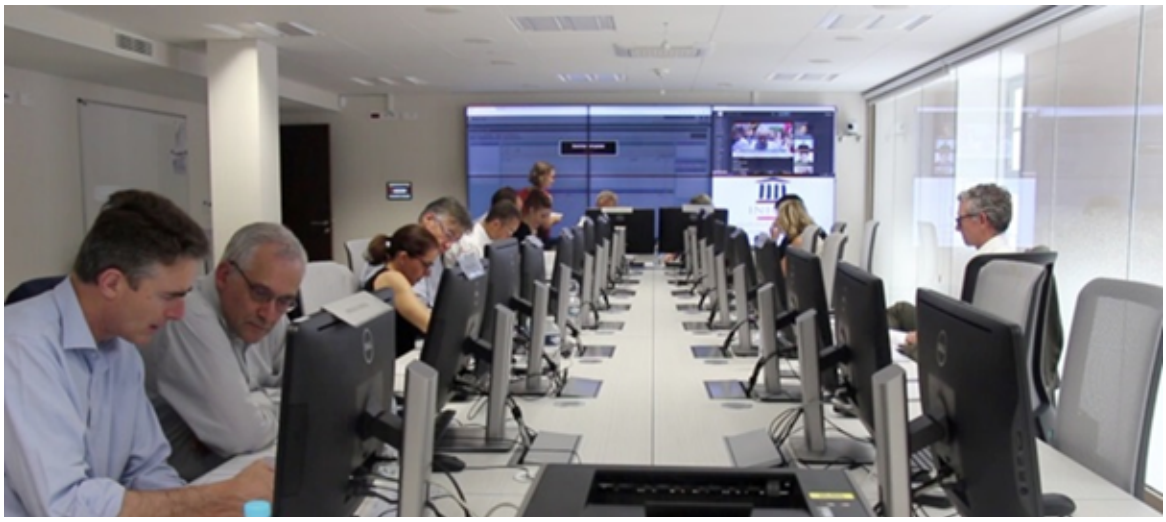


*Figure 10. Inside a crisis room for participants of the crisis management platform in the French National Institute of Higher Studies in Security and Justice*

- iCrisis

iCrisis is a technical and organizational device that organizes, animates and debriefs exercises in simulations of crisis situations. This approach aims to connect several crisis teams from different organizations to jointly manage the simulated crisis situation. The animation of the simulation is carried out by an expert group on the basis of a developed scenario. This approach aims to be very flexible so that the animation

adapts to the participants to take them towards the main objective which is to confront the characteristics of the crisis (figure 11).

The peculiarity of this approach is that it is based on a computer application of information transfer that allows the animation team to follow all the exchanges between groups so as not to miss any element.



*Figure 11. Animation team for an exercise involving all the Staff of University of Lorraine after a double terrorist attack carried out with iCrisis. 2016/06/16*

The simulation played on June, 16th 2016 carried out with iCrisis gathered three crisis units: two local crisis units of impacted sites and the crisis unit of the University of Lorraine head office. The scenario played was two simultaneous terror attacks in two different campuses of the University of Lorraine, one in the city of Metz and one in the urban area of Nancy. The objective was to assess the quality of the flow of information transferred from the local sites to the head office of the University and from the other side.

## 1.3. Pros and cons of crisis simulations

In this part, we discuss the main pros and cons of the crisis simulation. First of all the crisis simulation enables to fulfill its most seen objective: its brings knowledge. Its technical capabilities show that the simulations are flexible and easy to prepare and use. Eventually, some limits of such simulations are presented.

### 1.3.1. Bring knowledge

Nowadays, crisis management training increasingly includes simulation exercises, because learners' learning must remain at the heart of the concerns of a training session (Lapierre 2016). It is true that the opportunity to learn and put into practice skills remains one of the fundamental points of a simulation (Kosarzycki et al. 2002; Raybourn and Bos 2005). This experiential learning based on self-experimentation can be articulated around different elements of experimentation such as the detection of indices in a precise situation, the decision-making process in a particular environment as well as a training reasoning for example. A wide range of skills are also highlighted, such as those related to risk assessment (Caird-Daley et al. 2007) or more generally technical skills and non-technical skills (Tena-Chollet 2012).

The recreated environment by the simulations must be realistic (Borodzicz 2004), whatever its type, it must offer participants the possibility to perform tasks that are specific to the situation such as reflection, evaluation, decision-making and the application of actions and therefore to test the implementation of strategies (Andrews 2005; Kim et al. 2009). During a crisis simulation, participants do self-assessment and self-learning, this is a non-taught form of training. Self-assessment has several advantages such as metacognitive development skills (Cooper 2006); individual responsibility because of the significant number of self-reflection possibilities (Cyboran 2006); critical thinking development and improvement (Cooper 2006). In general, self-assessment provides the trainee with a heightened awareness and understanding of himself or herself as a learner (Ministère de l'éducation de l'Ontario 2002).

Finally, the simulation exercises allow the trainees to understand, learn from their mistakes without endangering the lives of real people. The exercises are accompanied by feedback as well as specific recommendations following the completion of the tasks (Kosarzycki et al. 2002; Maran and Glavin 2003).

### 1.3.2. Easy and flexible

Based on the principle that the simulation must recreate a situation as accurately as possible, the definition of this situation is important because it must meet the objectives and constraints of the expectations of the client but also the capabilities of the simulation approach. One of the advantages of the simulations is that they can be flexible and should be adapted to the chosen formulas on several levels concerning:

- the objectives ;
- the financial aspect;
- the number of parties involved;
- the places of execution;
- and the scenario.

Depending on the objectives and on the constraints of the organization for which the simulation is carried out, a large number of solutions exist allowing the best adaptation and the making of a good quality simulation. The elements mentioned above can be taken into consideration in the setting up of a simulation project leading to the selection of an adequate simulation approach which, once chosen, can show flexibility and adaptation beyond its execution rules.

This adaptability is provided by the trainers who are able to control the learning environment, modulate the environmental distractions, vary the educational objectives pushing the trainees to be critical on their decisions and behaviors (Beaubien and Baker 2004) in order to fit with the first goal of a simulation which is recreating an environment as accurately as possible regarding the defined objectives and thus the linked simulated environment.

### *1.3.3. Limits of crisis simulations*

In the case of crisis management training, simulations depend highly on the level of realism because this parameter - combined with other pedagogical criteria - will influence the involvement of players and therefore their learning.

The first of the limits lies in the very nature of the crisis simulation. Because this denomination implies that a crisis must be recreated as precisely as possible. However, it has never been validated that simulation solutions that want to be «crisis» simulations recreate the crisis (Judek et al. 2019). This translates concretely into realism. It is essential that the simulated situation experienced by the participants is realistic, that they can «believe it». We can therefore consider two dimensions of realism:

Physical realism that focuses on the recreation, as precise as possible, of the physical environment: furniture, sound effects, means of communication, visualization tools, work tools.

The psychological realism which concentrates rather on the psychological feeling of the participants.

Often, physical realism is considered the most important because it has a showcase effect on the participant who recognizes his real environment at first glance and during the session since he will be able to use his tools as usual. Crisis simulation developers are therefore more easily able to take into account this first dimension, the validation of which can be done visually. Regarding the psychological realism that materializes by the feelings of the participants, this dimension being difficult to apprehend because of its subjective and complex nature, most of approaches of simulations of crisis do not try to justify the taking into account of this aspect.

Simulations are mostly used in a pedagogical framework with the aim of allowing the trainees to learn. However, a number of parameters that are not easy to understand influence the ability of a participant to learn. Tena-Chollet (2012) reminds us that, regarding the trainee, it is important to know:

- If he understands (Noyé and Piveteau 2011);
- if he participates in an exercise directly related to reality (Coureau 1993), the simulation approach used must not require too much thought to be understood and to make the link with the professional activity of the trained person;
- if he understands and accepts the objectives (Coureau 1993);
- if he engages personally in the simulation (Mucchielli 2008). An involved person who decides on his thoughts and actions tends to remember better;
- if he is confronted with success and failure (Noyé et al. 1987). It is therefore important to bring the participant to success and to explain precisely his failures;
- if he feels that he is a participant, active and not guinea pig and forced, feeling «useful and unused, considered and not judged, capable and uncomplexed» (Muchielli 2008).

These parameters are necessary for a simulation to fulfill its educational purpose. Although there are studies showing that crisis simulation allows participants to acquire well-identified skills, there is no method of assessing their ability to learn today.

Simulations historically served to train the participants and help them getting experience. Numerous types of simulations have been developed in order to fit with these objectives. Inasmuch as almost all of the simulations focus on specific pedagogical objectives related to specific skills that the managers must acquire in order to know how to apply the predefined procedures, this position seems in fact a little contradictory with the nature of the crisis that is defined as unique and unknown, causing the collapse of the landmarks of those who suffer. In fact, we find in the use and organization of «crisis simulations» and «crisis exercises» the confusion, discussed in the previous chapter, between critical situations of an urgent nature for which plans and procedures must be applied and the crisis that requires a certain openness and adaptability in an unknown and uncertain environment. In a context where the situation is said to be «unmanageable» since it is not known, no response plan can exist, it seems complicated to be able to evaluate that an action is correct or incorrect without any element of comparison. For this reason and in order to work with trainees not necessarily specialists in the management of the emergency, we find a certain relevance to focus on the sensitization. Crisis simulations are therefore a solution to gain experience in an uncertain environment, by being confronted to the characteristics of the crisis in order to better know oneself reaction and to consider types of behavior intended to help steering out from an unmanageable situation.

# 2. iCrisis, an original philosophy for crisis simulations

iCrisis belongs to the virtual full scale simulation category. It only concerns crisis units at a strategic level and does not rely on computer modeling.

## 2.1. History

The iCrisis approach as known and used today is based on observations and a philosophy from several years. Before being developed at Mines Nancy (Nancy School of Mines), a school of engineers by Professor Thierry Verdel's team in the early 2000 (Verdel et al. 2010), the idea relies on Claude Hansen's work.

### *2.1.1. Claude Hansen's precursor work*

Mrs Claude Hansen worked in the field of crisis psycho-sociology for research purpose in the framework of European research project 86-94 (Unconscious disinformation processes in major technological hazards: any remedies (86-90) *«Peut-on modifier les processus mentaux de représentation et de décision en situation d'urgence ?»* 90-94)[16]. She was hired by the French emergency ambulances service as a trainer of trainers. She mainly focused her thoughts on how to prepare/train people? And how do people responsible for dealing with urgent, unexpected and severe situations could be prevented from only referring to their usual theories / practices as emergency response experts?

A first observation: the military model could not be suitable for personalities of the civil society. Indeed, a military model works for an organization structured around a single authority. In a democratic society, powers are divided and there is an obligation to negotiate between these powers.

Second observation: We cannot expect from people representing civil society to train regularly to pilot the crisis.

Based on her training as an adult pedagogue, Ms. Hansen managed to gather and motivate a team to work on the need to invent new pedagogical methods that compensate these lacks.

The methodology was developed in the framework of the European project «Can we change the mental processes...» This methodology is based on three pillars of the functioning of adult learning: modeling; narrate; simulate.

- Modeling: being able to transcode a message, to make transformations from linear to graphic, to move from a speech to a schema, to transcode from one

[16] CEE n° STEP - CT 90-0094

universe of representation to another. The interesting point is that people have different cultures and approaches and can agree at that time and have a common representation.

- Narrate: Ask people who have lived through a serious post-accident crisis to come and tell what they have experienced, observed. Bringing their testimony stimulates the listeners their imaginative capacity. People build themselves and create a range of representation of their imagination. The interesting point is that by bringing people who have lived critical situations, they tell and allow people to imagine / build / consolidate their imagination.
- Simulate: Put into practice, confront a scenario as close as possible to a real situation. The interesting point here is to allow to practice a game whose purpose is to recreate a unique crisis that allows us to change the rules gradually. It is therefore a game between existing constraints and imaginative capacities.

To make a coherent simulation with the general pedagogy it was interesting that several crisis units operate in parallel and share between them what diminished the predominance of the animation team because one is no longer in a format one against one. Still in the perspective of a sharing of responsibility, there was no question in the first seminars that elected representatives, officials of state services, industrial representatives play their own role in order to enrich their experience. They had to take the role of a function that in reality posed a problem for them to better understand how the other functioned.

### *2.1.2. A pedagogical tool*

In 1992, Nancy School of Mines introduced a new course for his students entitled «Management of natural and industrial risks». In 1995, the course was extended to cover a wider range of subjects and was renamed as «Cindynics» (the Sciences of Danger). In 2002, came an interest about crisis situations and the idea of developing a new kind of practical exercise emerged. In 2003, the first exercise was created, animated by Claude Hansen and based on the exchange of written messages between 3 groups of students playing different roles. At that time, the messages were written on papers and photocopied to the animation group. In 2004, the same exercise was based on exchanging messages through skype. This raised the interest in developing a specific software. In 2005, a group of students at the Nancy School of Mines developed the first version of a software which has been used for several simulations (figures 12, 13 and 14).



*Figure 12. Animation team using skype to transfer messages to the other groups in the first simulations carried out at Nancy School of Mines in 2004*

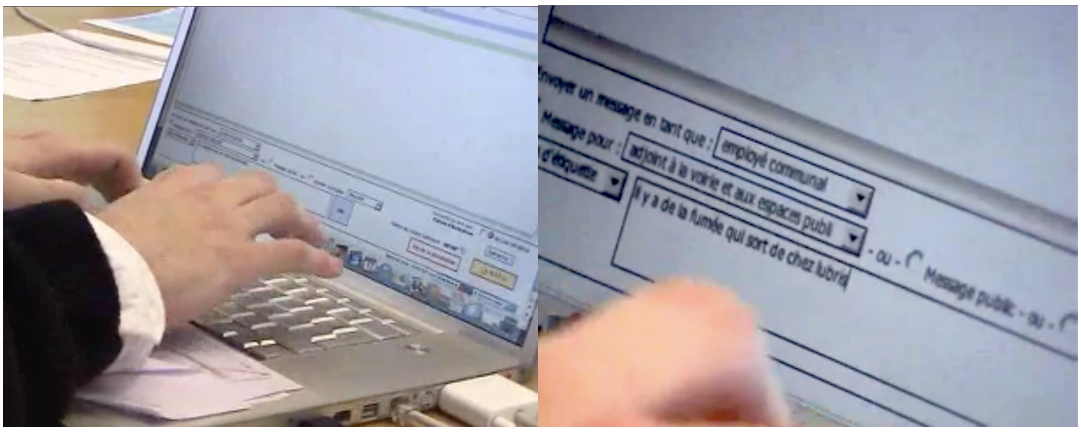
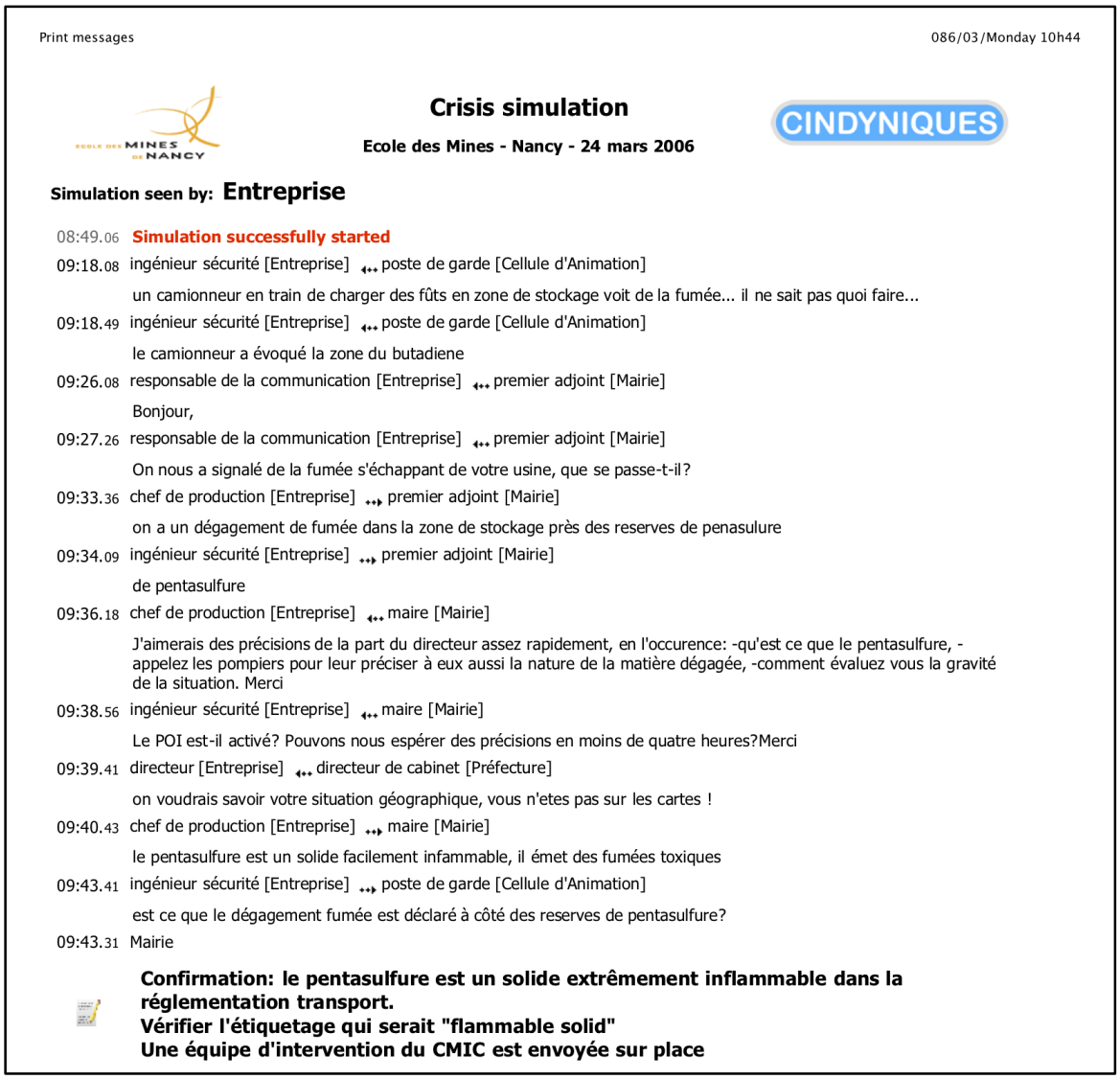



*Figure 13. The interface of the first version of iCrisis based on mysql and php*



Print messages 086/03/Monday 10h44

**Crisis simulation**

**Ecole des Mines - Nancy - 24 mars 2006**

CINDYNIQUES

**Simulation seen by: Entreprise**

08:49.06 **Simulation successfully started**

09:18.08 ingénieur sécurité [Entreprise] ↔ poste de garde [Cellule d'Animation]

un camionneur en train de charger des fûts en zone de stockage voit de la fumée... il ne sait pas quoi faire...

09:18.49 ingénieur sécurité [Entreprise] ↔ poste de garde [Cellule d'Animation]

le camionneur a évoqué la zone du butadiene

09:26.08 responsable de la communication [Entreprise] ↔ premier adjoint [Mairie]

Bonjour,

09:27.26 responsable de la communication [Entreprise] ↔ premier adjoint [Mairie]

On nous a signalé de la fumée s'échappant de votre usine, que se passe-t-il?

09:33.36 chef de production [Entreprise] ↔ premier adjoint [Mairie]

on a un dégagement de fumée dans la zone de stockage près des reserves de penasulure

09:34.09 ingénieur sécurité [Entreprise] ↔ premier adjoint [Mairie]

de pentasulfure

09:36.18 chef de production [Entreprise] ↔ maire [Mairie]

J'aimerais des précisions de la part du directeur assez rapidement, en l'occurence: -qu'est ce que le pentasulfure, -appelez les pompiers pour leur préciser à eux aussi la nature de la matière dégagée, -comment évaluez vous la gravité de la situation. Merci

09:38.56 ingénieur sécurité [Entreprise] ↔ maire [Mairie]

Le POI est-il activé? Pouvons nous espérer des précisions en moins de quatre heures?Merci

09:39.41 directeur [Entreprise] ↔ directeur de cabinet [Préfecture]

on voudrais savoir votre situation géographique, vous n'etes pas sur les cartes !

09:40.43 chef de production [Entreprise] ↔ maire [Mairie]

le pentasulfure est un solide facilement infammable, il émet des fumées toxiques

09:43.41 ingénieur sécurité [Entreprise] ↔ poste de garde [Cellule d'Animation]

est ce que le dégagement fumée est déclaré à côté des reserves de pentasulfure?

09:43.31 Mairie

**Confirmation: le pentasulfure est un solide extrêmement inflammable dans la réglementation transport.**
**Vérifier l'étiquetage qui serait "flammable solid"**
**Une équipe d'intervention du CMIC est envoyée sur place**

*Figure 14. Example of some messages (in French) exchanged by a group after a simulation carried out with the first version of iCrisis.*

### 2.1.3. The iCrisis project

iCrisis platform for virtual crisis management simulations and their debriefing has been then developed in the frame of a project financed by the French Ministry of Ecology (2006-2010) and used in several schools of engineering in France to educate engineers to crisis situations. It has also benefited from the experiences of regional or national authorities responsible for real crisis management who have been regularly invited to participate to simulations and to provide feedbacks.

The objective of the iCrisis project was the development of a role play on the one hand, and a technological internet based application on the other hand, for the preparation and execution of (post-accident) crisis simulations, intended for the training or preparation of the actors likely to be involved in the management of this type of

situation, for one reason or another. In this project, the proposed working method was mainly based on the development (upstream phase), implementation and feedback (downstream phase) of 6 crisis simulation exercises, 4 of which directly involving local actors from the prefectural services, emergency services, industry, local authorities and 2 involving students in engineering schools. In addition to setting up at the local level a network of researchers from different scientific backgrounds who were interested in the issue of risks and crises, in addition to putting this network in direct contact with the administrative authorities responsible for public safety to create joint interests. This project also aimed to offer the training market an original product for emergency or crisis preparation for a wide audience, both of professionals and students, who could be deployed remotely via the use of the internet. It should be then able to allow an in-depth study on the processes of collective decision-making in critical situation, based on stored data of the realized sessions.

## 2.2. Technical features of the tool

iCrisis as a software is a web platform for handling all messages exchanges between simulation participants. From the participant point of view, it looks like as a mail system where participants write messages from one to another. From the animation point of view, the mail system is enriched by a vision of all messages exchanges between the participants.

Technically, iCrisis was firstly developed as a set of php scripts connected to a mysql database. Therefore version V1 included :

- a credential system for users with several privileges (admin, animator, observer, user)
- a database with appropriate tables for managing the identification of users, the exchanges messages, and so one.
- simple tools for counting the number of messages and displaying the list of messages of each group.

iCrisis V2 was a new version redeveloped from scratch and using the AJAX technology to minimize the server load as Ajax technology is used to update a limited information displayed on a web page and not the whole page as the previous php based method was doing. This version also introduced the labeling of message in order to build new statistics about the messages exchanged during a simulation (figure 15) and a series of tools for analyzing the data (statistics about the number of messages and their types, graphics about the number of messages versus time, graphics to analyze the types of messages, etc), some of them using Google APIs (figure 16)

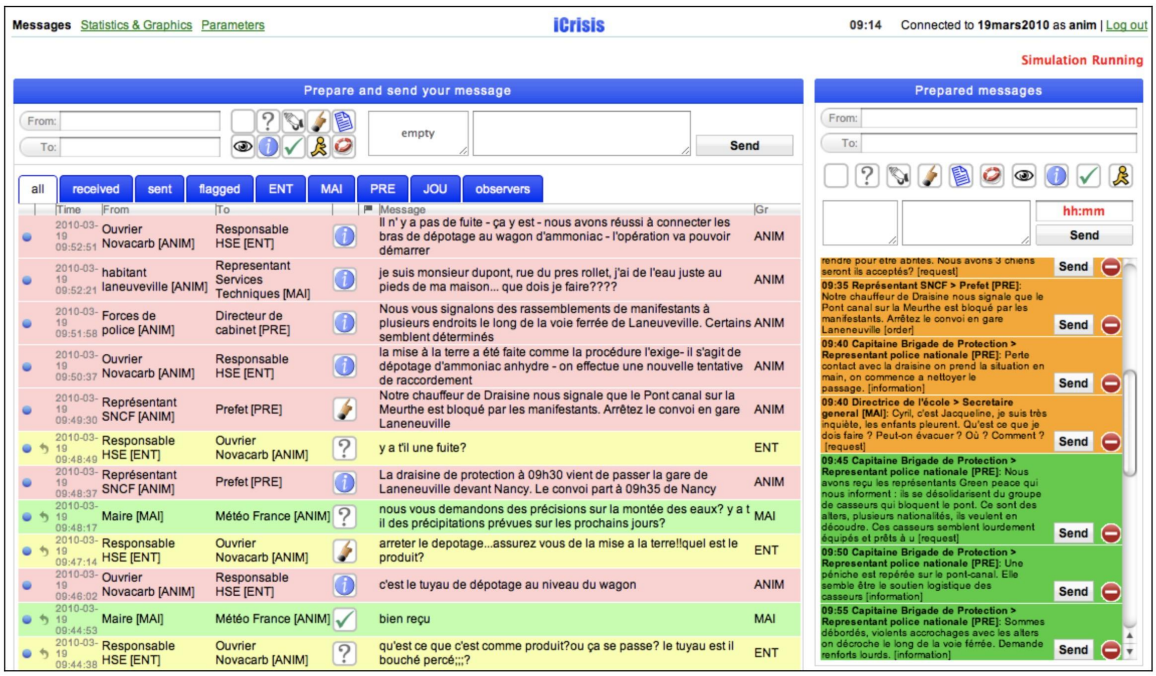



*Figure 15. Interface of iCrisis V2 providing new functions such as message labeling through the use of 8 possible icons symbolizing several types of messages (top-left close to the from and to fields)*

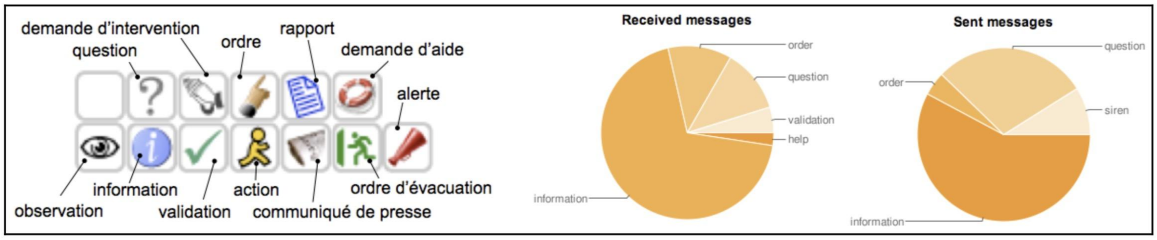



*Figure 16. Graphics provided by iCrisis V2 based on Google APIs*

iCrisis V3 has been redeveloped from scratch again using Node JS technology where the web browser carry as many tasks as possible regarding the display of information on the screen and allow real time dynamic changes on the screen without reloading all the necessary data, such as sorting messages according to different criteria, selecting a subset of messages attached to specific users, displaying conversation and so one. iCrisis V3 also introduced a notification system to highlight new incoming data as well as new graphical capabilities such as word clouds, and google maps display.

Figures 17 to 20 shows the completely redesigned interface of iCrisis in version V3 with new graphical capabilities useful for the debriefing.

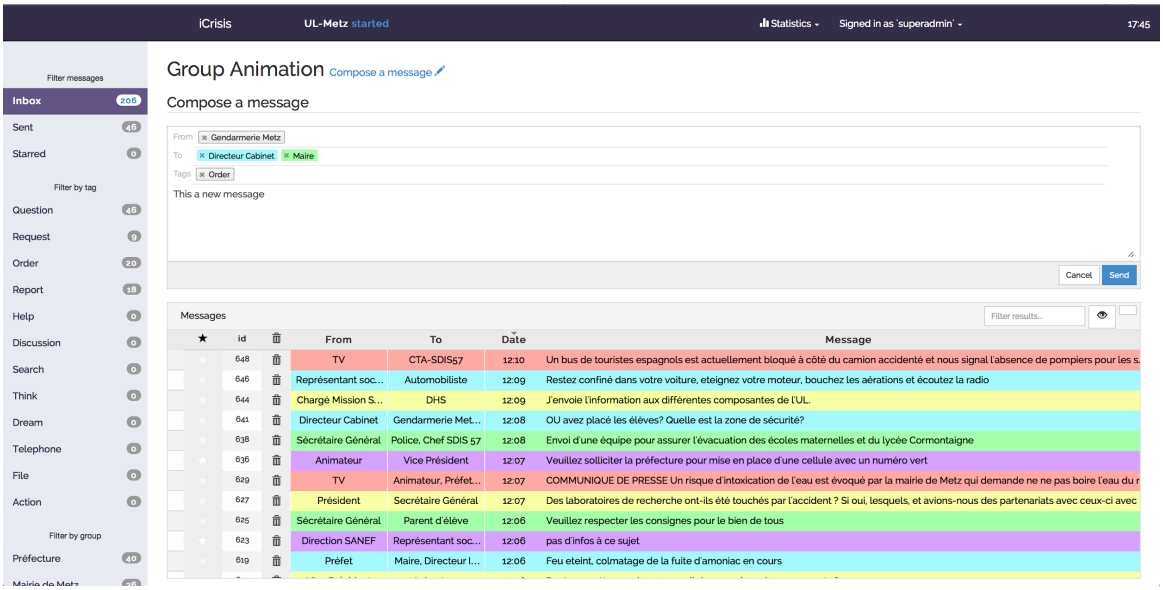



Figure 17. iCrisis V3 introducing new interface design and real time statistics on the left side

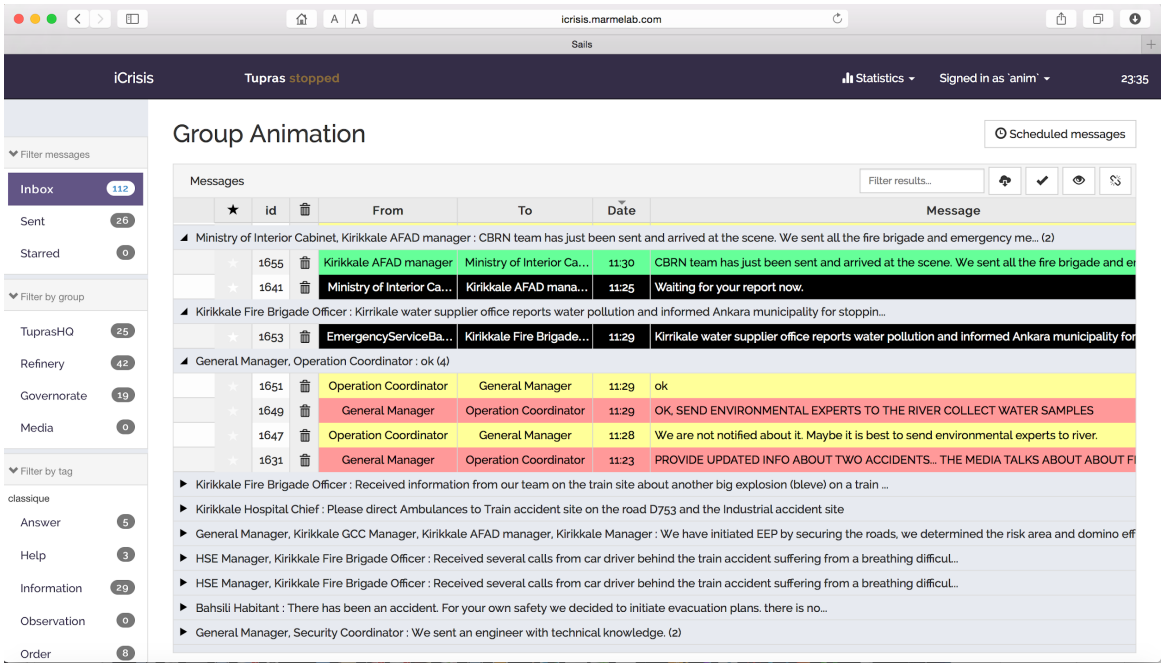



Figure 18. iCrisis V3 introducing new capabilities such as conversation display

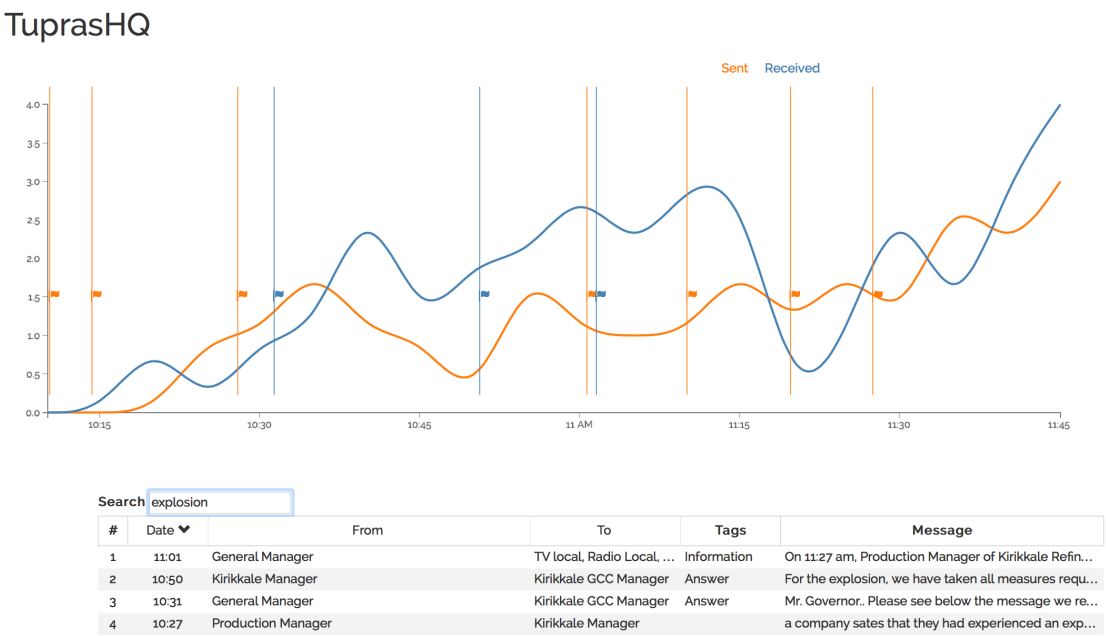



*Figure 19. iCrisis V3 introducing new graphical capabilities*

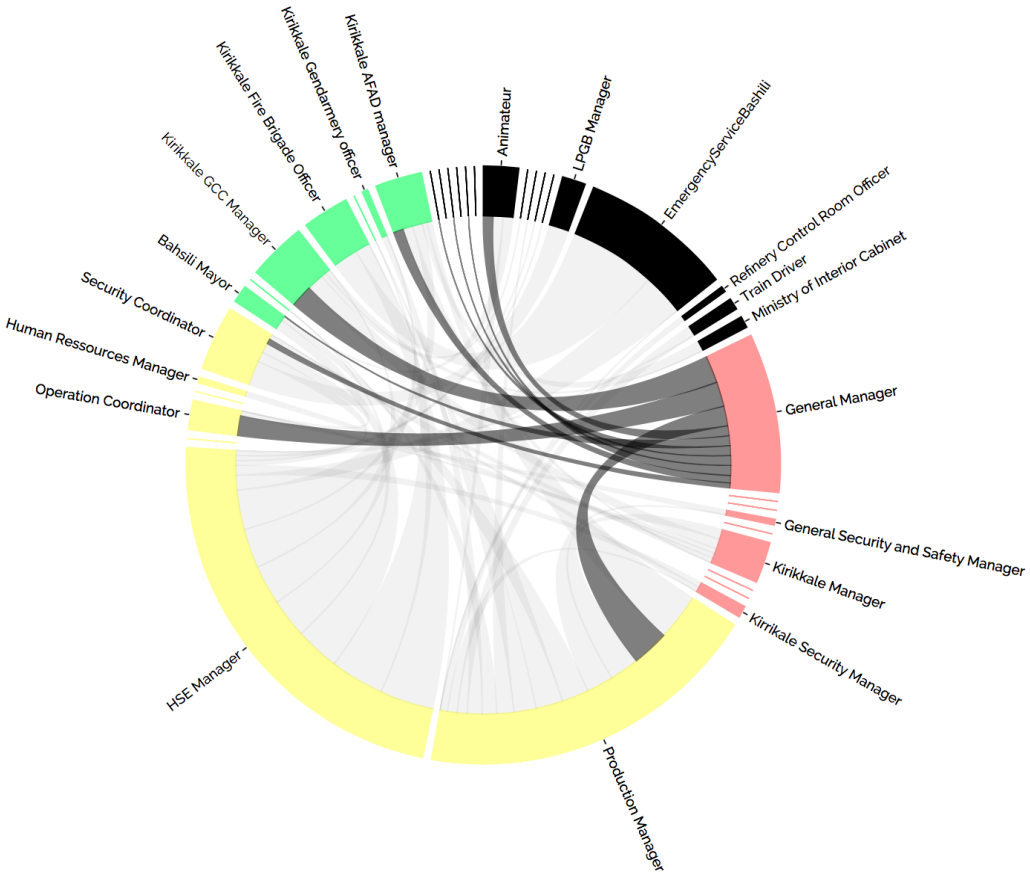



*Figure 20. iCrisis V3 introducing social graphs*

## 2.3. Strength and Weaknesses of iCrisis

A pros and cons analysis of iCrisis has been carried out to position iCrisis in the world of crisis simulation tools. Table 7 summarizes the main points of this analysis.

### *2.3.1. Strength*

The iCrisis application is web-based, it can be reached and used by several users in the same time and therefore enables to run several simulations simultaneously. The iCrisis tool and the developed simulation approach make this simulator flexible. It is possible to play in a large number of different configurations (either the number of crisis units or the number of players). As a web-based application, it is possible to connect to the iCrisis application from any computer with an internet access and an internet browser which makes it a very «light» simulator. In addition, it is a very interactive simulator because any player can have access to the platform, as a defined role, and communicate through it. The objective of the simulation is to allow players to be confronted with the crisis (which by definition is unmanageable) so this scenario can only serve to raise awareness of the participants. This type of objective has the consequence of not focusing on a particular type of crisis but rather on the characteristics of it so it is possible to play crisis scenarios of very different natures (malice, natural, technological, political, etc.). Finally, the scenario scripting of the simulation is based on a method that allows to create an «open» scenario. Indeed, only the main stages of the story are written then the rest of the events is invented by the experts who are present in the animation team during the simulation in order to always adapt to the reactions of the players. For these reasons, the simulations are easy to prepare.

### *2.3.2. Weaknesses*

The main weakness of iCrisis simulation regards its approach. Since the animation team has access to all the information circulating between the crisis units, it is necessary for the animation team to manage a very large amount of information and so to control this flow, it is necessary to have a large number of animators. Another point of weakness is the fact that it is not a training tool. Indeed, the iCrisis simulations, although very close to the psychological reality are considerably different from the «physical» reality since the rooms are not original, the tools are not the same, communication do not use real tools or even phone used should be limited, etc. For these reasons, it is not a simulation approach to evaluate the application of a plan or procedure.

*Table 7. Simplified SWOT vision*

| Strengths | Weaknesses |
|---|---|
| - Enable to run several simulations simultaneous<br>- Flexible (not only one simulation mode)<br>- Raise awareness<br>- Light (need only an internet connexon)<br>- Interactive<br>- Simulations easily prepared<br>- Manage different types of crisis | - Cannot train because it does not evaluate<br>- Need several animators |

The iCrisis tool that has been developed relies on historic principles carried by Mrs Claude Hansen. She was already convinced that there was a need to immerse people and make them understand by themselves the complexity of the crisis. For this reason, when Professor Thierry Verdel started the iCrisis tool, he thought about creating an easy to use software whose functioning is easily understood by players. The data base of exchanged messages is of great interest to help the participants of the simulation realize what did they do. The characteristics of the tool associated with a particular simulation approach form a protocol that must lead to the achievement of the primary objective: recreate the impact. In the following, this simulation approach is presented.

# 3. iCrisis simulation approach

The iCrisis tool as presented above has features that are clearly positive while running a crisis simulation. For example the fact that the animation team is able to see every single message that is exchange, even between two other groups, enables to make playing at the same time several crisis units. This capability is essential because in real life crisis units are in connection with other crisis units at a strategic level.

Nevertheless, the simulation approach brings a framework and precise elements to be sure that the objective of creating a crisis and more precisely that the participant feels as immersed in a crisis. Thus, from the preparation to the debriefing, the next pages depict the approach that has been developed during the PhD work.

## 3.1. What? Objectives

iCrisis simulation approach has been developed for two main objectives: experiencing and sensitizing. First, while participating to an iCrisis simulation, the participants must

be confronted to the characteristics of crisis in order to feel them and experience his/her reaction when facing such particular situation (high level of stress, information overflow, colleagues' reactions etc.). Secondly, the participants must be sensitized of the fact that a crisis is different than a situation only characterized by urgency and important aftermaths, it must help them feel this distinction. Participants are also sensitized to responsibilities and difficulties that other roles than their regular professional position can encounter in the process of crisis steering.

In the contrary, iCrisis simulations do not set success objectives. The reason why, is because it relies on the will to make participants feel the crisis as defined earlier, as a situation that surpasses the known references and therefore requires adaptation and innovation. In this context, when developing the iCrisis approach, the choice was made not to evaluate the participants but rather encourage them focus on feeling their reaction.

## 3.2. Who? Participants

The participants of an iCrisis simulation are of two main profiles:

- Students in Master's degree from different fields such as engineering, industrial risk management, management. These students, once recruited, will have executive positions and due to their important responsibilities, they could be involved in crisis steering processes.
- Professionals who want to learn how to cope with a crisis situation . They can be of different profiles such as public administration, industrials, services either at a strategic or tactical level.

Because the objective of an iCrisis simulation is to aware participants to the crisis by enabling them to experience the characteristics of the situation as well as the characteristics of their reaction while facing the crisis, the profile of the participants can be of anytype. The capability of designing an open scenario and to gather experts within the animation team makes it possible to adapt from novice profiles to experienced profiles.

## 3.3. How? Organization - Routine Use Mode

Running a simulation with iCrisis is a three-stage process:

- Constructing the scenario to be used (including collecting data for the participants);
- Running the simulation;

- Debriefing with participants to share their experience and to analyze the outcomes of the simulation.

### 3.3.1. Constructing the scenario to be used

A crisis situation is by definition unique, therefore regarding one situation, one group could feel as being living a crisis whereas another not, due to previous experience. For this reason, the iCrisis approach plays an open scenario that allows adaptation of the story depending on how the participants chose to cope with the situation. That is, only the main storyline with precise information about the events is fixed but the way this information is communicated in terms of manner (e.g. direct message or through an involved stakeholder) and nature (e.g. severity of the event) is left adjustable. This adaptation must be natural and relies on facilitators and experts (e.g. of the event's nature or the territory) expertise.

While each crisis is specific in terms of variables and outcomes, they all reflect similar characteristics. The crisis simulation must reproduce these characteristics (Limousin et al. 2016) through the scenario but also through the way of playing. More precisely, the scenario enables the creation of certain characteristics of the crisis:

- Unexpectedness: induced by the occurrence of an extraordinary event during daily routine management situations.
- Important consequences: structural or organizational aftermaths induced by the occurring events.
- Evolving nature of the problem: starting from a warning and continuing with the occurrence of the event.
- Irregular rhythm: by alternating slow periods and rapid sequence of events.
- Numerous stakeholders: induced by the number and the diversity of events affecting many systems.

Furthermore, other characteristics are created through the way of playing:

- Uncertainty: by conveying unclear information about the nature, the extent and the duration of the event.
- Information management issues: by conveying ambiguity and by creating a high flow of information.
- Media involvement: created by journalists playing their role as free electrons with the right to interview the participants.
- Chaos: induced by the accumulation of all the above features leading to impulsive choices.

The scenario building methodology specifies the whole set of elements which form the basis of the simulation content. To model a scenario, the iCrisis approach relies on several steps (table 8) that have been proposed by the literature and clearly sum-up by (Limousin et al. 2016).

*Table 8. Crisis simulation scenario building methodology used in iCrisis approach*

| | Scenario building steps |
|---|---|
| 1 | Write a synopsis to set the context (e.g. scale, location, nature of the problem) |
| 2 | Collect information on the territory: assets and hazards |
| 3 | Collect information about the involved organizations (e.g. missions and functioning) |
| 4 | Make a list of potential events (put all your ideas on the paper) |
| 5 | Select and put the events in order |
| 6 | Add side events of the regular life |
| 7 | Link events with a script and adjust if needed |
| 8 | Check consistency with the chronology |
| 9 | Verify compatibility with established objectives of the simulation |

The creation of scenarios is based on a multidisciplinary expertise and on documentation that must be as complete as possible, this collaborative work environment promotes realism through the expertise of professionals in the domains of the selected events. This expertise support is essential to complete each step of the methodology in order to develop a credible and plausible scenario. A very last step (n°9) comes as a «security» at the end of the scenario building process to make sure that the built scenario is compatible with the objectives of the simulation that have been pre-set.

### *3.3.2. Running the simulation*

An iCrisis simulation involves one to several (usually three) physically separated crisis management entities (crisis units) described later on, a media office and an animation team; all of which are connected through iCrisis. The crisis units generally consist of a Prefecture command post at the «département» level, a Municipality command post and a Company command post (figure 21). However, any configuration at a strategic level is possible. In each crisis units, there is a person observing the functioning of the players as crisis managers. iCrisis simulations are based on an observation methodology of the organization and management processes implemented by the groups. Observers are given observation forms to be used to observe players and giving feedback of the decision-making process in the group during the debriefing.

They can send message to the animation team during the simulation to report any problem or incident which could disrupt the effective running of the simulation.

Generally, a whole training session (running simulation and debriefing) is a full-day session. At the beginning of the training session all the participants are in one room for briefing them on the objectives of the training session and on the use of the iCrisis platform. Then they move to their separate rooms to start the simulation running. From the starting of the simulation, each crisis unit receive scenario injects from the animation team and media office also. Groups can exchange messages (see full line arrows in figure 21). The animation team can exchange messages with all groups and receives copies of all messages exchanged between the playing groups through the iCrisis application (see dashed arrows in figure 21). This helps the animation team to follow, in real-time, the interactions between the groups and interact itself with the groups in order to introduce new events. These interconnections and the presence of observers (see solid blue arrows in figure 21) allow the animation team to adapt the storyline based on the participants' reactions.

A simulation starts with an unspecified length but is usually run for a duration corresponding to approximately two to three hours. The duration depends on the reactions of the players and the simulation ends when the animation team judges that the participants experienced all the characteristics of the crisis situation and the crisis state. Once this state is reached, the animation team sends a message notifying the end of the simulation to the players.

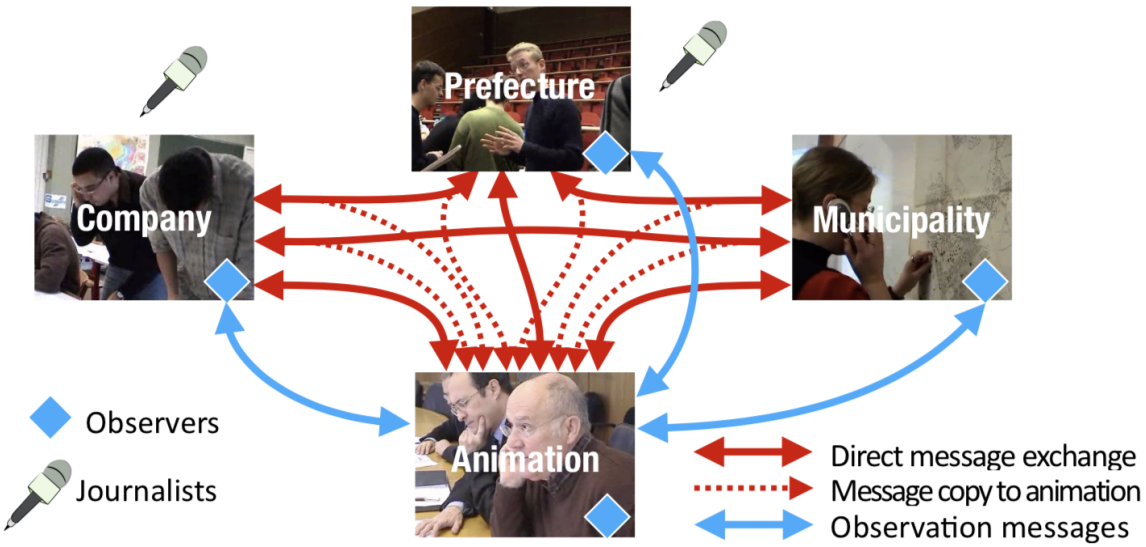



*Figure 21. General overview of the iCrisis simulation approach (arrows represent the flow of information via text messaging)*

In the following parts, the main stages of the iCrisis simulations are presented: the briefing; within a crisis unit; the debriefing.

### 3.3.3. Briefing

Before an iCrisis simulation, participants and animators are gathered in a classroom to proceed to a briefing that lasts not more than one hour. First of all the coordinator recalls the objectives of the simulation and of the whole day in order to make sure that participants and animators share the same expectations. Following this first part, a simultaneous presentation of the iCrisis web application and the «rules of the game» is done. The main rules are:

- all the shared information must transit through the iCrisis web application in order to create an exhaustive database of all messages and to enable the animation team to read the exchanges messages between the crisis units;
- it is forbidden to meet colleagues in the corridors because crisis units are supposed to be geographically distant from each other;
- only journalists are able to physically move from one crisis unit to another;
- the crisis units remain at the strategic level;
- everything dealing with the field is played by the animation team;
- the time during the simulation is respected.

Eventually, a folder holding documents in relation with the territory where the scenario takes place is given. In this folder, the members of each crisis unit find an agenda to hold a meeting which is the pretext why they are already together before the crisis.

Once all the participants are gone the journalists and the observers are quickly briefed and receive instructions of how to act and what to observe and focus on.

### 3.3.4. Inside a crisis unit

When participants are invited to get in their crisis room, they set up their own organization as they want. The simulation coordinator asks each group to connect them through the iCrisis application. Once connected, they can start their meeting while in parallel the groups begin to receive messages dealing with daily routine that they chose to consider or ignore them. As shown in the following pictures (figure 22 to 29), each room is different and each group chose to organize themselves as they wish, such as in square or divided into subgroups. During the simulation, the groups change their organization in order to naturally adapt themselves to the coping of the situation. In the course of events, the journalists can knock at the door of crisis units in order to interview one member of the unit (figure 30). They are equipped with microphones and cameras to record the announcements of the crisis unit. The journalists are also allowed to interview any character that is not played within the crisis cells. In that case, a member of the animation team is playing this character (figure 31). So as in real life, the journalists may face refusals.



*Figure 22. At the beginning of the simulation, the crisis unit is calm, working with serenity, dealing with few messages as shown on the displayed screen. The observer is sat in the left corner.*



*Figure 23. Sometimes, all members of the group are concentrating together on a single message.*



Figure 24. Journalists incoming in the crisis unit during the simulation



Figure 25. A typical organization of professionals that set up into a rounded/squared table




*Figure 26. The Journalists interviewing the director of the crisis unit inside the room*



*Figure 27. Again, as professionals, the members of the crisis unit are raising hands before talking*



*Figure 28. Members of the crisis unit gathering around the documents at the beginning of the simulation*



*Figure 29. Members of the crisis unit all separated one by one to cope with the situation*




*Figure 30. Freeze frame of an interview of the «communication manager», a role played by a participant*




*Figure 31. Freeze frame of an interview of the «Motorway director», a role played by the animation team*

### 3.3.5. Inside the animation team

Composition:

The iCrisis simulation approach relies on experts' expertise to make live the scenario through plausible messages. Several types of experts form the animation team:

- experts of the iCrisis simulation approach, who knows well the rules of the game, the objectives and the iCrisis platform;
- experts in the domains addressed by the scenario such as the type of the crisis units played by participants (e.g. municipality, company, prefecture) or the nature of the phenomenon played in scenario (e.g. toxic contamination; flooding; fire);
- emergency services experts from services susceptible to participate regarding the nature of events (e.g. fire and rescue services, police), who bring in the simulation their technical codified language;
- the coordinator of the simulation who is the main expert of iCrisis simulations. The coordinator knows the scenario by heart and is the master of the simulation.

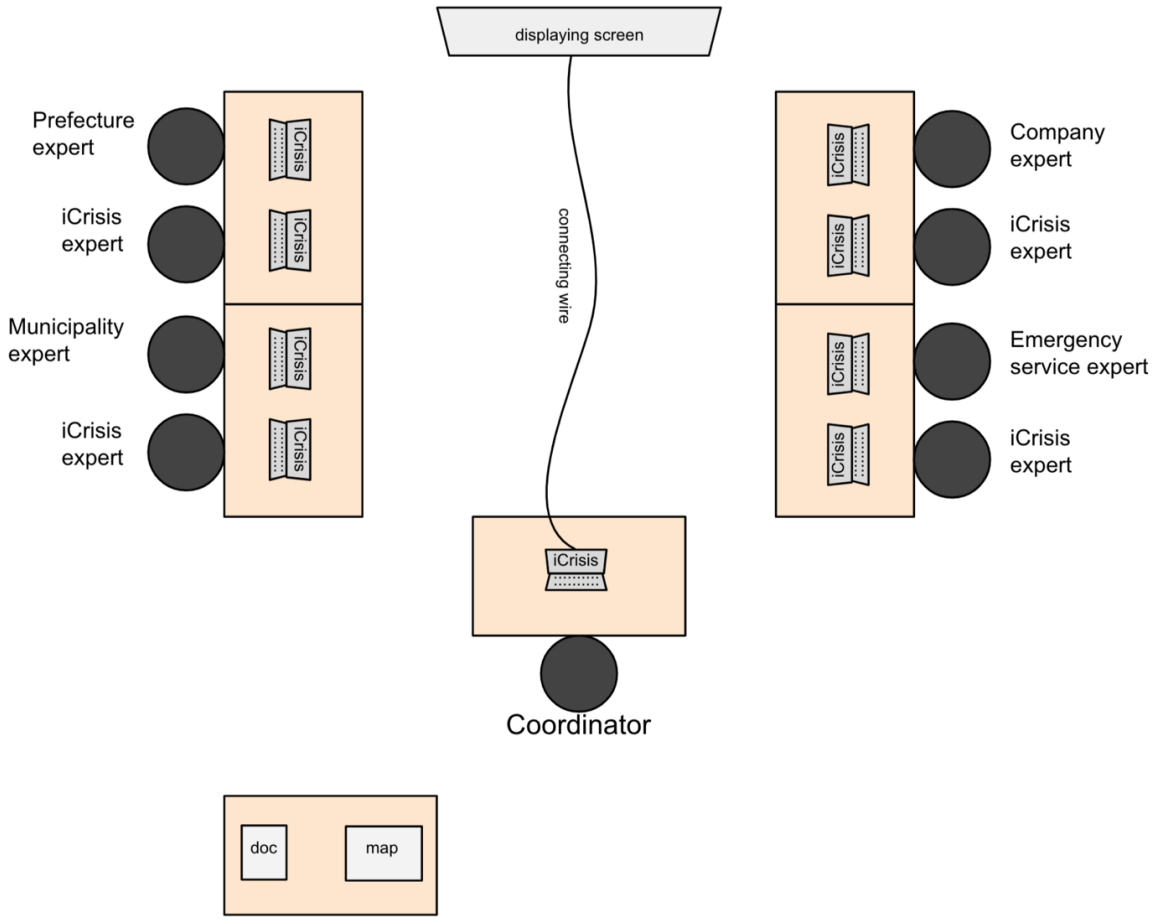



*Figure 32. Scheme of the animation team ideal configuration for an iCrisis simulation*

Functioning:

The animation team is gathered in one room where the coordinator of the game places each members, distributes their missions, present the scenario, recalls the main elements of the scenario during the simulation, make sure that the coherence between each pair of animators is kept and evaluates that the objectives of the simulation are reached. The ideal configuration (figure 32) suggests that a pair composed of one of both types of experts is in charge to follow one crisis unit of participants. Moreover, the emergency services experts who are present keep an eye on the entire situation in order to give to the participants, elements about their interventions on the field such as the number of victims or if they have set up a safety perimeter. This configuration enables to manage both the good development of the scenario and the achievement of objectives that is correlated to the perception and reaction of participants. As explained before, iCrisis is flexible, therefore the configuration relies on the available human resources. For example, an iCrisis simulation can also be animated by three experts of the simulation who know the scenario by heart, the objectives and the functioning of iCrisis.

### *3.3.6. Debriefing*

Each simulation is followed by a debriefing that lasts for approximately two hours. All participants leave their «crisis units» and gather in the same classroom. The debriefing is the opportunity for the participants, the facilitators (from the animation team) and the journalists to share their experiences of the simulation. During the debriefing, participants from each crisis unit relate their experiences. First, a representative of each crisis unit counts the following of the events they have lived during the simulation. Once done, the observer of each crisis unit presents the observations made all along the simulation. The observer explains how organized was the crisis unit, within the space as well as in their functioning (e.g. decision making process). The observer enables to make the participants realizing how they acted. The journalists present a press article and/or a TV news report based on the information they gathered during the simulation. This long phase of discussion permit to understand that each group does not live the same situation even though the events are the same. Moreover they figure out that the crisis units have their own objectives, their own operating mode and their own means. Facilitators lead the discussion and talk about the difficulties involved in dealing with the crisis situation in order to raise participants' awareness. Eventually statistics of the simulation are presented. They are generated by the application thanks to the database of the whole inter-groups exchanges that is created during each simulation. They are five types of different statistics:

- Pie charts (figure 33) present the nature of messages received and sent by each crisis unit. This type of statistics gives information regarding the profile of the crisis unit whether they provide information or they ask for actions and make decision for example.

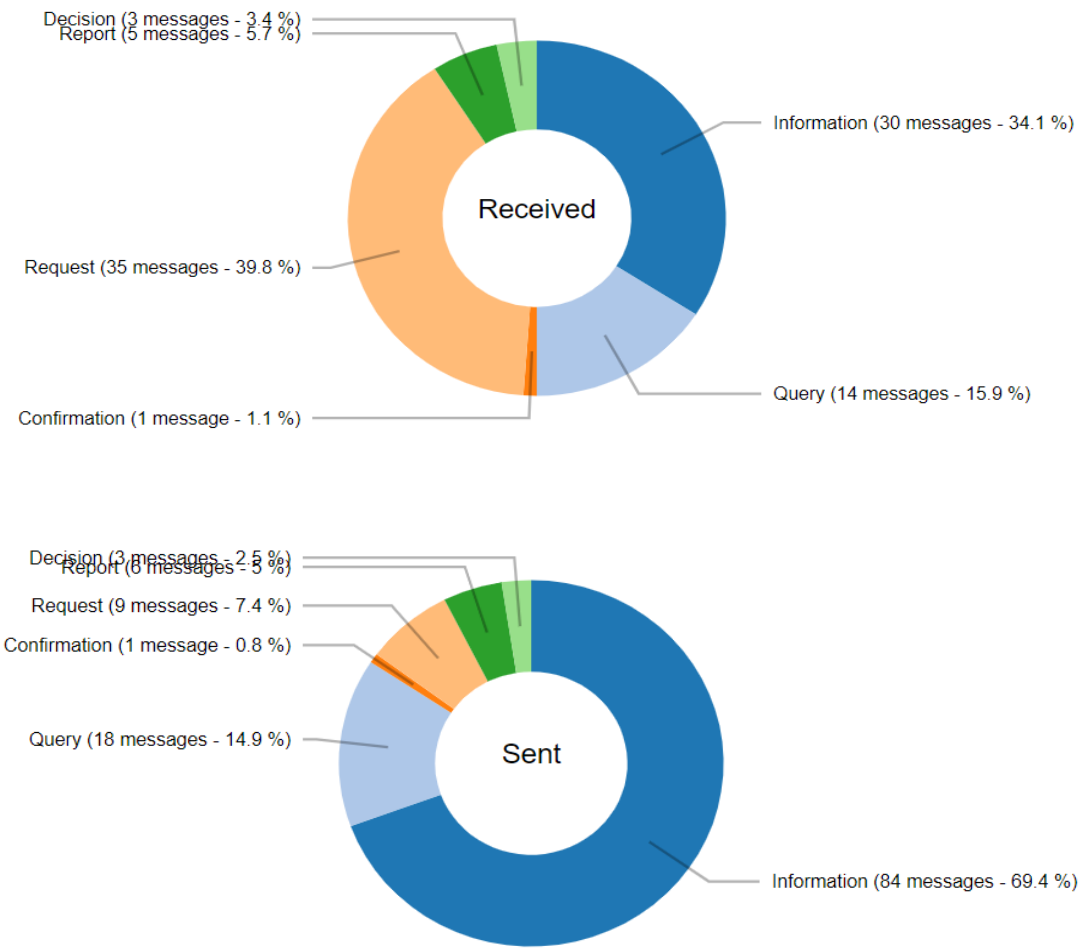



*Figure 33. Pie chart of type of messages received (above) and sent (below) by a crisis unit of participants*

- The table of crossed exchanges (figure 34) makes it possible to count the number of messages that the crisis units were sent. It highlights the relations between the crisis units enabling to identify a low or a high level of interaction between to groups.

Groups statistics

Refresh

| | Animation | Préfecture 33 | Ambarès et Lagrave | Foresa | Médias | Total |
|---|---|---|---|---|---|---|
| Animation | 0 | 69 | 95 | 63 | 41 | 268 |
| Préfecture 33 | 41 | 0 | 14 | 4 | 16 | 75 |
| Ambarès et Lagrave | 51 | 26 | 0 | 6 | 4 | 87 |
| Foresa | 40 | 11 | 8 | 0 | 17 | 76 |
| Médias | 20 | 26 | 26 | 26 | 0 | 98 |
| Total | 152 | 132 | 143 | 99 | 78 | |

*Figure 34. Table of crossed exchanges between crisis units of participants, the animation team and the media*

- The graph of the temporal dynamics of messages (figure 35) shows the messages sent and received by a crisis unit as a function of time. This makes it possible to highlight the Delta at a hiver moment between the messages received and sent. This graph also show the trends such as «the global rise in power» and the peaks. Eventually, this functionality associates together with temporal dynamics, the search of keywords that are displayed on the graph in order to have information on when these have been used and how many times.

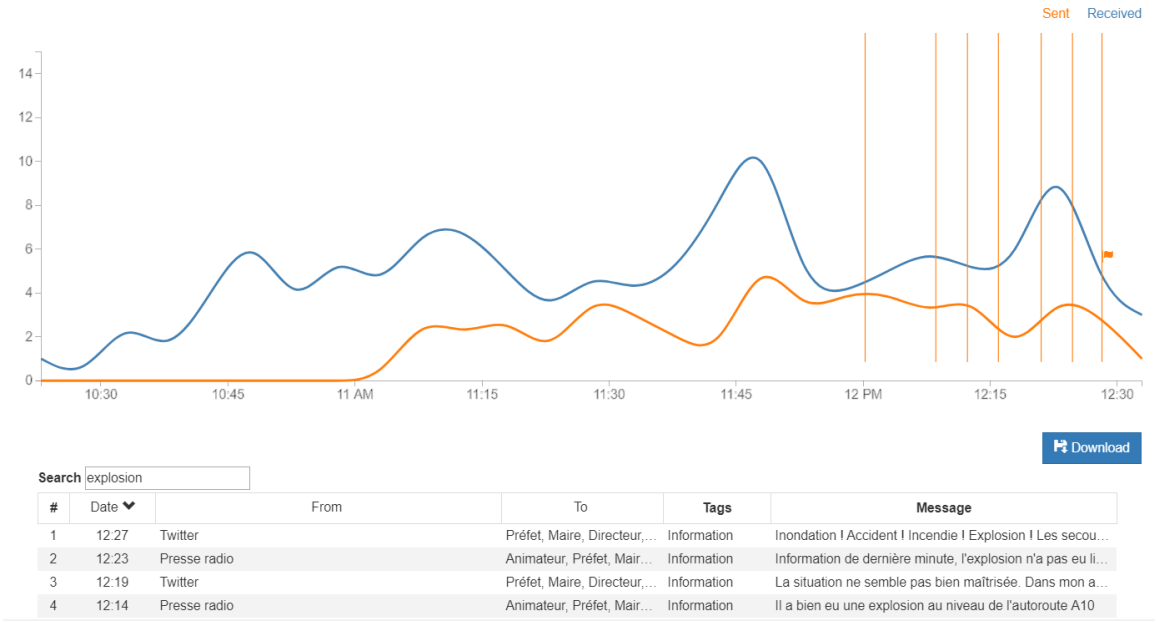



*Figure 35. graph of the temporal dynamics of messages*

- The social graph (figure 36) reveals the interactions during the simulation at the scale of the role played. In this example given on the figure, the colors represents the group in which each role is. The width of every circular segment gives an indication of the quantity of messages managed by one role. The curves shows how many messages have been sent (on one side) and received (one the other side) by one role. This type of figure enables to highlight the activity of one role (figure 37) revealing from which role the information came and toward which role the information was relayed. It also shows that a role had or not an activity of dispatching the information.

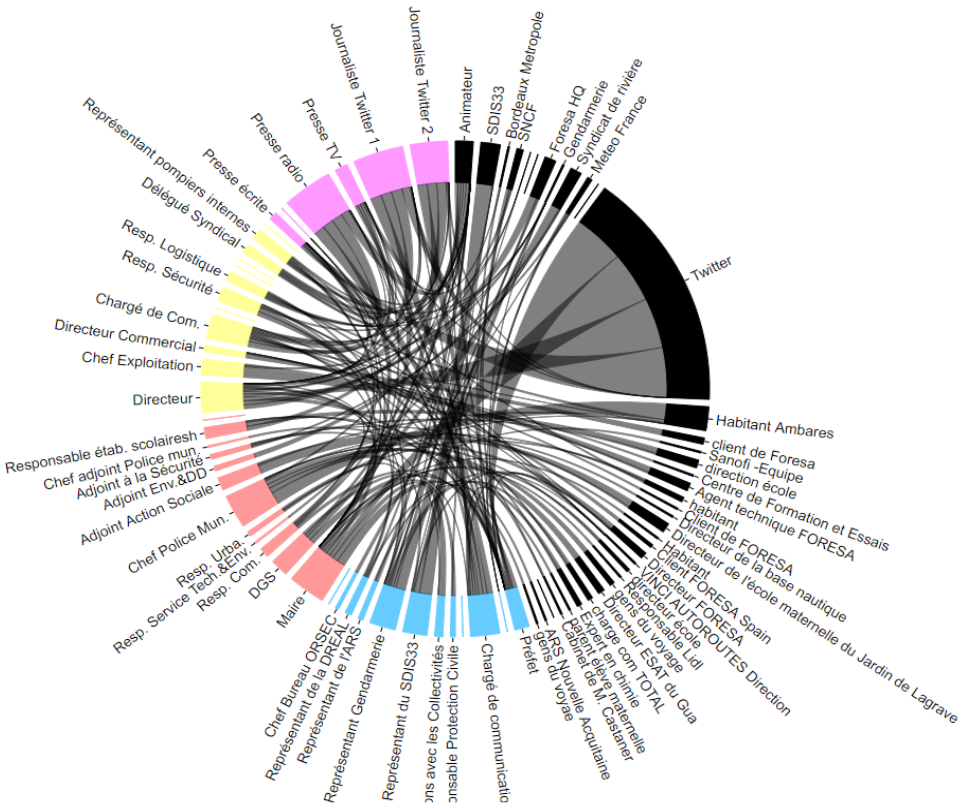



*Figure 36. Social graph of interactions between roles in a iCrisis simulation*

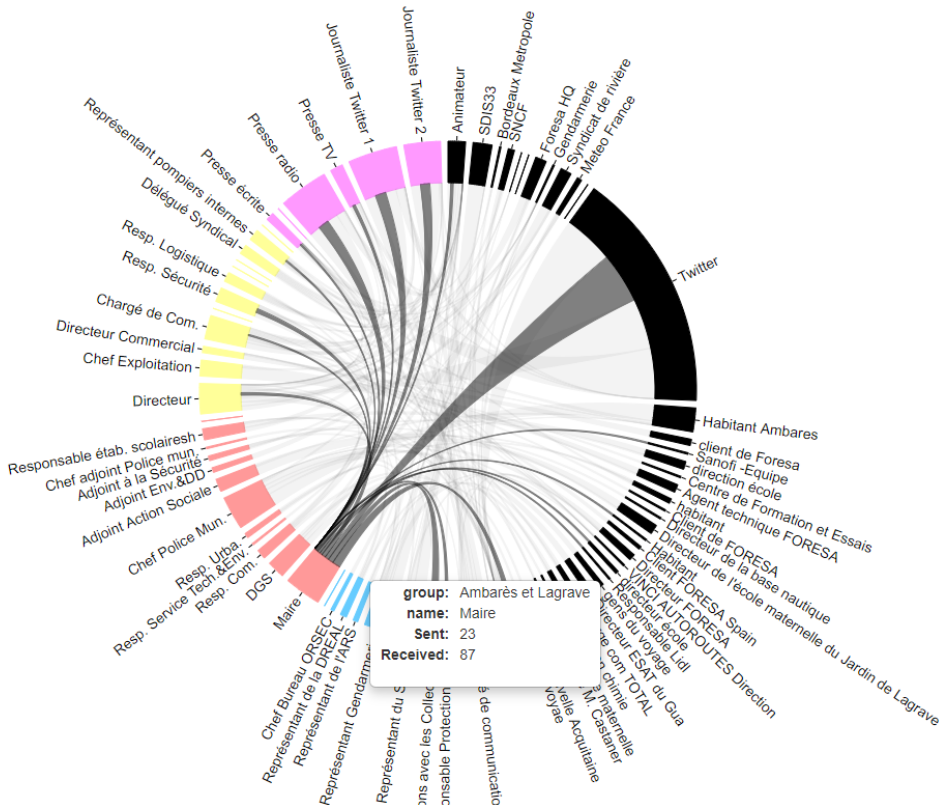



*Figure 37. Focus on one role's interactions during a iCrisis simulation*

- The word clouds of sent (figure 38) and received (figure 39) messages emphasize the fact that the crisis unit does not use the same communication style in comparison with the style used in received messages. For example, politeness formulas are often seen within messages sent by crisis units whereas messages written with a style more «direct» are received. It can be explained by the fact that the played crisis units are not crisis management professionals and also because during a crisis situation, the crisis units must deal with stakeholders they are not used to work with.

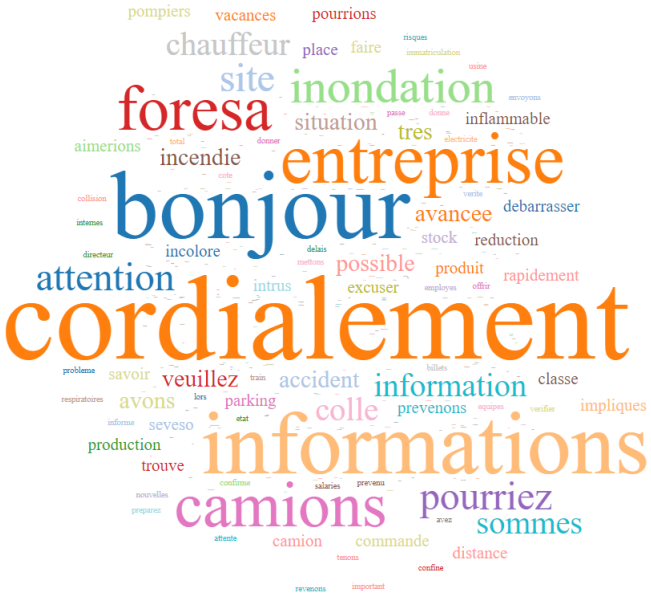



*Figure 38. Most frequently used words in the messages sent by a crisis unit of participants*




*Figure 39. Most frequently used words in the messages received by a crisis unit of participants*

## 3.4. iCrisis simulations carried out during the PhD period

*Table 9. List of simulations carried out during the PhD work using iCrisis. Many others have been carried out earlier or even after that work.*

| ID | Date | Participants | Type of participants | Played Scenario |
|---|---|---|---|---|
| 1 | 20/06/2014 | IRA Metz | Professionals in training class | île du Saulcy |
| 2 | 17/10/2014 | Turkish Ministry of industry | Professionals | Tupras |
| 3 | 19/11/2014 | University of Lorraine | Students | Séchilienne |
| 4 | 18/12/2014 | INSA Rouen | Students | Tupras |
| 5 | 25/03/2015 | Mines Nancy | Students | Tupras |
| 6 | 03/04/2015 | Mines Saint Etienne | Students | Tupras |
| 7 | 24/04/2015 | Rectorat de Corse du Sud | Professionals | Ajaccio |
| 8 | 24/06/2015 | IRA Metz | Professionals in training class | Frigex |
| 9 | 09/07/2015 | University of Lorraine board | Professionals | UL-Bridoux |
| 10 | 02/10/2015 | University of Lorraine | Students | Frigex |
| 11 | 19/11/2015 | 4 municipalities of Nancy area | Professionals | Frigex |
| 12 | 15/02/2016 | Université Paris Sud | Students | Séchilienne |
| 13 | 04/03/2016 | Mines Nancy | Students | Séchilienne |
| 14 | 25/03/2016 | University of Lorraine board | Students | Foresa |
| 15 | 06/05/2016 | UL présidence | Professionals | Terror attacks at UL |
| 16 | 01/06/2016 | INSA Rouen | Students | Séchilienne |
| 17 | 07/10/2016 | University of Lorraine | Students | Séchilienne |
| 18 | 08/11/2016 | 4 municipalities of Nancy area | Professionals | Frigex |
| 19 | 17/11/2016 | IUT Bordeaux | Students | Ambarès et Lagrave |
| 20 | 07/02/2017 | Université Paris Sud | Students | Séchilienne |
| 21 | 03/03/2017 | Mines Nancy | Students | Séchilienne |
| 22 | 17/03/2017 | Mines Saint Etienne | Students | Ambarès et Lagrave |
| 23 | 30/03/2017 | SPPPI Presqu'île d'Ambès | Professionals | Ambarès et Lagrave |
| 24 | 26/04/2017 | CascEff Project | Professionals | Séchilienne |
| 25 | 19/05/2017 | INSA Rouen | Students | Ambarès et Lagrave |
| 26 | 25/01/2018 | Mines Paris | Students | Varangéville |
| 27 | 06/02/2018 | Université Paris Sud | Students | Varangéville |
| 28 | 16/02/2018 | Mines Nancy | Students | Séchilienne |
| 29 | 23/03/2018 | Mines Saint Etienne | Students | Port de Bordeaux |
| 30 | 06/04/2018 | SPPPI Presqu'île d'Ambès | Professionals | Port de Bordeaux |
| 31 | 31/05/2018 | INSA Rouen | Students | Varangéville |
| 32 | 17/01/2019 | Mines Paris Tech | Students | Varangéville |
| 33 | 23/01/2019 | Mines Saint Etienne - Université de Lyon | Students | île du Saulcy |
| 34 | 31/01/2019 | Université Pairs Sud | Students | Séchilienne |
| 35 | 01/02/2019 | Mines Nancy | Students | Ambarès et Lagrave |
| 36 | 21/03/2019 | Mines Saint Etienne | Students | St Louis de Montfd |
| 37 | 29/03/2019 | SPPPI Presqu'île d'Ambès | Professionals | St Louis de Montfd |
| 38 | 07/06/2019 | INSA Rouen | Students | Ambarès et Lagrave |

During the PhD, 38 iCrisis simulations have been carried out (table 9). besides the traditional objectives of the iCrisis platform, these simulations fulfilled two main objectives: scientific, to carry experimentations and pedagogical, to sensitize the participants to the concept of crisis.

Two types of participants have taken part of the simulations: students in engineering school or universities in France and professionals from industries, public organizations and territory organizations, in France and abroad.

Each of the simulations carried out had the objective of raising awareness among participants in the crisis. However, these simulations were an opportunity to work on improving the methodology for placing people in crisis situations, but also to work on developing observation protocols that were created, used and corrected before using them in research work.

To carry out the simulations, 11 scenarios have been developed (table 10). The large panel of scenarios enabled to focus on different types of events such as technical, natural or malevolence.

*Table 10. List of the scenarios created during the PhD.*

| ID | Name | Type | Location | Description | Crisis Units |
|---|---|---|---|---|---|
| 1 | Ajaccio | Social | Ajaccio city, the major city of Corsica island (France) | In Ajaccio, a group of students from a high school in the city leaves their school following an incident involving a comrade. They are angry and provoke troubles on the public road. Some tension is felt among the students of other high schools in the city. Clashes take place in the city. In addition, on April 24, 2015, the operational forces will be understaffed in Ajaccio due to the visit of the Minister of Ecology in the region. | - Le Rectorat de l'académie de Corse<br>- Le Lycée Laëtitia Bonaparte<br>- La Préfecture de Corse du sud |
| 2 | Ambarès et Lagrave | Natech | Ambarès et Lagrave in the urban area of Bordeaux (France) | This scenario is split into two main stories:<br>- a traffic accident on the Highway "A10" involving two trucks, one carrying GPL and the other carrying formol. A fire is ignated and generating a risk of BLEVE. Direct consequences on the road network and indirect on a restriction area around the accident are the main aftermaths.<br>- a break on dike of a tributary river of the Garonne floods a plain of the municipality of Ambares et Lagrave reaching the industrial zone where a plant manufacturing formol. | - The industrial company directly involved<br>- The municipality of Ambarès et Lagrave<br>- The préfecture of Gironde |
| 3 | Frigex | Nat | Northeastern France | Météo France has announced significant snowfall in eastern France. The regions concerned and the defense zone activated their crisis center. At the national level, the interministerial crisis unit is also activated. Many events take place simultaneously throughout the territory: road, rail, electrical problems... | - The prefecture of Moselle<br>- The prefecture of Bas-Rhin<br>- The prefecture of Haut-Rhin<br>- The prefecture of Vosges<br>- The prefecture of Northeast defense area<br>- The national crisis centre |
| 4 | île du Saulcy | Social | City of Metz (France) | A student strike takes place on the esplanade of the Saulcy campus in Metz generating chaos.<br>An accident occurs on the bridge of Highway 31 spanning the campus. A truck transporting gas cylinders is involved. the gas cylinders are expelled and explode towards the campus. This causes a panic movement resulting in jostling and making access to the site difficult. | - The University of Lorraine<br>- The municipality of Metz<br>- The prefecture of Moselle |
| 5 | Port de Bordeaux | industrial | Ambès in the urban area of Bordeaux (France) | This scenario deals with a main event occuring in the municipality of Ambes: an accident involving a train of dangerous materials and a truck. The peculiarity is that there are different responsibilities mixing regarding the train: the french national company of railways (SNCF) and the Bordeaux harbour.<br>Other events are occuring in the harbour (e.g. social strike, boat unloading accident) to disturb the normal functioning and create the accumulation of pitfalls. | - The Bordeaux harbor<br>- The municipality of Ambès<br>- The prefecture of Gironde |
| 6 | Saint Louis de Montferrand | Natech | Saint Louis de Montferrand in the urban area of Bordeaux (France) | The Garonne river is flooding. In the municipality of Saint Louis de Montferrand, a wastewater and fuel tanks empty causing local contamination. In parallel, drinking water supply service disrupts | - The municipality of Saint Louis de Montferrand<br>- The metropolitan area of Bordeaux<br>- The prefecture of Gironde |
| 7 | Séchilienne | Natech | two locations in the Romanche valley in the French Alps: Séchilienne and Jarrie located 20 to 10 km away from Grenoble city (France) | An earthquake is felt in the region the does not causes structural damages at first sight. However, an explosion occurs on an industrial plant that impacts a train of dangerous substances parked close to the plant and causes a fire.<br>A replica provokes a major landslide in Séchilienne that blocks the river in the valley generating a flood upstream of the rock dam. | - The industrial company directly involved<br>- The municipality of Jarrie<br>- The municipality of Sechilienne<br>- The prefecture of Isère |
| 8 | Terror attacks at UL | Terrorism | two locations: Metz and Vandoeuvre les Nancy in the urban area of Nancy (France) | The University of Lorraine is settled all around the region of Lorraine in France. The management board of the university is in Nancy and must deals with every event taking place on one of its site around the region.<br>The two main events of this scenario are:<br>- a terror attack in an amphitheatre welcoming an international congress in Vandoeuvre les Nancy (Nancy urban area)<br>- a simultaneous terror attack in another amphitheatre located in Metz. | - The University of Lorraine campus de Saulcy in Netz<br>- The University of Lorraine sciences faculty in vandoeuvre les Nancy<br>- The University general management board |
| 9 | Tupras | industrial | Bahşili in the urban area of Kırıkkale (Turkey) | Tupras is the Turkish Petroleum Refineries Company. Railway equipment enables the transport of products by trains toward the North, Kırıkkale and Ankara. The road linking both cities of Hacılar and Bahşili (D753 on google plans) crosses the railway 2 km away from the Refinery. In the area of the crossing there is a wooded area on the southern side of the railway and housing on the northern side. The wooded area extends till the refinery. An allotment of approximately twenty houses is located in the wood. 400 meters down from the railway, the Kızılırmak river flows towards the North. An accident occurs at the railroad crossing causing a fire and a leak spreading toward the river. | - The Tupras refinery<br>- The municipality of Bahşili<br>- The governorate of Kırıkkale region |
| 10 | UL-Bridoux | Social | Metz city (France) | le local de stockage de produits chimiques du campus "Bridoux" à Metz est retrouvé ouvert. Des produits sont absents. Sur le campus, un colloque international est organisé dans un amphithéâtre où une bombe explose. | - The University general management board<br>- The local faculty of the University of Lorraine in Metz |
| 11 | Varangéville | Industrial | Varangéville (France) | In the underground salt mine of Varangéville, a group of students of the University of Lorraine is in visit when an accident in the bottom of the mine causing an underground fire. the laborious access as well as the difficulty of air ventilation makes problematic the intervention of rescue teams. | - The mine of Varangéville<br>- The municipality of Varangéville<br>- The prefecture of Meurthe et Moselle |

## Conclusion

We have seen that simulation has historically always been a learning tool, particularly in the area of war strategy. Today, simulation is a widely used teaching method. Jaffrelot (2013) explains that this is a proven method in terms of efficiency offering a safe space for training, evaluation and exchange, which allows professionals to confront critical situations. Simulation is used in a very wide range of areas of activity to train. Some of the most advanced fields in the use of simulations to train individuals are flying (e.g. aviation), medicine (e.g., surgery) or even rescue (e.g. fire extinction). Due to the specialized nature of these activities, the simulation solutions developed are high-tech tools, as demonstrated by flight simulators or operating theaters, for example.

In the field of crisis management, Lagadec (1991) tells us that the objective of a simulation is to train individuals and teams. He confirms his statements by noting from experience that after participating in a simulation, participants are «infinitely better prepared». He concludes by proposing that in the framework of crisis management the learning process must be initiated by a simulation in order to have a first experience on which to base the exchanges.

Another interesting point about the use of crisis simulations is its almost exclusive use to meet pedagogical objectives, while simulations are used in a large number of areas as a scientific and forecasting tool (climatology, finance etc.). However, because of its unique nature, better knowing the crisis and the behaviors of crisis managers during this situation appears interesting to study it. Crisis simulation in its strict sense is therefore a solution since it allows an observation of it which can be organized and programmed. It is true that it is unlikely to consider monitoring the steering of what could be a «real» crisis because firstly it does not inform and secondly it is not easily detectable at the time. For these reasons, the simulations have undeniable advantages.

There are different types of crisis simulators that focus on recreating certain dimensions of reality such as the environment, the views, the proper mechanisms of this situation (protocols etc.), the characteristics of crisis…

The iCrisis simulator by its flexibility makes it an interesting tool to be used as a scientific platform. With this choice, a real study must be made to be certain that the simulated situation can be considered as a crisis. Today, in the literature, no study has been done to verify that a crisis simulation can be simulated. We will therefore study its ability to recreate the characteristics of the crisis situation as well as the state of crisis in which managers are immersed.

In the next chapter, we present the study conducted on iCrisis simulations that aims to observe the emergence of the crisis characteristics. Although the validation is difficult to consider, especially because of the subjectivity of the crisis, this study is essential to justify that we could use iCrisis as a scientific platform.

# CHAPTER 4: EMPIRICAL STUDY TO INVESTIGATE THE CRISIS CHARACTERISTICS IN THE FRAMEWORK OF ICRISIS SIMULATIONS

## Introduction

Crisis simulation is intended to allow managers to cope with a virtual but realistic crisis situation that raises opportunities for the organization experiencing it. To create simulations capable of creating such opportunities, it is important to verify that the simulations reproduce the specific conditions of a crisis, as well as to ensure that managers experience the most realistic crisis environment possible (Borodzicz and Van Haperen 2002). Crisis simulators propose to increase awareness by placing people under crisis conditions. They aim to reproduce the atmosphere of a crisis as precisely as possible, knowing that it is subjective to anyone and recalling that one of the characteristics of the crisis is the relative nature of the crisis perception. Simulations mimic a real-world process or system over time; thus, crisis simulation approaches propose to imitate real-world crisis situations. However, we have mentioned earlier that it is difficult to define crisis situations because of their unique and relative nature. This problem of definition complicates the need to ensure that crisis simulation approaches actually simulate crises. According to Gredler (1992), crisis simulations should produce the same reactions and feelings in participants as real-life crisis events. Borodzicz (2004) stated that simulations should reproduce as accurately as possible the fundamental elements of a crisis (considered as the pre-cited characteristics here in this study) to allow the participants to experience crisis conditions. Therefore, we assume that if a simulation can arouse the participants' reaction characteristics to a crisis, then the characteristics of a crisis situation have been simulated well. Previous research has noted that no validation methodology exists for simulations (Hays and Singer 1989; Feinstein and Cannon 2002).

Some studies have assessed the non-technical skills required to manage a crisis, including decision-making (Dautun et al. 2007; Sommer and Pearson 2007; Hadley et al. 2011) and leadership (Yusko and Goldstein 1997; Amabile et al. 2004; Hadley et al. 2011; Tena-Chollet 2012; Boin et al. 2013). These studies were based on observations made during crisis simulations. However, even for simulations that involved crisis-like characteristics, such as information overload, ambiguity and urgency, no existing crisis simulation approaches have shown that their participants experienced the characteristics of a crisis situation. One exception is proposed by Sneizek et al. (2002), who suggested that the computer-based simulator «DC-Train» was psychologically realistic after testing the human performance of its trainees. This study shows that it is possible to create a methodology to test whether a crisis simulation approach recreates the psychological effects specific to a crisis situation.

The iCrisis simulation approach is often used with the objective of raising participants' awareness regarding the «steering process» of a crisis situation. With respect to the participants thinking that they experience a crisis situation as well as for scientific purposes, it is relevant to make sure that iCrisis simulates what it states.

The chapter depicts the study made empirically to observe the crisis characteristics. A first part presents the methodology of the study focusing on how a crisis situation can

be generated and how to measure the participants' perception of crisis. Then, a second part depicts the results of the study.

# 1. Methodology of the study

To observe that iCrisis simulation can recreate a crisis situation, we examined whether it can reproduce the characteristics of a crisis situation and whether the participants perceive the characteristics of reaction to a crisis. We analyzed data from two iCrisis simulations carried out in 2015. The choice of taking two simulations relied on the fact that it was important to have at least two different groups of participants in order to have a first opinion that the approach of simulation override the environment effect. The other reason why only two simulations have been selected is the fact that preparing and carrying out such investigation is a heavy process that needs time especially to get the acceptance of the group who will participate. The simulations involved 119 participants from France. A first group was formed by 45 professionals, who are members of the local crisis units from 4 municipalities of the Meurthe-et-Moselle department. As members of local crisis units composed of mayors, executive directors, assistants and directors of dedicated activities (e.g. roads, schools etc.), their sensitization about crisis situations depended on their own experiences and their opening mind. A second group was formed of 74 students from the Institut Régional d'Administration de Metz, a French institute that trains and teaches future territorial managers who are about to work in Prefectures. The peculiarity of these students is that they are sensitized about crisis situations whereas they don't have much experience yet. Members of both groups are used to work together. In response to a simulation of coping with a winter storm, the professionals played their own roles within their municipalities; the students played prepared roles representing the broader strategic level of France's Prefecture. No comparison objective between professionals and students was set since it was not the purpose of this study even though the results for both are displayed. In this part, the iCrisis simulation approach is presented in details regarding how it implements the characteristics of the crisis situation and then we expose how to control the reaction of participants.

## 1.1. Generation of a crisis situation

The iCrisis approach begins with a given scenario but then allows for adaptation of the story depending on how the participants chose to cope with the situation. Thus, the facilitators can easily implement the characteristics of their chosen scenario. The context of the scenario and the role-playing methodology both allow the crisis situation to be established.

Through the imagined events of the scenario, the story includes the evolving nature of the problem; for example, starting with a snowfall warning that evolves until the occurrence of the snowfall. It initially includes slight problems such as people falling, but eventually much larger problems occur, such as severe weather conditions. These problems have important consequences that can be both structural (blocked roads and power outages) and organizational (regular plans and procedures becoming ineffective). This main storyline is supplemented with routine incidents, forcing the participants to cope with the larger events as well as dealing with everyday problems leading to unexpected events. The number and diversity of events requires the involvement of many stakeholders, who are progressively included. The combination of everyday incidents that cause delays due to the lack of available resources, in addition to rare or unusual events that require innovation to design an adequate response, contributes to a situation characterized by complete disorder and confusion (definition of the chaos) among the participants.

The iCrisis platform implements some crisis situation characteristics by the addition of information depending on the scenario and on participant reactions. The content of the message influences the nature of the information, conveying uncertainty. To increase the uncertainty in the minds of the participants, the nature, extent, duration and consequences of the events must remain unclear. A message sent by the animation team (always playing a specific role for that message) could be perceived as urgent because it describes a situation as requiring an urgent response; this could be exacerbated by repetition or by giving shocking details. In addition to message content, the tempo of messaging is important because makes the participants feel that the rhythm of events is irregular and unpredictable, alternating between slow periods and rapid sequences of events. The creation of an irregular rhythm relies on the storyline as well as on the cadence of messaging. Careful control of the information given to participants in a noisy room can help induce information management issues for the participants. A loud environment in a crisis unit can have as consequence to influence the capability of people to stay focused and therefore leads to difficulties to manage to high flow of information. Without being erroneous, some messages are intentionally ambiguous and/or have information that is not appropriate to the person who is receiving the message.

To implement media involvement in the iCrisis simulation, between 2 and 6 participants are identified as journalists. A facilitator briefs them on behavior characteristic of journalists, including tenacity, aggressiveness and scrutinizing the situation. In the iCrisis simulations, journalists are free to move between groups and ask questions to anyone. The participants in the crisis units can then react as they wish. These interactions make the information in the simulation to evolve. The objective of the journalists is to create an article or a TV report to be shown during the debriefing period.

## 1.2. Measurement of the participants' reaction to the simulated crisis situation

To estimate the reaction of the participants dealing with the simulated crisis situation, we made a survey regarding the cited characteristics which was a document that was distributed to the participants who filled it immediately after the simulation. This survey has been divided into two parts. The first part deals with validated questionnaires to analyze the anxiety and the time pressure. While the second part deals with questions (Appendix 1) to analyze the astonishment, the changes in relationship and the relative nature of the crisis as a second part because no validated tool focusing on these last characteristics exist and could have been exploited. The choice of surveying through simple questionnaires has been made taking into account the environment of the simulation, because we feared that psychological tools to assess such parameters being long to fill up would have had as a consequence to take the participants out from the context of crisis.

Anxiety was measured using the State-Trait Anxiety Inventory Form Y (STAI-Y), which was developed by Spielberger in 1983. For this study, we used the French version validated by Bruchon-Schweitzer and Paulhan (1993). Participants rate each of the twenty items with (appendix 1, p.2) a score of 1 («not at all»), 2 («somewhat»), 3 («moderately so») or 4 («very much so»), yielding a total score ranging from 20 to 80. This scale has mainly been used to investigate emotional reactions during crisis steering situations. The instructions given to the participants were as follows: «A number of phrases that are used to describe yourself are given below. Read each sentence and check the box that best matches what you feel now. There are no right or wrong answers. Do not spend too much time on either of these proposals, and indicate the answer that best describes your current feelings». To interpret this scale, a threshold of 39-40 has been suggested (Knight et al. 1983; Addolorato et al. 1999) to clinically identify the symptoms of a state of anxiety.

To evaluate time pressure during the simulation, we used item number 4 (in bold) of the NASA Task Load Index (NASA-TLX) test (Hart and Staveland 1988). This tool is a short questionnaire that subjectively measures the individual workload through 6 items:

- Frustration;
- Performance;
- Physical demand;
- **Temporal demand**;
- Effort;
- Mental demand.

To assess one should put a line on a one-dimensional line segment that goes from 0 to 100: 0 denotes very low time pressure and 100 denotes very strong time pressure. The instructions given to the participants were as follows: «On the axis located below the question, which goes from 0 to 100, where 0 is «very low time pressure» and 100

is «very strong time pressure», what pressure did you feel during the execution of tasks? Put a line or a cross on the line to the place that best fits how you felt».

Two questions assessed the participants' feelings about based on a Likert scale (with 7 levels from «never» to «all the time»): their perceived astonishment; and their perceived changes in relationship. Using a 7-grade scale allows to assess how much these characteristics were felt by the participants. However, for the concern of our study, the purpose was to highlight whether these features were felt. Intensity of perceived feelings will be certainly discussed as a perspective, however it is not an objective to study it. Therefore, this grading was only used as making a distinction between the first grade «never» and the rest.

Regarding the relative nature of the crisis, we asked the participants to evaluate (with yes or no) whether they would characterize the simulated situation that they experienced as a crisis situation.

## 2. Results and discussion

In this part, we present how did crisis situation characteristics were adequately simulated by giving observations and we propose to present and discuss the reaction of participants illustrated by questionnaires' answers. Two groups are displayed: professionals and students to let the reader have an overview that among the type of participants and the fact that a crisis is relative to anyone, the perception of the crisis characteristics are following a similar logic.

### 2.1. Situation characteristics observation

During the simulations carried out with iCrisis, a database is automatically created because information is transferred via electronic messages. We analyzed these simulation data to examine whether the characteristics of a crisis situation were present. Figure 40 shows the evolution of the story in both simulations. Each begins with a winter storm warning, and later the winter storm begins. The situation worsens with cascading effects, including power grid disruption due to ice and/or snow, which induces blackouts in several areas. Therefore, the managers in the simulation must not only handle a bad weather situation but also more serious issues related to transportation and blackouts; thus, the nature of the problem evolves.

The events generate important consequences since many roads were blocked, including cross-border roads; this shut down urban public transport and caused traffic jams and traffic accidents with fatalities. Simultaneously, many trains were blocked, including national and international high-speed trains. Due to the weight of the snow, the roof of a supermarket collapsed.

This contextual situation engages the participants mentally and encourages them to imagine many potential consequences. Side events were inserted to surprise the participants. For example, a truck carrying hazardous materials was involved in an accident, and there was an intrusion into a nuclear power plant. The participants were mentally prepared to cope with a winter storm and were therefore surprised when an unrelated event occurred unexpectedly.

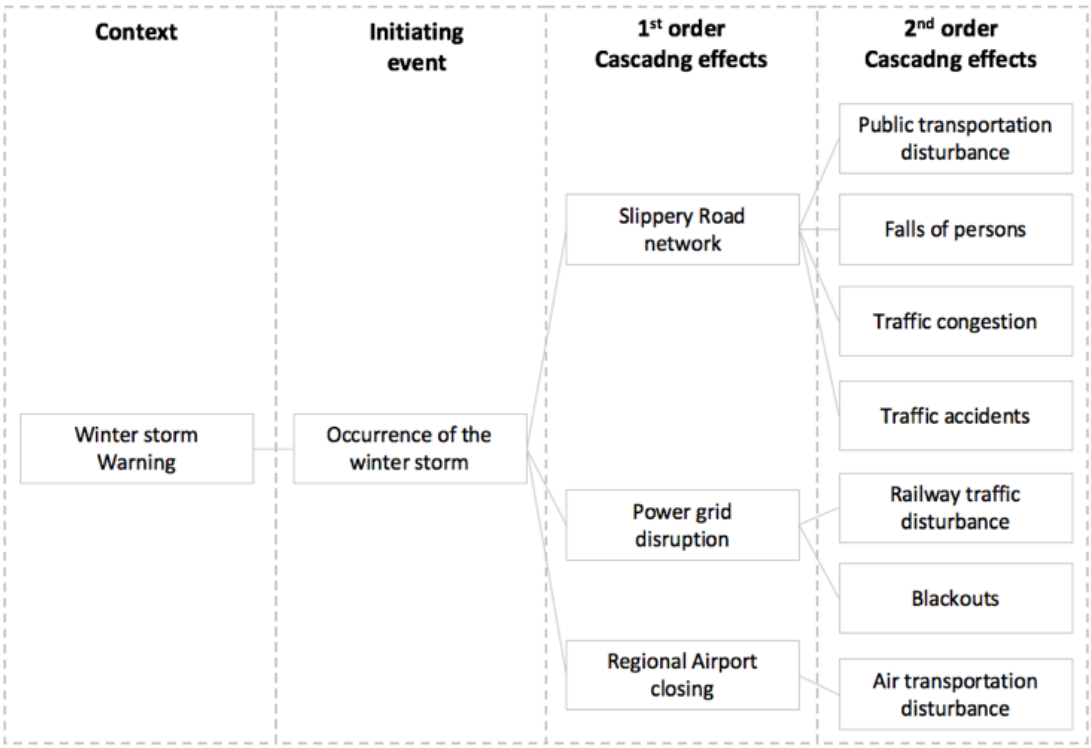



*Figure 40. Main issues associated with the scenario experienced by participants during the simulation*

The combination of events associated with the storm and unrelated side events helped to create a chaotic situation. When the participants were asked to answer yes or no to whether they experienced a chaotic situation, 59% of the students and 57% of professionals replied YES.

Many stakeholders were involved in the crisis situation simulation. In addition to the roles responsible for crisis management in France, the nature of the events and their consequences led to the creation of 37% (36% for professionals and 38% for students) of additional roles such as a weather forecast expert; a regional roads manager; an elementary school director or; a supermarket manager for examples. These roles have been created by the animation team when the participants to the iCrisis simulation requested to have a contact with.

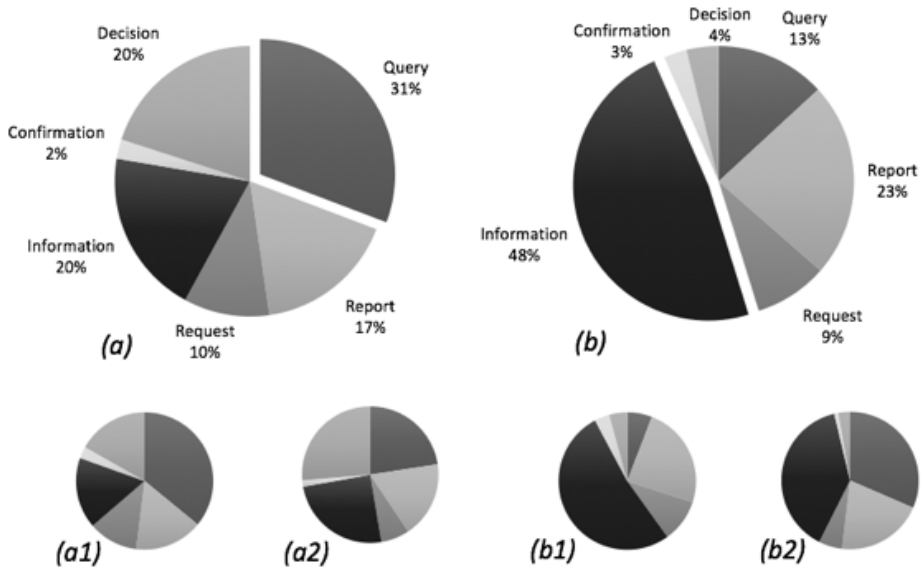



*Figure 41. Type of messages sent by the participants (a) and the animation team (b). (a1) Type of messages sent by students; (a2) Type of messages sent by professionals; (b1) Type of messages sent by the animation team to the students; (b2) Type of messages sent*

Identifying the type of sent messages («query»: ask a question; «report»: make a report regarding a known situation; «information»: give a new fact; «request»: call for something; and «confirmation»: make certain what has been announced) shows that the most frequent message type sent by the participants (31%) was queries (Figure 41). Queries are questions asked by participants which aim to get information. This information is indispensable for the crisis teams to help them clarify the situation and create a representation of what is happening. This mechanism contributes to lower the level of uncertainty. To provide the crisis units with information, the animation fulfilled this role by sending 48% of this message type. We also made a distinction between the simulations with students and professionals (Figure 41 a and b). Regarding messages sent by the animation team towards both types of participants (Figure 41 a1 and a2), we note that the animation team received a few more queries from the students regarding the professionals. This emphasizes that each simulation was different in terms of situation management and level of information. It seems normal that the professionals who better know the geography of their municipality and their procedures did not need to make as many queries.

The irregular rhythm of events during the simulation is shown in Figure 42. It is clear that the pace of information sent and received was irregular in both simulations. The pace oscillates from short periods of inactivity with 0 sent or received messages in 10 minutes to a more rapid rate of 13 sent or received messages in 10 minutes.

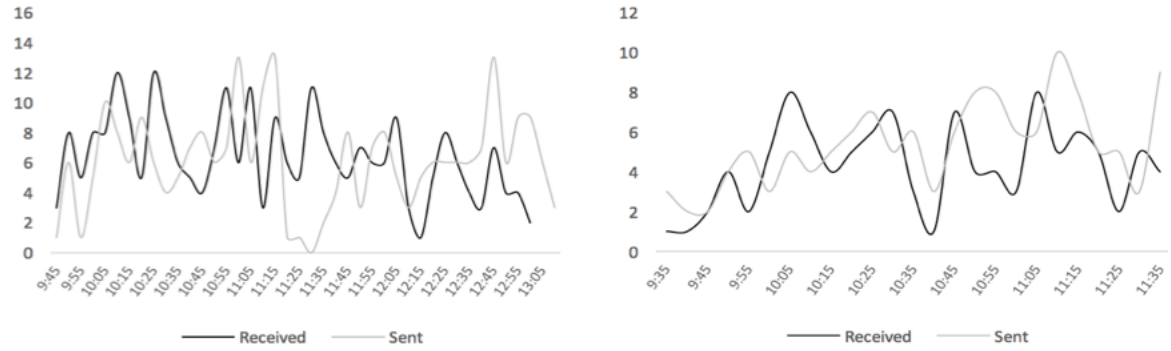



*Figure 42. Pace of messages sent or received by crisis units within a 10 minutes time slot in the simulation with students (left) and professionals (right)*

Information management is difficult inside a crisis unit room. The capacity of participants to remain concentrated is threatened by the level of noise and management of the high flow of sometimes unclear information. So as not to interfere with verbal communications and complex tasks, a room should have a maximum noise level between 49 and 58 dB (Hemp et al. 1995). Typical open-office noise conditions, including conversation, typing sounds, ringing phones, and drawers being opened and closed involves an average level of 55 dB with peaks up to 65 dB (Loewen and Suedfeld 1992; Evans and Johnson 2000). In the crisis units, microphones placed in the middle of the crisis unit table provide an average noise level which is comprised between 60 dB and 70 dB with peaks up to almost 100 dB. Under these noise conditions, we assume that the capacity of crisis managers to remain focused is altered. Beyond the environmental conditions influencing the cognitive capabilities of crisis managers, the flow of information that members of crisis units must manage can reveal difficulties. During iCrisis simulations, participants managed an average of 2 (professionals) to 2.5 (students) messages sent and received per minute. Evidence suggests that human cognitive systems have a limited working memory capable of holding no more than 5 to 9 pieces of information in a few seconds (Miller 1956). Without repetition, information will be lost after 20 seconds (Bhandary et al. 2016). The quantity of information is not the only issue to be managed; relevant information is also crucial. Relevant information is information that is understood and certified. For example, 21.4% (25% for the students and 18% for the professionals) of the messages included abbreviations that could be unfamiliar to certain stakeholders and thus misunderstood. Therefore, although relevant information might have been present in those messages, there were many messages and thus the relevant portions might have been difficult to identify. During crisis situations, the need to be quick influence the quality of the messages that are rarely completely precise. While participants waited for more information, they could not avoid attempting to interpret the first message and forming expectations. For example, a message about a problem at a nuclear plant was interpreted as a radiation issue although it was an intrusion.

As free agents, the journalists took advantage of their mobility to gather information during the simulations. Their objective was to gather information and understand what

was occurring to relay the information through social media and other information channels (newspapers, TV, radio). To complete this task, crisis units were visited several times and they received a regular flow of questions during the simulation which contributed to make experience media involvement. For example, one of the crisis units in the simulation carried out with students was visited 7 times. Up to 25% of the students and 31% of the professionals found that the journalists were intrusive; additionally, up to 34% of the students and 86% of the professionals thought that the media informed the members of the crisis units by transferring information collected from the field (characters played by the animation team). From the field, they received information with a high level of details that is different from the scale at which a strategic crisis unit works contributing to astonish the members of the crisis unit and to give the impression that the media know more about the situation.

## 2.2. Perception of participants' reaction to the simulated crisis situation

To analyze the reaction of the participants, they were asked to respond to questions using a Likert scale from 1-7 (ranging from «never» to «all the time»). The questions were as follows: «During the simulation, did the course of events arouse astonishment?» (q1); and «During the simulation I noticed changes in relationship between participants» (q2). Table 11 shows the mean and standard deviation of the answers given by the participants. Mean scores suggest that participants felt each of both characteristics to some extent.

*Table 11. Mean and standard deviation of the participants' answers to whether the felt astonishment and changes in relationship*

| Characteristics | Mean (standard deviation) | N |
|---|---|---|
| Astonishment | 3.92 (1.58) | 112 |
| Students | 4.15 (1.15) | 68 |
| Professionals | 3.57 (1.61) | 44 |
| Changes in relationship | 2.99 (1.69) | 112 |
| Students | 3.15 (1.71) | 68 |
| Professionals | 2.75 (1.64) | 44 |

We suggest the following interpretation of the data: responses at level 1 indicate an absence of noticing feelings of surprise due to astonishment and changes in relationship. Responses at levels 2-7 indicate that these states were felt or seen at least once during the simulation (table 12). The results show that during the simulation,

the sequence of events triggered astonishment or surprise (chi-squared = 82.286, p <.001) and changes in relationships (chi-squared = 30.036, p <.001).

*Table 12. Distribution of answers to q1 and q2 after transformation of the ordinal variables into nominal variables*

| Characteristics | No | Yes | N |
|---|---|---|---|
| Astonishment | 8 | 104 | 112 |
| Students | 2 | 66 | 68 |
| Professionals | 6 | 38 | 44 |
| Changes in relationship | 27 | 85 | 112 |
| Students | 15 | 53 | 68 |
| Professionals | 12 | 32 | 44 |

The STAI-Y1 test assesses the level of anxiety felt by the participants during the simulation. A total of 31% of the participants exceeded a threshold of 39-40 (39.2% of students and 16% of professionals). This result is very interesting since it reveals that a significant part of the participants felt state anxiety. In addition to this assessment, observations of the crisis units showed behaviors that could be related to a state of anxiety among the participants. For example, in one crisis unit during the simulation carried out with students, an observer noted 30 instances of behaviors, such as voice intensity, aggressive facial expressions, and nervousness. Even if the STAI-Y1 indicator does not reflect the stress levels observed in the simulations very well, it can help to compare the subjects. Additionally, at the level of the group, even though not every participants can be considered as feeling anxiety in regard to the STAI-Y1 test, it is clear however that anxiety was raised anyhow in the crisis units since 31% of the participants scored a high rate of anxiety. Eventually, the STAI-Y1 scores are interesting because they are significantly correlated with the results for astonishment (p-value <.01) and changes in relationship (p-value <.05) despite low association forces (respectively equal to 0.253 and 0.205).

There is no threshold established for the NASA-TLX test to assess the significance of the time pressure experienced by the participants. Using a significance level of 50% to evaluate time pressure, a test of the median (using the sign method with 63 values > 0.5 and 53 values ≤ 0.5) results in rejection of the null hypothesis that the median is ≤ 0.5 with a p-value = 0.01. Therefore, at the 0.05 significance level, we conclude that the perceived temporal pressure was significant.

To the yes or no question («Do you characterize the experienced situation as a crisis situation?»), 58% of the participants said «Yes» (64% of professionals and 54% of students). This result emphasizes that most of the participants felt that they actually

experienced a crisis situation. The fact that all participants did not give the same answer even though they experienced the same situation illustrates the relative nature of the simulation, which is characteristic of crisis situations.

These results show that the characteristics of the crisis can be observed at the scale of the group of participants during an iCrisis simulation. While going into details we observed that different groups, or even different individuals from the same group do not react in the same way (Judek et al. 2018). This is explained by the fact that, each individual is different (experience, environment, state of mind, etc.) and each situation is different generating different reactions and perceptions.

## Conclusion

Because crisis situations are unpredictable and unique, it is impossible to be prepared for any specific situation. However, decision makers can be prepared to cope with the characteristics and consequences of a crisis situation; specifically, they can be prepared to perceive their own crisis reaction. We have seen that crisis simulation approaches such as iCrisis aim to accomplish this.

The iCrisis simulation approach relies on the assumption that participants can benefit from experiencing the characteristics of a crisis. However, it must be clear at the outset that the participants will experience a crisis situation, as defined earlier, because these are often confused with emergency situations. One can recall that an emergency situation can be simulated through an exercise aiming to assess the implementation of a procedure whereas a crisis simulation rather aims to sensitize participants to crisis characteristics. This is explained with the definition of crisis which brings concepts such as unique, unpredictable, relative to anyone. For this reason, in contrast to an emergency situation, we have seen that a crisis situation cannot be really managed because as soon as the situation is starting to be controlled, it is not a crisis anymore.

Validation of crisis simulations remains complex. In this study, a clear definition of a crisis was important to set. Although there are many different definitions of crises in the literature, they share common elements that can be used to identify a crisis based on its characteristics. Given these commonalities and the fact that a crisis situation involves both the situation itself and the reaction it induces among the managers, we proposed that crises include these two categories of characteristics. We noted that some characteristics could fall into both categories (e.g., surprise and time pressure), although we made a justified decision to place them in just one based on our interpretation. Most of these characteristics rely on the feelings of the participants which can be surveyed even if they are subjective. This subjectivity means that some of the results are questionable because while comparing subjects or groups of subjects, results can be different. This relies on the fact that each situation is different, because of elements of the scenario as well as each individual, because of their

experience and their reaction. However, they enable useful comparisons and analyses and thus constitute a relevant avenue of research.

We showed that the characteristics of the reaction to a crisis could be observed among the participants in iCrisis simulations. Assuming that verifying the reaction of participants being congruent with the stated characteristics allow to think that the situation was simulated well, we conclude that iCrisis simulation approaches enables to reproduce the aforementioned characteristics of a crisis.

Due to the fact that there is very little research conducted on the topic of crisis simulation validation, we assume that this study was exploratory. However the questions explored here are important because crisis simulations are widely used for training and research due to the crucial issues encountered by organizations during a crisis. Therefore, although crisis situations have subjective characteristics, our results emphasize that it is possible to observe whether a simulation reproduces the characteristics of a crisis situation.

Our study has several limitations, such as the difficulty in defining a crisis and the arbitrary, but justified, nature of categorizing crisis characteristics. The wide range of existing simulation approaches makes it difficult to propose a standard methodology. Moreover the use of indicators, such as STAI-Y1, may not always be helpful because of the difficulty in setting appropriate thresholds. Then for each parameter, a study to identify the most appropriate method observation/assessment must be carry out in order to optimize the general methodology.

Even though it was not an objective of this study, the presentation of both results from professionals and students showed that there were major differences between these two types of participants certainly because of environmental factors, different levels of experience and individual capabilities. This is an interesting outcome that should be further studied because here the process of simulating a crisis situation seemed to put at the same level both groups.

We assume that simulations are a useful way to gain experience and that the use of such tools and/or approaches is beneficial for managers. Validation can help increase the credibility of simulations and managers' willingness to use them. Our results emphasize that although crisis situations have subjective characteristics, it is anyhow possible to design a protocol to evaluate them. This study can be considered as innovative due to the will to make a complete evaluation of the simulator's approach capability to create crisis conditions. The limits that carries this study must be an opportunity for future research to improve this protocol of evaluation since it appears as an interesting starting point.

The upcoming chapter deals with the use of the iCrisis platform to carry out investigations regarding issues dealing with crisis. Two studies with very different objectives have been made using iCrisis.

# CHAPTER 5: ICRISIS AS A PLATFORM TO CONDUCT EXPERIMENTATIONS

## Introduction

Simulators have always been developed and used to create a situation the closer possible to the reality in order to consider it, better understand it, confront it. Since the beginning of this study, we have seen that the simulation has focused mainly on simulation for pedagogical purposes. However, such as in other sectors of activity, simulation can also serve as a study platform because it has the great advantage of being able to be made and repeated, but also because it is adaptable and can therefore integrate new parameters. In civil engineering, in the field of banking and insurance, as well as in many industrial processes, simulation is an essential validation milestone in the general research and development process. Today, this tool is therefore omnipresent in activities and is often used as or even as a decision-making tool because it has «proved its worth». To reach this stage, the simulator has been validated as performing.

Crisis simulation has not historically been a validated approach. However, in the previous chapter it was noted that it was possible to validate such an approach. Indeed, a first step, presented earlier, made it possible to emphasize that the characteristics of the crisis could be observed, which tends to justify that the simulation approach recreates the crisis well.

Considering that it has been observed that the crisis can be observed in the context of crisis simulations carried out with the iCrisis approach, it is therefore feasible to initiate studies on the crisis. In fact, the crisis and its consideration are such complex elements that it is necessarily relevant to set the objective of better understanding them.

This is why this chapter is devoted to the presentation of two studies on the crisis. The first focuses on individuals who are trying to manage the situation that immerses them into a state of crisis. It is therefore a study on the evolution of individual and collective mental workload in the context of a crisis unit. The second study aims to evaluate the contribution of knowledge on cascading effects in the context of a crisis unit.

These two studies are presented following the template of a scientific communication. Elements already presented earlier in the manuscripts are not depicted and make references to adequate parts in this document.

# 1. Crisis managers mental load assessment

## 1.1. Introduction

Crisis situations are recognized to be complex situations (Lagadec 1997) to handle by an organization. In addition to its complex nature, there is a critical requirement for crisis managers to efficiently cope with the situation in order to recover and retrieve

normal operating condition (Pearson and Clair 1998). For an unprepared organization, the management of certain incidents can lead to a crisis-like reaction of managers. The term crisis may then be used to define the situation.

Characteristics of crisis situation as well as characteristics of the managers' reaction who cope with it influence psychological characteristics (*e.g.* Mental Load) and consequently the effectiveness. The concept of mental workload is defined as the difference between an individual's available cognitive resources and a cognitive task demand's (O'Donnell and Eggemeier 1986). The collective workload is defined as an index of the ratio of the team available resource regarding cognitive task demands (Ilies et al. 2007). Research often highlighted that a high level of workload has negative effects (Sellers et al. 2014). Thus, to better our understanding there is an issue in assessing how does the individual and collective perceived workload behave during the steering process of a crisis situation at a strategic level.

Simulations mimic a real-world process or system over time (Peck 2004). Crisis simulation is therefore a solution to recreate a crisis situation as accurately as possible allowing participants to cope with a virtual but realistic crisis situation.

## 1.2. Material and method

### *1.2.1. iCrisis simulation presentation*

Refer to chapter 3

### *1.2.2. Individual and collective mental load assessment*

The Nasa Task Load Index, developed in 1988 (Hart and Staveland 1988), is a short questionnaire that subjectively measures the individual workload (IWL). This tool has been widely used in a large variety of domain such as aviation or surgery for examples (Hart 2006). Participants have to score on a scale from 0 to 100 their perceived feeling regarding 6 items. The admitted assumption is that the combination of these dimensions is apt to correspond to the workload perceived by individuals (Hart and Staveland 1988). A limitation of the NASA-TLX is its interpretation since no threshold values exist regarding the scores. Nevertheless, it can still be a relevant tool to use to make comparison.

The Team Workload Questionnaire (TWLQ), developed in 2014 (Ilies et al. 2007), is a tool that allows measuring the collective workload (CWL). It has been designed based on the 6-dimension structure of the NASA-TLX. As well as for the NASA-TLX, the mean of the 6-dimension scores gives the collective mental load score. The fact that both tools propose a scale on the same scale is interesting to make comparisons afterwards.

#### 1.2.3. Method

Seventy-five (42 women; 33 men) students from the “Institut Régional d'Administration de Metz” participated in the study by being involved in an iCrisis simulation. This simulation was part of their training class. Their average age was 31,7 (SD = 8,2) years, with age ranging from 23 to 55 years. Divided into six crisis units, representing department prefectures (regional level), the participants have managed, during a 3-hour simulation, a winter storm striking North-eastern France. The crisis simulation was carried out following the iCrisis approach in order to recreate as accurately as possible the characteristics of the crisis. A control group has also been surveyed, there were twenty-seven students of the *«Ecole des Mines de Nancy»* (7 women; 20 men) with age ranging from 20 to 34 years old (M = 22,3; SD = 2,7). This control group is tested in order to give mental workload data for people off context of crisis. It has been decided to select different people to control because we have observed that the context of the simulation influenced the psychology of the group of participants, even before starting.

The individual workload of participants has been investigated off the context of crisis with the control group of students in the framework of regular training class and then in the context of crisis during the simulation with the group of participants (± 2 hours after the start of the simulation). Regarding the collective mental load, it has only been investigated in the context of crisis during the simulation (± 2 hours after the start of the simulation). It was only relevant to assess the collective workload individually (a person as a member of a group) while they were performing a group task. The investigation was made with a questionnaire (Appendix 2) given to participants when doing a task in context of crisis and off context of crisis. The filled questionnaires have been gathered and processed one by one to calculate the scores.

### 1.3. Results and discussion

Heatmaps show a data matrix where coloring gives an overview of the numeric differences and the sorting relies on correlation calculations. This statistical tool was used to identify groups of individuals. Indeed, since the crisis is relative to anyone, individuals do not experience the situation by sharing the same feelings.

The IWL heatmap (figure 43) shows that the population can be divided into three groups regarding the perception of the IWL with groups 1 and 2 (n = 52) scoring around 50 and more (respectively M = 47.2 and M = 63.6). However, individuals of group 3 (n = 23) perceived a low IWL (M = 26.9).

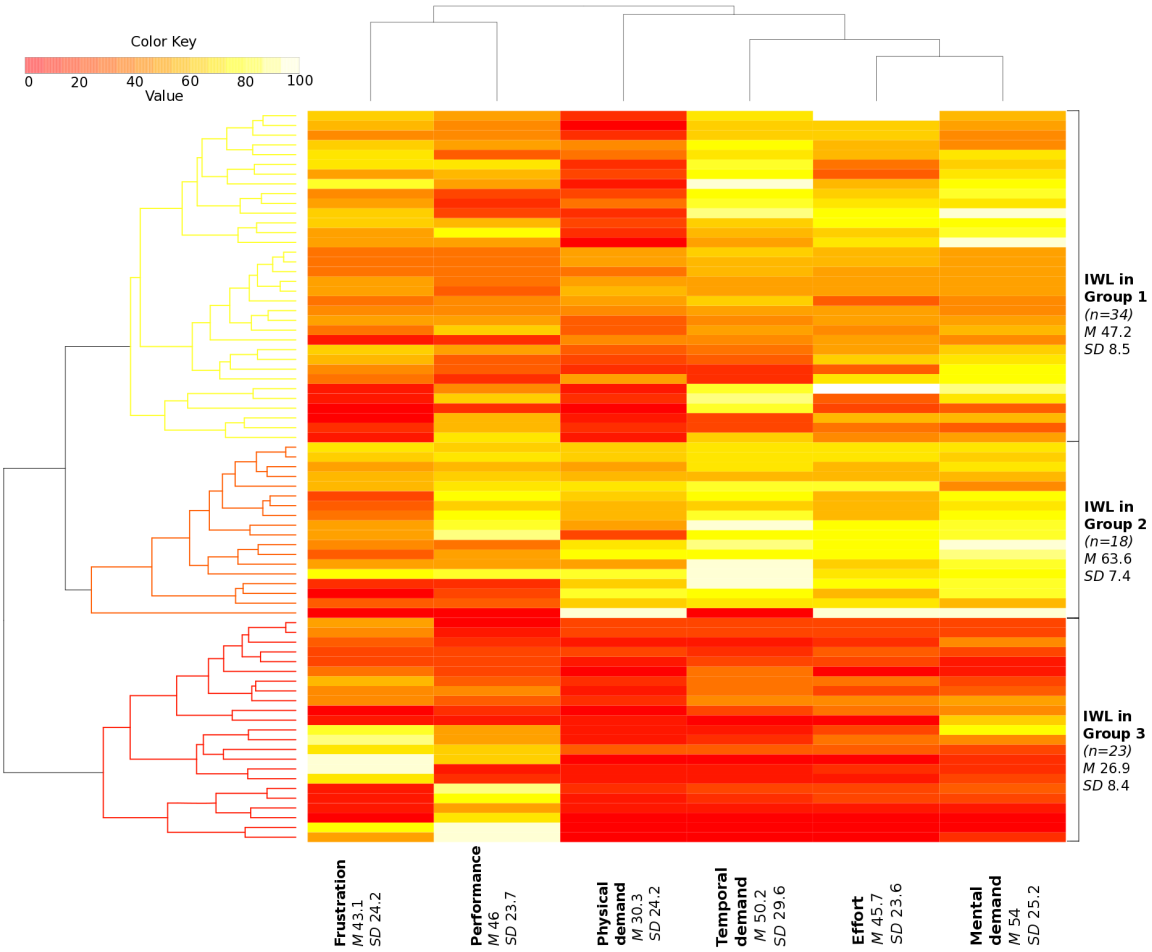



*Figure 43. Heatmap of IWL (Individual Workload) in context of crisis.*

Within group 3, scores for «Frustration» are for some individuals very high (> 80) although the other items have been scored very low reflecting the fact that these individuals did not accept the crisis nature of the situation which is by definition unmanageable and it resulted in making them perceive a high frustration. Still within group 3, another sub group can be defined due to very low scores (< 20) except for performance for which scores increased (> 60). This fact is interesting because it means that for these individuals, they found the situation as being a manageable situation since they perceived their performance as being good. Eventually, within group 3 a third subgroup can be identified as a group of individuals that perceived very low IWL (< 20). This last subgroup is an illustration of the fact that in crisis units, some people give up.

Regarding the items of IWL, they indicate that both items «Effort» (M = 45.7) and «Mental Demand» (M = 54) are correlated (Pearson product-moment correlation, r = 0.8) and what is more they are the most important items perceived during a crisis situation. The high scores as well as the correlation between them show that during

the crisis situation, the mental demand is such that the perception of making an effort is important for individuals.

Off context of crisis (contral group), the obtained results (M = 26.2; SD = 15.2) show that the IML is lower in comparison with In context (p-value < 0.001) highlighting the fact that the crisis situation asks for more psychological resources. When going into the details of each item (figure 44), this difference is clear for most of them, only the performance is perceived to be psychologically demanding as well in both context (p-value > 0.5).

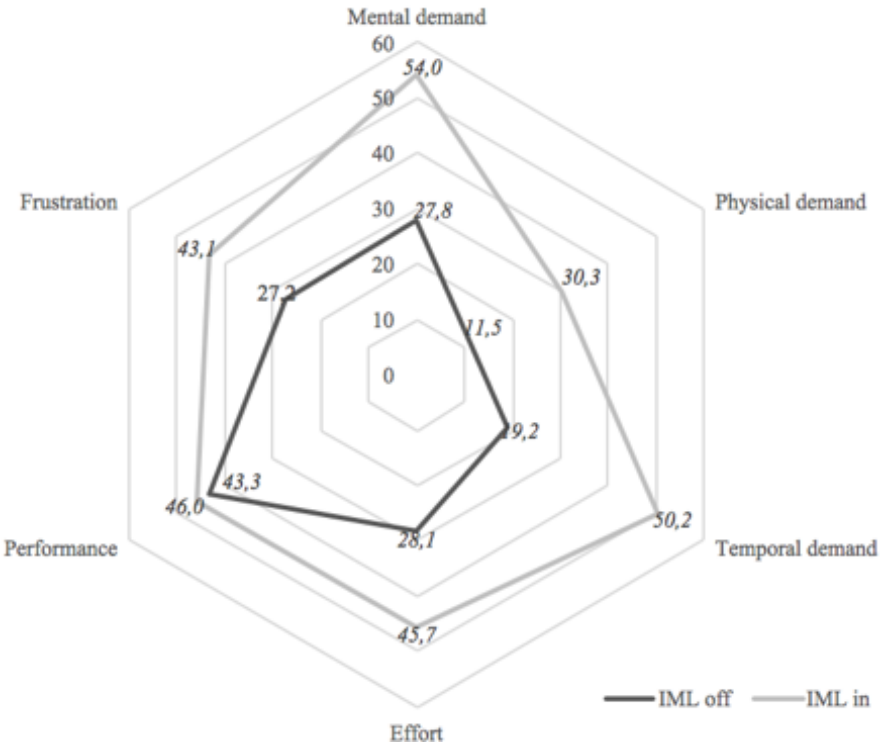



*Figure 44. Individual Mental Load in and off context of crisis.*

The CWL representation of the scores (figure 45) highlights that a majority of individuals (groups 4, 5, and 6 : n = 66) perceived a strong CWL (≥ 50) in the context of crisis, whereas the members of the group 7 (n = 9) perceived a low CWL (M = 25.3). The six items of the CWL are divided into two classes regarding their mean scores. Actually, «Coordination» (M = 63) and «Communication» (M = 67.9) are considered as very high compared to «Team emotion demand» (M = 41.7), «Team support» (M = 45.1), «Team performance monitoring demand» (M = 47.3), «Timeshare demand» (M = 52.8). This reveals that in crisis situation, coordination and communication aspects are found by the members of the groups to be an issue that affects considerably their collective workload. With regards to group 7, in addition to the fact that the scores are

very low, no differences can be observed between items highlighting a low involvement.

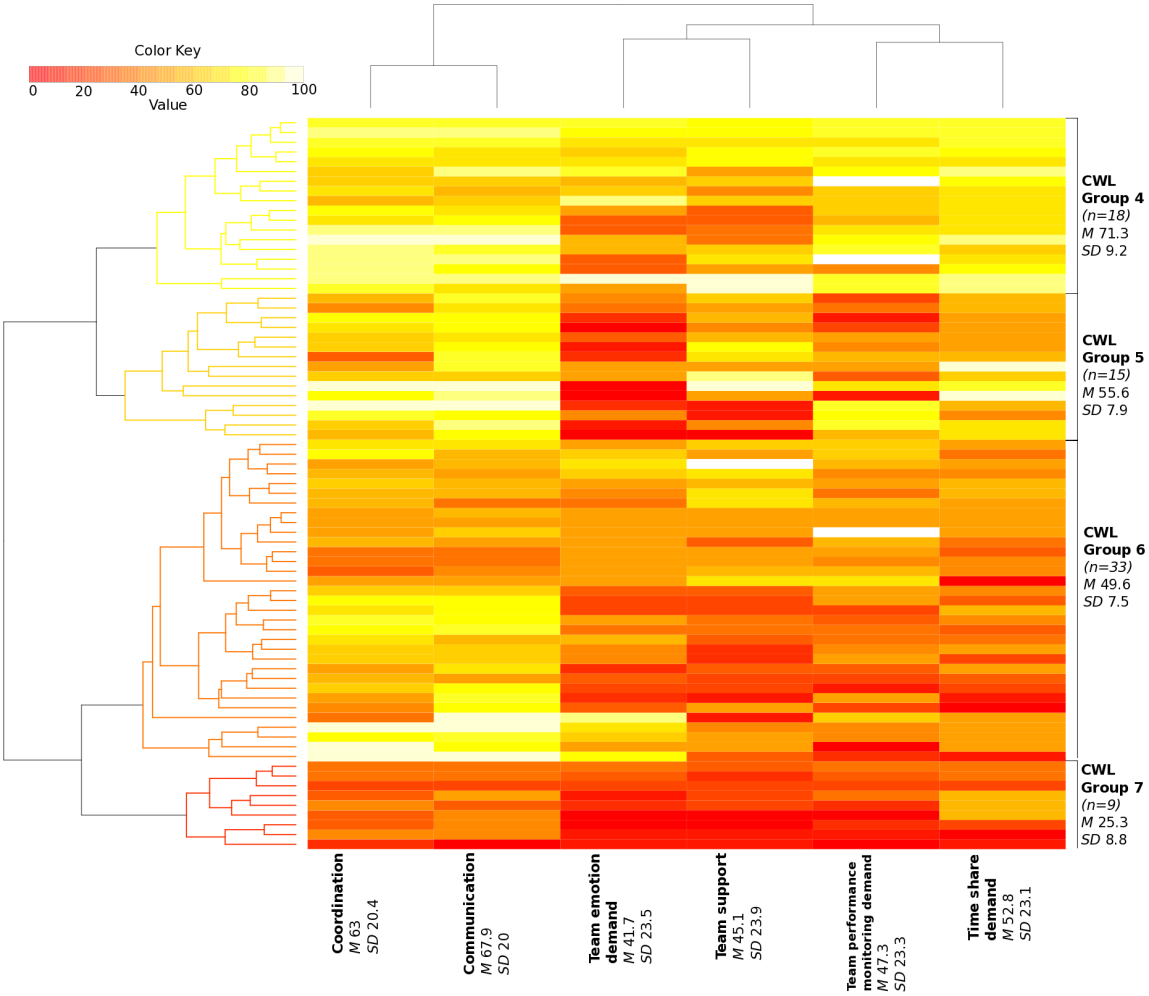



*Figure 45. Heatmap of CWL (Collective Workload) in context of crisis.*

In the context of crisis (table 13), CWL is higher than IWL (p-value < 0.001) showing that collective effort is perceived to be more important than individual. Whether groups given by CWL heatmap distribution (figure 45) are considered, this increase is put into evidence (p-value < 0.05) for groups 4 and 5, whereas for group 6 this increase is not significant. In opposition, members of group 7 perceived an as low CWL as IWL. For groups given by IWL heatmap distribution (figure 43), groups 1 and 3 show a higher CWL whereas for group 2 the scores for both parameters high and almost of the same intensity. Beyond the fact that most of the results show high scores, analysing the CWL of group 3 and group 7 allow to distinguish them even though their IWL scores are very low (<30). Indeed, while group 7 scores indicate a low IWL and a low CWL, members of group 3 perceived a low IWL whereas their perception of CWL was higher.

Observations made emphasize that the perception of the CWL is superior to the perception of the IWL except two cases:

- when IWL is very high then the CWL is very high (group 2) showing that the task demand on individuals is too important to perceive a «group effect»
- when both IWL and CWL perception are very low (group 7) showing a lack of involvement of the individuals.

*Table 13. Comparison between CWL and IWL in context of crisis based on statistical groups.*

| | | **Gr. 1** | **Gr. 2** | **Gr. 3** | **Gr. 4** | **Gr. 5** | **Gr. 6** | **Gr. 7** |
|---|---|---|---|---|---|---|---|---|
| IWL | M | 47.2 | 63.6 | 26.9 | 55.9 | 47.8 | 48.8 | 29.7 |
| | SD | 8.6 | 7.4 | 8.4 | 15.6 | 13.3 | 15 | 11.2 |
| CWL | M | 54.5 | 62.8 | 43.4 | 71.3 | 55.7 | 49.6 | 25.3 |
| | SD | 11.2 | 13.9 | 17.6 | 9.2 | 7.9 | 7.4 | 8.8 |

## 1.4. Conclusion and perspectives

This study emphasizes that the crisis situation as well as the perception during a crisis influence the cognitive performances of the persons as individuals or as members of a group. More precisely, we highlighted differences between groups of individuals which therefore indicates that feelings are relative to anyone due to experience and involvement for instance.

We emphasized that the CWL is higher than the IWL. This finding should be studied further more into details because of the multifactorial nature of both tests as well as the fact that they do not consider the same items. However, this comparison brings insight on the fact that crises are steered out by crisis units which are groups. Thus, studying the psychological parameters at the scale of the group becomes relevant since until now, the individual dimension has been privileged.

Beyond the fact that we observed that the IWL is higher in context of crisis, this study allowed to emphasize that during a crisis situation some workload items were more important than other. Regarding the IWL, the most perceived items are Temporal demand, Effort and Mental demand during a crisis situation. It has been highlighted that there is a correlation between the Effort produced by an individual and the perception of the Mental demand. For groups of individuals perceiving very low IWL, the focus on both items: Frustration and Performance, allowed to put into evidence that some individuals could find the situation easy to deal with, by scoring a level of Performance, or unmanageable by perceiving a high level of Frustration. Regarding

the CWL, it was shown as an evidence that Coordination and Communication were items that participants perceived as the most important in context of crisis situation.

Highlighting the fact that individuals do not behave equally and the fact that some parameters are more important than others while coping with a crisis situation is an interesting result for professionals. This type of findings aims to aware the professionals to the issues that can be encountered while managing at a strategic level a crisis situation

As a perspective, the use of specific tools that assess more precisely the items could be used to carry out more detailed studies such like on performance or anxiety for example. Moreover, the analysis of the workload enables us to make a study (under conduction) on the relation between workload, anxiety and performance during a crisis situation.

# 2. Assessment of the added-value of cascading effects knowledge on their consideration

## 2.1. Introduction

The technological transition that the world is experiencing makes it more and more interconnected which can be an opportunity of productivity on one hand but also a threat of dependence on the other. Events such as hurricane Sandy or the eruption of the volcano Eyjafjallajökull highlighted the risk of cascading effects induced by an initial event.

In order to improve the capability of risk managers to take into account cascading effects, the CascEff project aims to propose a methodology to identify and to model the potential chains of events.

Within the CascEff project, knowledge about cascading effects has been developed based on the identification of systems on a territory, their vulnerabilities regarding type of effects they could be sensitive to and their ability to generate a new effect that can damage other systems or hinder their ordinary functioning (Carré et al. 2017).

Also known as cascading failures or snowball effects, the cascading effects are the chains of events propagated between systems due to interdependencies and that has been initiated by an initiating event. The CascEff project proposes that cascading effects (Hassel et al. 2014) are *«the result of an **initiating event** where **system dependencies** lead to **impacts propagating** from one system to another system, and the combined impacts of the propagated event are of greater consequences than the root impacts, and multiple stakeholders and/or responders are involved»*.

Considering cascading effects enables to draw dependences between systems and spay disturbances among the systems for identifying the potential scenarios which could occur regarding the evolution of an initiating event. By doing so, it would help stakeholders to improve the risk mitigation.

Prior to the development of the CascEff methodology to analyze the cascading effects, it has been decided to make an assessment at this stage whether the philosophy of this tool would be understood and if it would bring an advantage in the context of a crisis situation.

To fulfil the objective of assessing the potential added-value of having knowledge about cascading effects during a crisis situation, it has been chosen to make the investigations in the framework of a crisis situation simulated with the iCrisis approach since it is an approach that focuses at the strategic level, where crisis units make decisions, and also because it has been studied that the characteristics of crisis could be observed during simulations.

## 2.2. Material and method

### *2.2.1. iCrisis simulation approach*

cf.

### *2.2.2. CascEff knowledge about cascading effects*

Within the framework of the CascEff project, brainstorming and investigations have been carried out to develop a methodology to model the cascading effects and the so-called Incident Evolution Methodology (Carré et al. 2017). In this part, a global overview is presented with the purpose of understanding how to consider the cascading effects in order to take them into account within a crisis situation scenario.

The literature provides several definitions of cascading effects. The one underlying this research is the definition provided by Reniers and Cozzani (2013) and adopted by the CascEff project. According to them, cascading effects are *“the result of an initiating event where*

- *system dependencies lead to impacts propagating from one system to another system, and*
- *the combined impacts of the propagated event are of greater consequences than the root impacts, and*
- *multiple stakeholders and/or responders are involved”.*

*Table 14. Asset categories description (Carré et al. 2017)*

| Asset categories | |
|---|---|
| Power supply | Sea transportation |
| Telecommunication | Agriculture |
| Water supply | Business and industry |
| Sewage supply | Media |
| Oil and gas | Financial asset |
| District heating | Governmental asset |
| Healthcare | Emergency response |
| Education | The public |
| Road transportation | Environmental assets |
| Rail transportation | Political assets |
| Air transportation | Food supply |

*Table 15. Effect categories (Carré et al. 2017)*

| Effect categories | Effects sub-categories | Code |
|---|---|---|
| Natural | Flood / Water | (WA) |
| | Epidemics | (EP) |
| | Wild fire | (FI) |
| | Ground movement | (GM) |
| | Storm | (WS) |
| | Tsunami | (TS) |
| Accidental | Blast | (PRI) |
| | Projectile | (MI) |
| | Toxic effect | (TO) |
| | Thermal radiation | (TH) |
| | Fire | (FI) |
| Functional | Service degradation | (SD) |
| | Communication service degradation | (CS) |
| | Water service degradation | (WSD) |
| | Workforce service degradation | (WFS) |
| | Energy service degradation | (ES) |
| | Food supply degradation | (FS) |
| | Transportation service degradation | (TSD) |
| Intentional | Bombing | (PRI) |
| | Social effect | (SO) |
| | Hostage taking | (HO) |
| | Shooting | (SH) |
| | Fire | (FI) |

Several steps are needed to identify the potential cascades. The first consists in identifying the assets[17] within the area, then characterizing these assets with regard to the category of assets (table 14) to which they belong to, the geographical location, the surface, the components, the services or products provided to other assets and the services or products needed from other assets for their proper functioning. The next step is the definition of the assets vulnerabilities (or effects that they are sensitive to) as well as their potential outgoing effects they can generate. Table 15 summarizes the different categories of effects.

With reference to the retained definition of cascading effects, it is clear that there will not be cascading effects without dependencies between assets. Figure 46 shows a sample of dependencies between a set of assets. The purpose of this step is the identification of these dependencies as they will allow to predict which assets can be affected by the disruption of other assets and to which extent.

Eventually, the last step consists in setting the initiating event that can be described as the first event in a sequence of several events that may affect one or more of the assets within the study area. Once the initiating event is set, one can identify the assets impacted by the outgoing effects of this event then assess the outgoing effects of these impacted assets in order to identify the assets which would be affected by the assessed outgoing effects.

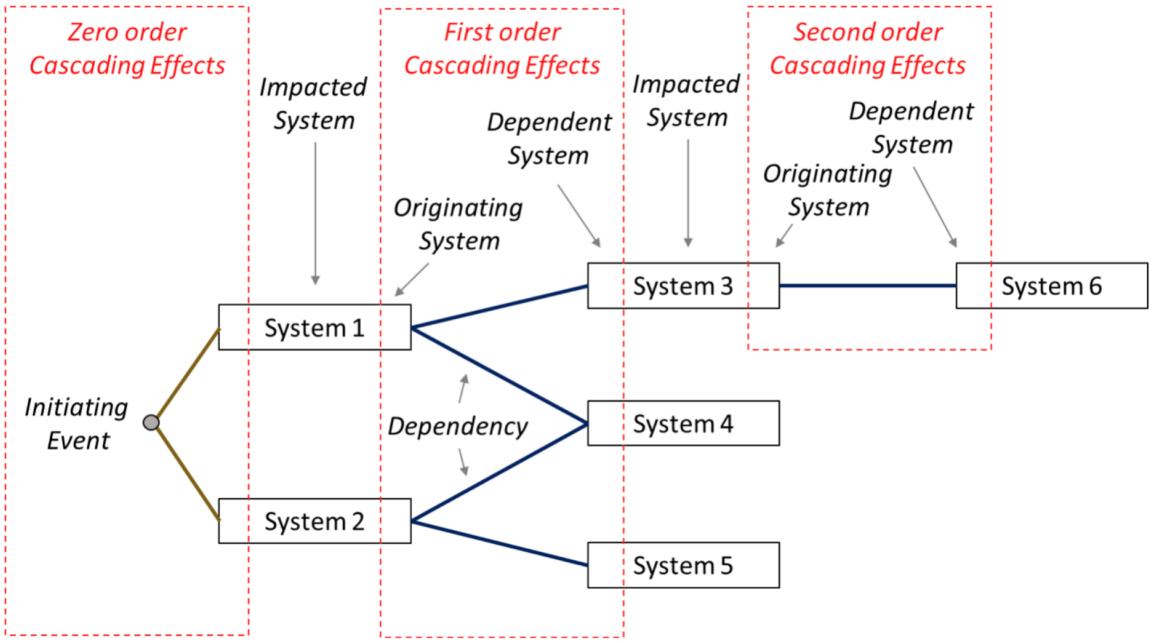



*Figure 46. Schematic representation of cascading effects (Hassel et al. 2014)*

[17] In this study the terminology "asset" is chosen and refers to the word "system" previously used in the definition of cascading effects

### 2.2.3. Crisis simulation scenario building methodology that considers cascading effects

The scenario building methodology used in the iCrisis approach originally aims to recreate crisis situations. To run a crisis simulation that considers cascading effects, the design of the scenario has been adapted. Because the principal objective of the simulation remains unchanged, the regular scenario design methodology was kept. However, the CascEff approach to model cascading effects brings elements that had been selected to identify interdependencies between assets and thus to draw potential cascades that can be taken into account in the scenario. The main steps of the cascading effects modelling approach that have been chosen to be integrated in the iCrisis scenario building methodology are presented hereafter:

- Identify assets: on the chosen territory, relevant assets are identified;
- characterize assets: a certain number of parameters are provided for each asset such as the categorization, its location, its surface, its own services, its connected services with other assets, its number, the number of people, economic information etc. This list must be adapted by the scenario designer in regards with the relevant needed information;
- definition of incoming effects: based on a list of effects, the scenario designer has to determine to which effect an asset is vulnerable. At this stage, values about effects and threshold can be implemented if needed;
- definition of outgoing effects: same as the incoming ones but for the effects an asset can generate;
- identification of dependencies: based on previous information about assets, physical and functional interdependencies between assets;
- set of initiating event: it generates an effect whose aftermaths trigger the cascade.

These six steps resume the process to draw potential cascades on a territory and with regards to chosen events that must be considered. The adaptation of the regular crisis scenario building methodology consists in precising some steps to obtain the relevant information in order to draw cascades. This adaptation is presented in the table 16 where the majority of the original steps remains unchanged or adjusted (1-3 and 9-12). Former steps 4-5 “Make a list of potential events (put all your ideas on the paper)” and “Select and put the events in order” (Table 8 - chapter 3 ) dealing with the created events and their order of occurrence defined based on brainstorming have been removed and replaced by steps to frame the determination of the potential cascade of events (in bold in table 16).

*Table 16. Steps of crisis simulation scenario building methodology considering cascading effects*

| | **Scenario building steps** |
|---|---|
| 1 | Write a synopsis to set the context (*e.g.* scale, location, nature of the problem) |
| 2 | Collect information on the territory to **identify assets** and hazards |
| 3 | Collect information to **characterize assets** |
| 4 | **Determine asset vulnerability** in regard to incoming effects |
| 5 | **Determine the asset potential generated effects** |
| 6 | **Draw the assets interdependencies** |
| 7 | **Set the initiating event** |
| 8 | **Choose a potential cascade** based on the initiating event and a possible propagation |
| 9 | Add side events of the regular life |
| 10 | Link events with a script and adjust if needed |
| 11 | Check consistency with the chronology |
| 12 | Verify compatibility with established objectives of the simulation |

This methodology can be implemented on any type of crisis simulation scenario (natural, industrial or intentional disasters). It is adjustable in terms of asset categories, effect types as well as in terms of data level of precision which enables to apply it with simulation participants of different backgrounds (e.g. students, professionals).

### *2.2.4. Implementation of the methodology: The Alpine area scenario*

The Alpine area scenario is a fictitious scenario that belongs to low probability with high consequences type of scenario. The established database for this scenario has been created with information found in public publications and discussions with experts. However, for confidentiality reasons, the assets and locations remain unnamed herein. The situation takes place in an alpine valley where assets characterized by cities, chemical industries and main roads are mostly gathered in the bottom of the valley surrounding a mountain stream. This fictitious scenario takes place nearby the city of Grenoble in France. One particularity of this alpine valley is that there is a mountain slope characterized by constant rockslides that threatens to collapse entirely which would create a natural rock-dam in the valley causing retention upstream and potentially a flood wave downstream once the natural rock-dam collapses. Basically, the scenario consists in a double cascade of events induced by an earthquake:

- the rockslide of the entire mountain slope that creates a natural rock-dam in the valley which interrupts the stream of the river generating a flooding upstream and finally, the pressure of the water retention provokes the collapse of the natural rock-dam creating a flooding wave downstream;

- a disruption in a chemical process of a plant generating a blast affecting a train carrying hydrocarbon that fires causing multiple disturbances in the industrial area causing aftermaths at a wider scale.




*Figure 47. Alpine area scenario assets location (zoom view)*

The identification of the assets on the territory is presented on a map (figure 47). The list of assets has been thoroughly made in regards to the objectives of the simulation to focus on buildings open to the public. The characterization of the assets enables to categorize them and to be represented with different colors as shown on the map. The geolocation of assets brings out an insight on the configuration of the territory and the spatial distribution of the assets. It reveals that the assets are mainly concentrated in the valley which accentuate the proximity between them. The other characteristic of this alpine valley is that there is only one main road and potentially one rail way which enables the entirety of the local travels.

For each asset, its vulnerability, its potential generated effects and dependent assets are defined and highlighted (here for two examples) in a table (table 17). For this scenario the analysis has been conducted under the expertise of relevant experts such as a local inhabitant; an industrial-risk expert; a local natural-risks manager; an officer from Fire and Rescue services; and a regional authority representative. By doing so, for each asset on the territory its potential dependent asset is identified showing for instance that if «S3» is impacted by a fire (FI) which causes the generation of a toxic effect (TO) then nineteen assets and the surrounding neighborhood would be impacted. The power of this methodology is its capability to improve the level of details.

Indeed, whether one would want to develop a scenario at a higher level of description, values of effects and vulnerability threshold for example could be added (Carré et al. 2017).

*Table 17. Examples of assets incoming and outgoing effects analysis and dependencies*

| ID of asset | Asset cat. | Asset vulnerability effect | Pot. gener. effects | Potential impacted assets |
|---|---|---|---|---|
| **S3** | B. & I.* | WA, EP, FI, GM, WS, TS, PRI, MI, TO, TH, SD, CS, WSD, WFS, ES, FS, TSD, PRI, SO, HO, SH | TH | Nd* S1 S4 S7 S13 S56 S57 S59 S58 S60 |
| | | | PRI | Nd S1 S4 S7 S13 S56 S58 S60 |
| | | | FI | Nd S1 S4 S6 S7 S13 S41 S56 S57 S58 S59 S60 S63 |
| | | | TO | Nd S1 S4 S6 S7 S13 S14 S15 S16 S30 S37 S38 S39 S41 S42 S43 S44 S56 S58 S60 |
| | | | MI | Nd S1 S4 S6 S7 S13 S41 S56 S57 S58 S59 S60 S63 |
| **S4** | B. & I. | WA, EP, FI, GM, WS, TS, PRI, MI, TO, TH, SD, CS, WSD, WFS, ES, FS, TSD, PRI, SO, HO, SH | TE | Nd S3 S7 S59 S60 |
| | | | PRI | Nd S3 S7 S58 S60 |
| | | | FI | Nd S3 S7 S57 S58 S59 S60 |
| | | | TO | Nd S3 S6 S7 S57 S58 S59 S60 S63 |
| | | | MI | Nd S3 S6 S7 S57 S58 S59 S60 S63 |

* B. & I. = Business and Industry; Nd = neighborhood

Eventually, based on the dependency analysis, the scenario designer makes choices to come upon with potential cascades and the scenario under the shape of a swim-lanes diagram (figure 48). The swim-lanes diagram appears to be a relevant manner to present the crisis situation scenario that considers cascading effects for two reasons. : Firstly, it illustrates the dependencies between the involved assets very easily with enough information about the time (impact time, resistance time etc.) and the nature of effects (incoming and outgoing) for instance. The second reason is, the fact that there are no predefined messages. This, gives to the simulation animators a certain freedom regarding how to inject the information in order to adapt the story to the players reactions.

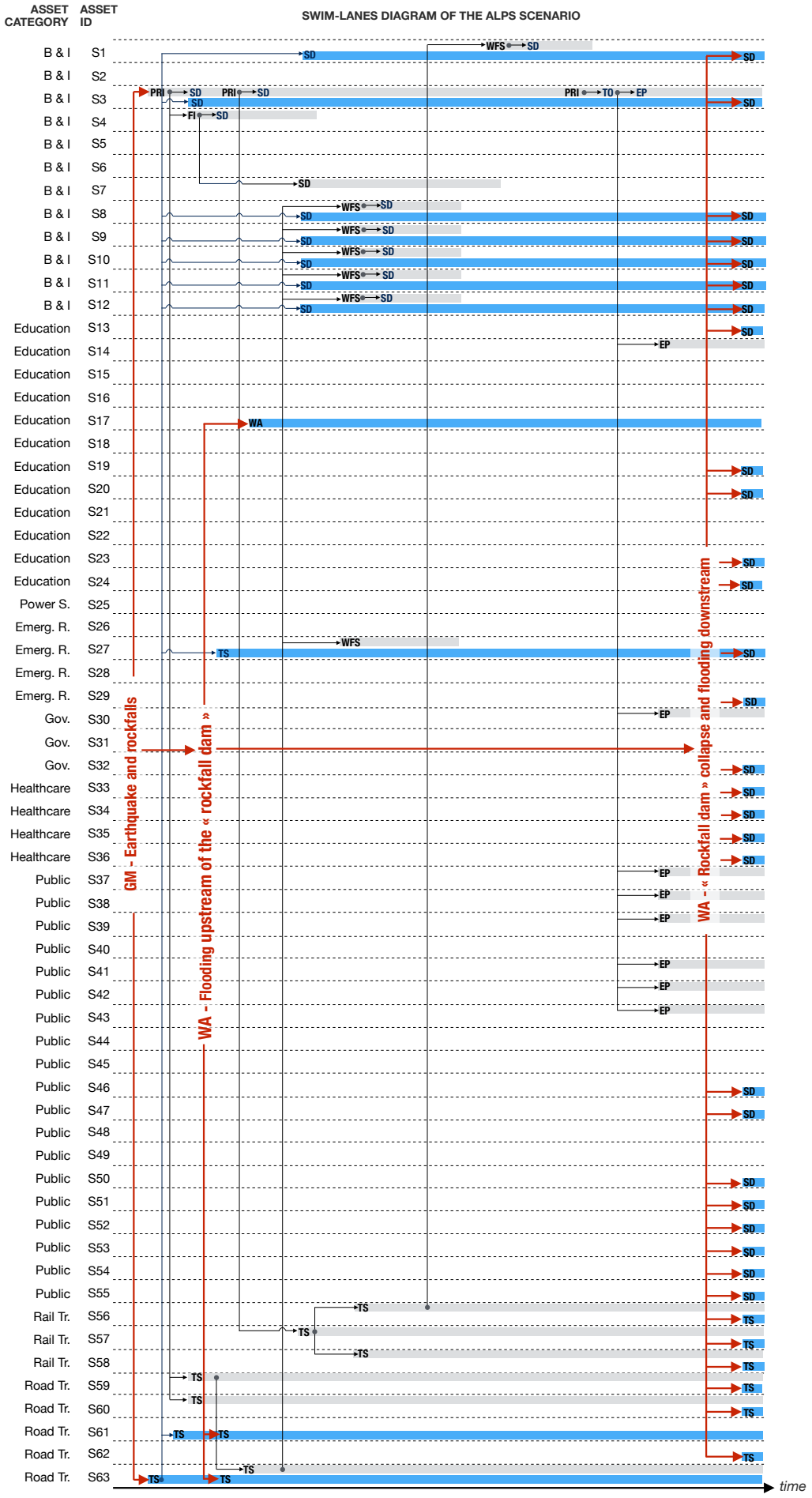



*Figure 49. Alpine area scenario assets location (zoom view)*

For the Alpine area scenario, as mentioned above, two main events are occurring. They are illustrated in the diagram by two colors: blue for the cascade of events in relation with the rockslide whereas grey is used for the cascade induced by the industrial accident. The red represents the initiating event which is the earthquake and the problems that deal with the natural rock dam which is not an identified asset even though it plays an important role behaving as an asset (vulnerable to incoming effects and generator of potential outgoing effects). This synthetic way of representation shows easily the cascade(s) of events with the possibility to quickly focus on a part of the chain where or when the consequences could be very critical. In our case, one example is the clear representation of the high consequences that would be if the collapse of the «rockfall dam» occurs with thirty three on the sixty three systems would be affected.

This methodology highlights that, starting from the regular crisis scenario methodology to which elements of the cascading effects analysis methodology are added, a crisis scenario considering cascading effects can be created. However, the characterization of the environment, here the systems needs to be a dedicated work in order to develop a chain of events that responds to the most important condition of scenario which is : plausible and credible. To do so, a very good knowledge of the territory is required, inducing the support of experts (technical, local etc.).

### *2.2.5. Running iCrisis simulations session tests*

For this test, two iCrisis simulations were conducted in February and March 2016 with two groups of students from engineering schools in France. These participants did not have specific prior requirements about cascading effects, so they provided unbiased answers to questions on the given information on cascading effects that was available for them. Because the general interest of the CascEff project was to assess the added-value of such knowledge for decision-making process at strategic level, only the 21 participants of “Prefecture” crisis unit (over 55 participants in total) received the package of cascading effects information.

The cascading effects package was formed with a map with all systems already identified and characterized (Figure 47); a table with all the effect each system is vulnerable to, the effects each system can generate and every systems that could be affected regarding the generation of a specific effect (Table 17); and probabilistic models of propagation realized based on the analyze of more than 200 events (Casceff, D2.3[18]). The full package can be found in appendix.

[18] Not public deliverable: http://casceff.eu/publications/

For estimating the potential interest of knowledge in crisis management decision-making process (considering the context of incident response), a questionnaire (Appendix 3) has been submitted to the participants for gathering their opinion about the cascading effects knowledge (Appendix 4). In order to make comparison with participants who were not provided with the cascading effect knowledge, some questions have been asked about the perception of the situation to identify whether the cascading effects knowledge would have an influence. Both questionnaires were distributed to the participants providing feedback on the perception of the situation and more precisely on the notion of cascading effects. The group with cascading effects knowledge received additional questions concerning the use of it. This setup on one hand allows to have feedback on what could bring such knowledge and on the other hand on how this tool could affect the perception of the handled situation compared to other groups who were managing the situation without it.

## 2.3. Analyzing results from the testing of the cascading effects knowledge

The questions about the influence the crisis units have on the situation either for groups with and without the cascading effects knowledge package, give results that are similar regarding their feeling on their actions influencing the situation (69 % for players without the cascading effects knowledge package and 70 % for those with the cascading effects knowledge package) and more precisely when this influence is favorable (without: 48 %; with: 50 %). Otherwise, when asking if their influence was unfavorable regarding the course of the events, then a major difference between the participants without the tool answering almost 2 times more (71 %) than the participants with the tool (39 %). To conclude, we can say that in general, all the participants feel that they are quite influencing the situation. This influence is felt to be positive at a medium level whereas it is felt to be unfavorable at a high level for the participants without the tools and lower for the participants with the tool.

Regarding the use of the cascading effects knowledge package, figure 49 shows that it has been used in general at an interesting level since they have mainly marked “often”.

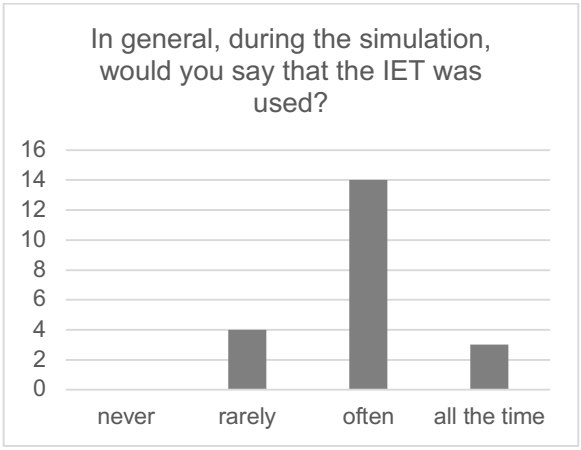



*Figure 49. Frequency of the use of the cascading effects knowledge package by participants during the simulation*

The graphs shown in figure 50 emphasize on the use of the cascading effects knowledge package to visualize the involved systems. The results show that it has been used quite often and the participants have considered that it helped to do so.

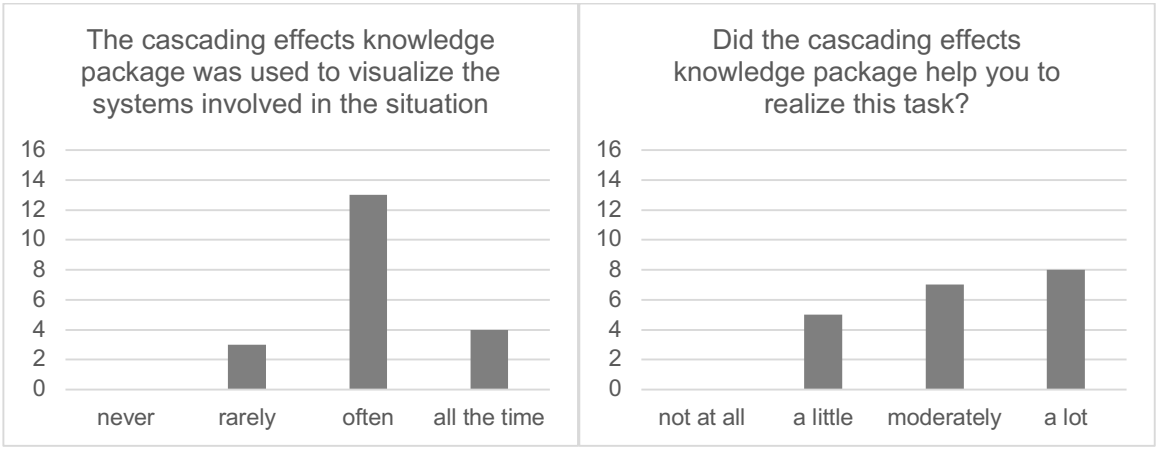



*Figure 50. Use of the cascading effects knowledge package to visualize the systems involved in the handled situation*

The question about the identification of dependencies between systems presents results that are mainly around “rarely” and “often” (figure 51). These two intermediate levels represent the major proportion of the answers whereas only three participants said that they did not use the tool. Regarding the help that the tool could bring, the results are heterogeneous with a higher score for “moderately”. This enhances the fact that in a group people do not share the same actions and visions.

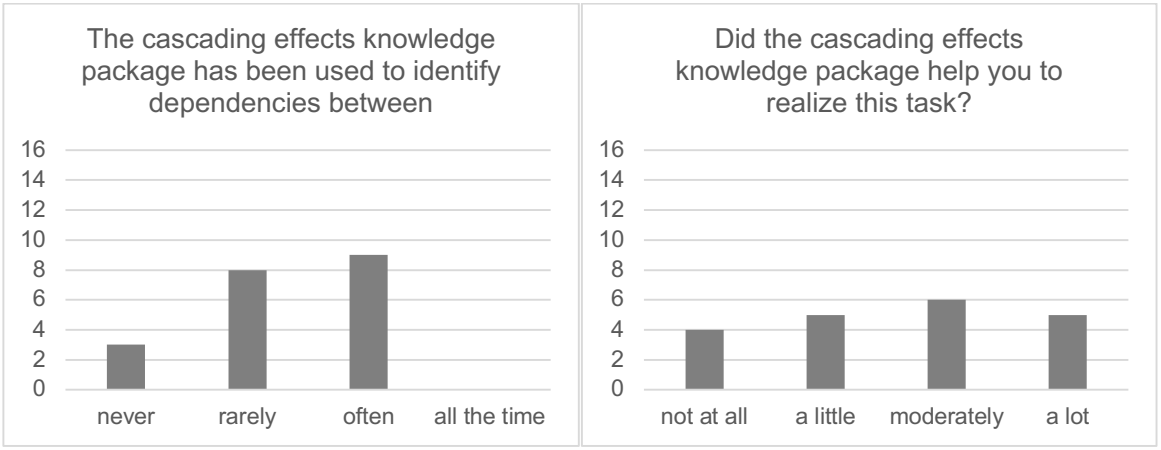



*Figure 51. Use of the cascading effects knowledge package to identify dependencies amongst the systems involved in the handled situation*

The cascading effects knowledge was used to identify the first order of cascade in general but it could not be used all the time. This is probably because during a crisis situation, there is a high time pressure which prevents the managers to spend a lot of time on this reflection. The results also show that the cascading effects knowledge helped to realize this task with only three people saying, “not at all” (figure 52).

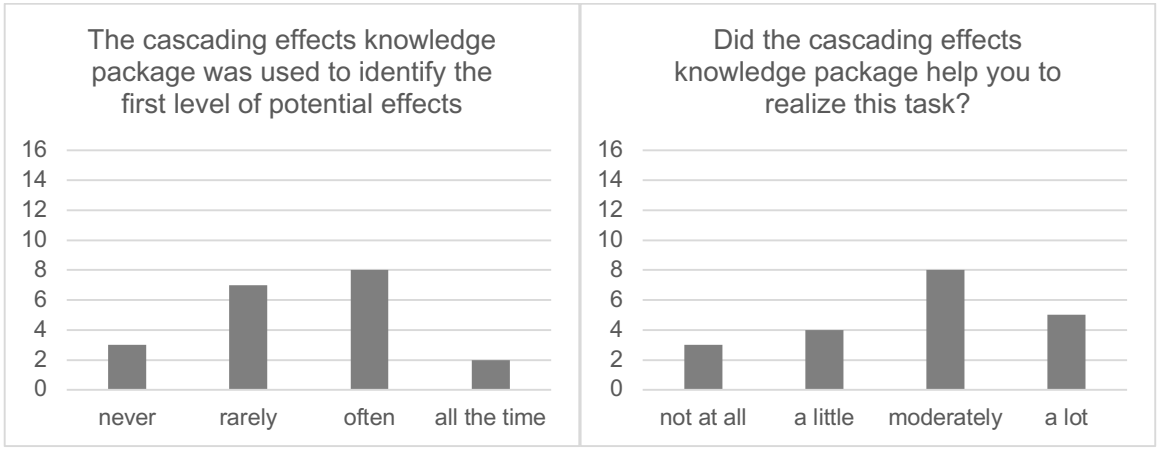



*Figure 52. Use of the cascading effects knowledge package to identify the first order cascading effects*

The potential second order cascading effects were less considered regarding the results shown in figure 53. For the reflection at this level, the tool helped a little or moderately.

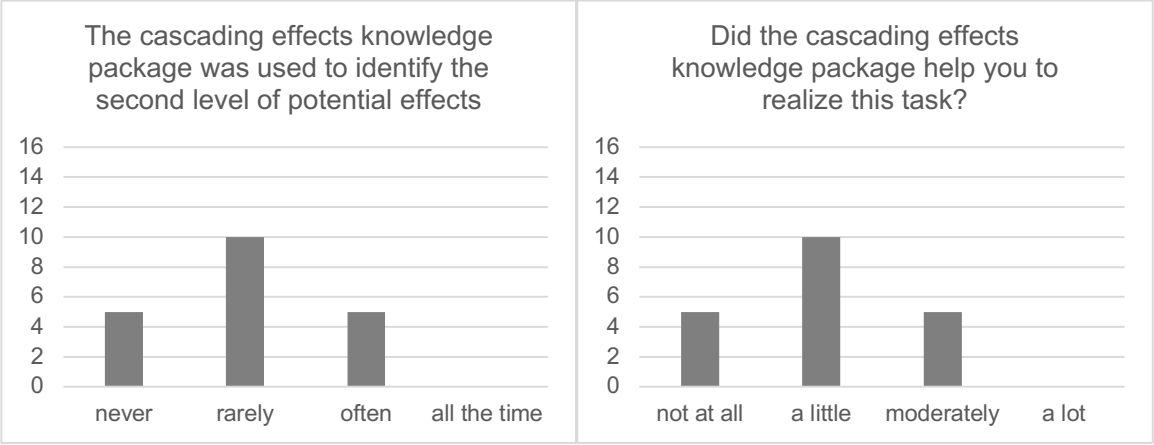



*Figure 53. Use of the cascading effects knowledge package to identify the second order cascading effects*

Regarding $n^{th}$ order (n>2) cascading effects, the tool was almost not used because it probably could not really help to do so (figure 54). This could be explained by the fact that in a crisis situation the need to react quickly is important. The cascading effects knowledge package appears time-consuming, in the adopted setup, to gather needed information. This seems to be a limit of the cascading effects knowledge package which makes difficult the manual calculations and the visualization in comparison to a informatics solution.

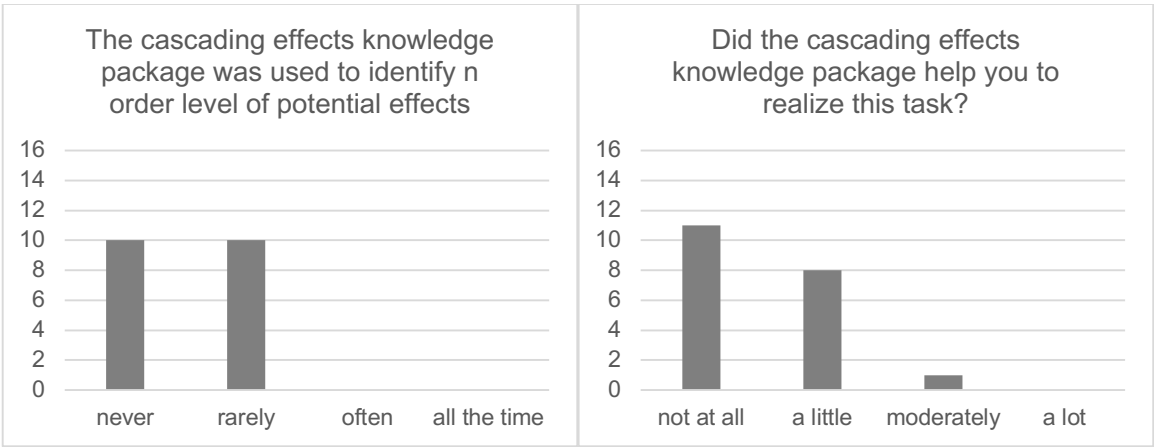



*Figure 54. Use of the cascading effects knowledge package to identify the nth order cascading effects*

The graphs (figure 55) show that the information from the cascading effects knowledge has clear impact on the process of decision making since it allowed to initiate quite often a decision and confirm it. At a lower level, it permitted to challenge sometimes the decision and even correct a prior one.

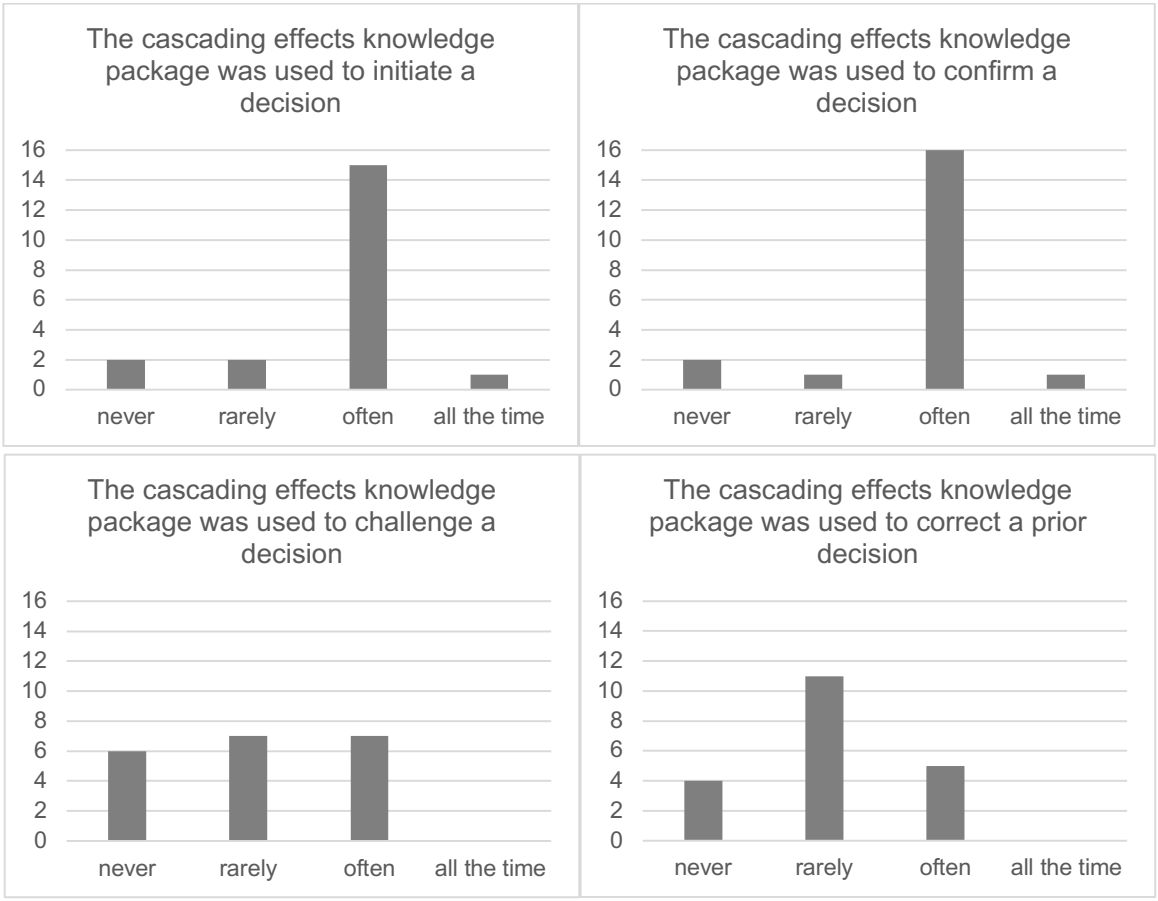



*Figure 55. Use of the cascading effects knowledge package to identify the $n^{th}$ order cascading effects*

This investigation aimed at assessing the added-value and the interest of the information that could bring the cascading effects knowledge in a context of strategic crisis management.

The main results show that although all the participants have thought that they have influenced the evolution of the situation, participants with access to the cascading effects knowledge felt that their decisions and actions to a greater extent influenced the incident resolution in a positive way, compared to participants who did not use the tool. Regarding the applicability of such tool, the tests showed that it is generally used until the first level of cascades. It appeared that it would need more time to search and combine the information required for anticipating cascading effects at a higher level than the first one. This is interesting because this limit will be pushed with an informatics tool that will make automated calculations for modelling high order cascading effects.

Moreover, this study allowed to have an idea on the potential interest of knowledge on cascading effects in the process of decision-making when managing crisis situations. To assess the added value of such methodology within the process of decision making, we gathered the perception of participants regarding the influence of their decisions

regarding the evolution of situation. Three questions have been given to both groups at the end of the simulation: Q1: *"The decisions made by the Crisis Unit influenced the course of events"*; Q2: *"The decisions made by the Crisis Unit have favorably influenced the course of events"*; Q3: *"The decisions made by the Crisis Unit have negatively influenced the course of events"*. A comparison is made between a group of participants who did not have the cascading effects methodology composed with 25 subjects (G1) and another group with the methodology composed with 15 subjects (G2). The results show that the participants of both groups perceived that their decisions influenced the ongoing situation (G1: 70%; G2: 69%, p-value > .05). Moreover, both groups perceived that their decisions influenced favorably the ongoing situation (G1: 46%; G2: 40%, p-value >.05). Contrariwise, it has been observed that when asking whether the groups' decisions influenced negatively the ongoing situation, the group with the methodology felt it less than the group without the methodology (G1: 60%; G2: 45%, p-value <.05).

## 2.4. Conclusion of the study

In the risk management community, there is a growing concern on better understanding cascading effects, its representation and its consideration in the risk cycle and also during a crisis situation. To respond to this need, crisis simulation approaches which originally focus on the basic objective to recreate a crisis situation, thus had to consider the implementation of cascading effects within the methodology. Regarding the notion of cascading effects, since it deals with the simulated story, it was decided that its consideration should be done through the scenario.

Based on the knowledge produced by the CascEff project about the concept of cascading effect, it was studied how the original crisis simulation scenario building methodology should be adapted to consider them. The choice of adapting the original methodology relies on the fact that the main objective remains the creation of a crisis situation. Based on that fact, it was clear that the nature of the story to be played through the scenario could take into account cascading effects whose modelling relies on improving and precising original steps about the characterization of the environment.

The study enabled to highlight the added-value of cascading effects knowledge for a crisis unit at a strategic level. However, it was clear that when *n* order cascades can be defined then it is difficult for the managers to visualize well the situation. The investigation depicted that the crisis units focus on the first and second order cascades for which they think they can intervene. An automatic calculation tool cool bring to the user a clear tree view visualization of the potential ongoing situation that could help.

The second interesting result of the study is that the cascading effects knowledge seemed to give confidence to the members of the crisis unit. Although every crisis units

perceived that their decisions influenced the situation, the crisis units without the cascading effects package felt quiet much that their decisions influenced unfavorably the situation. This depicts that when decision makers can rely on reliable information they are more inclined to make decisions that they think are good.

## Conclusion

This section presents two studies, one on the evolution of mental workload and the other on the consideration of cascading effects, both in the context of crisis situation. They made it possible to highlight some interesting elements.

The first study was an opportunity to address an important issue in the functioning of a crisis unit, which is the psychology of the members who compose it. Mental workload is an indicator of cognitive demand that can attest the difficulty (in terms of cognitive resources) in managing the situation. It is known that the mental load is high among members of a crisis unit. However, this statement has not been studied. It was therefore interesting to carry out a supervised investigation using simulation. This study helped to confirm that the mental workload evolves in the crisis manager in situations but also at the group level.

The second study aimed to assess the contribution of cascading effects knowledge on their consideration in crisis situations. This survey identified elements that are exploitable in the CascEff research project, the end-goal of which is the development of a cascading effects modeling tool.

We have therefore illustrated through two case studies of a very different nature and with very different objectives that crisis simulation could be used to carry out investigations on issues applied to the crisis situation. The iCrisis simulation approach, because of its flexibility, is an approach that is appropriate for this type of study because it is easily adaptable to the study's requirements (adaptation of the scenario, questionnaire survey protocol).

Although these examples may have shown that the simulated crisis situation could be used as a support to carry out studies, we are aware that there are limits. Indeed, Chapter 4 focused on presenting that the iCrisis simulation approach recreated the characteristics of the crisis, but it is not a scientific method validation due to the difficulty of working on subjective indicators.

# GENERAL CONCLUSION -
## *CONCLUSION GÉNÉRALE*

This work intended to question the ability of the iCrisis crisis simulation approach to place strategic managers in a situation with characteristics similar to those of a «real crisis». We also discussed the possibility of using simulation in a scientific context to study problems in the context of crisis.

Throughout this manuscript, we have addressed aspects that allow us to provide answers to our initial problems.

In the first chapter, we presented the structuring of the French civil security response for two reasons. First, because it made it possible to propose such a description in English and, second, because this structure has greatly influenced crisis management as it has been defined in organizations. We then presented how the crisis is perceived by organizations and how crisis management is structured. This part also had the objective of challenging the use of crisis management as it is perceived because it is too often confused with emergency management, which although it shares common characteristics such as serious consequences and urgency, it is no less distinctive. Crisis management is actually considered by emergency services and organizations as a process of crisis avoidance with appropriate functioning and procedures. This vision leaves little or no chance for the uniqueness of the crisis, requiring skills in the field of agility and innovativeness. Under these conditions, crisis simulation cannot have the same objectives according to the meaning given to the word crisis. The difficulty to position and differentiate the crisis management regarding the emergency management has consequences on objectives of sensitization to the unknown. When considering crisis as part of the emergency management domain, experts focus on the response capability of an organization which is assessed regarding a response plan. It is then difficult to raise awareness on coping with an unknown situation for which no plan is available. As says Todd Laporte, in the context of crisis: “The problem is not to prepare to avoid surprises, but to prepare to be surprised” (Lagadec 2009).

The second chapter aims to position our research on the concept of crisis. In this chapter, a semantic reminder from etymology is provided. Then, we discuss the fact that the crisis can be a concept that goes beyond the nature that characterizes it because, beyond the generated situation, the state of crisis in which the people who live it are inseparable from it. It is the combination of these two dimensions that makes the crisis because, for example, for the same situation, depending on the experience of the people who have to cope with it, it could be a crisis or not. Let's take the example of a fire in a house, for the experienced firefighter, although the consequences are important, there is an urgent need to react, there are many sources of information, as an experienced professional, he will be able to recognize the model of situation in which he is in order to be able to apply the adapted procedure and extinguish the fire. If we take the same example but from the inhabitant of the house's point of view, then his non-experience of this kind of situation added to the fact that he sees his dwelling threatened in survival (the fireman is emotionally detached from this situation) are factors that may suggest that this person may be in a state of crisis. It is therefore not possible to define a situation as a crisis without mentioning the angle of perception.

These elements of definition and positioning are essential before considering the simulation. Future research should improve this two dimension characterization by providing other characteristics and discuss other potential dimensions.

Chapter 3 is devoted to crisis simulation. In this chapter, a review of the origin of simulation is given in order to understand that it is a tool widely used in all fields of activity. The rest of the chapter focused on so-called crisis simulation platforms. The panel presented showed that there are very different formats for achieving such different objectives. Most simulators are designed to put individuals in situations to test their ability to apply a particular plan or procedure. If we base ourselves on the definition of the crisis as a unique situation, it seems contradictory to seek to validate capacities to apply a procedure for managing the unknown... in the context of the crisis, we would prefer to set ourselves an awareness objective by allowing participants to confront the crisis. Finally, a last part was devoted to the iCrisis simulation approach, the support of our studies. In particular, the details of the crisis simulation approach developed and its use were presented.

In order to provide some answers as to the capacity of the iCrisis approach, Chapter 4 presented an empirical study to observe the characteristics of the crisis in the context of iCrisis simulations. This study verified that it was possible to observe the characteristics of the crisis situation as well as those of the state in which crisis managers are immersed. Even though we cannot speak of a validation process, this study is innovative in that it is the first attempt at verification. We have seen that crisis simulation approaches are not validated although it seems very important to verify the ability of such approaches due to the objectives that they intend to reach. As a perspective, this research aims to provide a first basis of a more complete process with more precise observation protocols and maybe more adapted assessment tools such as for the anxiety. To make improvements, more simulations should be carried out to keep on verifying that the characteristics can be observed and other investigation tools should be tested as well. Another perspective would be to assess the capability of other crisis simulation approaches to recreate crises. This could also be the opportunity to test whether the characteristics of the crisis could be observed with other types of crisis simulation approaches.

In the last chapter, two case studies of using iCrisis to investigate issues in the context of crisis were presented. The first study showed that the mental workload of crisis managers increases in crisis situations. The second study provided an opportunity to show that the iCrisis platform could be used to test the use of tools in the crisis situation. This chapter shows that we limited ourselves to 2 case studies. However, they are fundamentally different with a first study focusing on the state of crisis managers (mental workload) and a second more oriented on the crisis situation (cascading effects). These two different studies show the ability of the iCrisis simulation approach to study, at least partially, crisis management situations.

Finally, the choice of iCrisis as a research support tool is interesting because of at least one of its quality. The system makes it possible to keep the memory of the exchanges in order to build a database. These databases of all exchanges are useful material for many possible studies in a crisis context, such as information processing, decision-making processes, etc.

*Ces travaux visaient à s'interroger sur la capacité de l'approche de simulation de crise iCrisis à placer les gestionnaires stratégiques dans une situation aux caractéristiques similaires à celles d'une «crise réelle». Nous avons également discuté de la possibilité d'utiliser la simulation dans un contexte scientifique pour étudier les problèmes dans un contexte de crise.*

*Tout au long de ce manuscrit, nous avons abordé des aspects qui nous permettent d'apporter des réponses à nos problématiques initiales.*

*Dans le premier chapitre, nous avons présenté la structuration de la réponse de la sécurité civile française pour deux raisons. D'abord parce qu'elle a permis de proposer une telle description en anglais (chose peu voire pas présente dans la littérature) et ensuite, parce que cette structuration a fortement influencé la gestion de crise telle qu'elle a été définie dans les organismes. Nous avons ensuite présenté comment la crise est perçue par les organismes et comment la gestion de crise est structurée en leur sein. Cette partie avait également pour objectif de remettre en cause l'utilisation de la gestion des crises telle qu'elle est perçue car elle est trop souvent confondue avec la gestion de l'urgence (emergency management), qui, bien qu'elle partage des caractéristiques communes telles que des conséquences graves et l'urgence, n'en est pas moins singulière. La gestion des crises est en fait considérée comme un processus de prévention des crises par les services et les organismes d'urgence, avec un fonctionnement et des procédures appropriés. Cette vision ne laisse que peu ou pas de chance à la nature unique de la crise, qui nécessiterait plutôt des compétences dans le domaine de l'agilité et de l'innovation. Dans ces conditions, la simulation de crise ne peut avoir les mêmes objectifs selon le sens donné au mot crise. La difficulté de positionner et de différencier la gestion de crise par rapport à la gestion de l'urgence a des conséquences sur les objectifs de sensibilisation à l'inconnu. Lorsque la crise est considérée comme faisant partie du domaine de la gestion des urgences, les experts se concentrent sur la capacité d'intervention d'un organisme qui sera évalué en fonction d'un plan d'intervention. Il est alors difficile, dans ces conditions, de sensibiliser les gens à faire face à une situation inconnue pour laquelle aucun plan n'est disponible. Comme le dit Todd Laporte, dans un contexte de crise : «Le problème n'est pas de se préparer à éviter les surprises, mais de se préparer à être surpris» (Lagadec 2009).*

*Le deuxième chapitre visait à positionner nos recherches par rapport au concept de crise. Dans ce chapitre, un rappel sémantique sur l'étymologie du mot a été présenté.*

*Ensuite, nous avons discuté du fait que la crise peut être un concept qui va au-delà de la nature qui la caractérise. En effet, par-delà de la situation événementielle qui est générée, l'état de crise dans lequel les personnes qui la vivent sont immergés est indissociable des caractéristiques de la crise. C'est la combinaison de ces deux dimensions qui fait la crise parce que, par exemple, pour une même situation, selon l'expérience des personnes qui doivent y faire face, cela peut être une crise ou non. Prenons l'exemple d'un incendie dans une maison, pour le pompier expérimenté, bien que les conséquences soient importantes, il y a un besoin urgent de réagir, il y a beaucoup de sources d'information, en tant que professionnel expérimenté, il sera capable de reconnaître le modèle de situation dans lequel il est afin de pouvoir appliquer la procédure adaptée et éteindre le feu. Si l'on prend le même exemple mais du point de vue de l'habitant de la maison, sa non-expérience de ce genre de situation s'ajoute au fait qu'il voit son logement menacé de péril (le pompier est émotionnellement détaché de cette situation) sont des facteurs qui peuvent suggérer que cette personne est peut-être en situation de crise pour l'habitant. Il n'est donc pas possible de définir une situation comme une crise sans faire référence à l'angle de la perception. Ces éléments de définition et de positionnement sont essentiels avant d'envisager la simulation. Les recherches futures devraient améliorer cette caractérisation à deux dimensions en fournissant d'autres caractéristiques et en discutant d'autres dimensions potentielles.*

*Le chapitre 3 était consacré à la simulation de crise. Dans ce chapitre, nous avons passé en revue l'origine de la simulation afin de comprendre qu'il s'agit d'un outil largement utilisé dans tous les domaines d'activité. Le reste du chapitre s'est concentré sur les plates-formes dites de simulation de crise. Le panel présenté a montré qu'il existe des formats très différents pour atteindre des objectifs aussi différents. La plupart des simulateurs sont conçus pour mettre les personnes dans des situations afin de tester leur capacité à appliquer un plan ou une procédure particulière. Si l'on se base sur la définition de la crise comme étant une situation unique, il semble contradictoire de chercher à valider les capacités à appliquer une procédure de gestion de l'inconnu... dans le contexte de la crise, on préfère se fixer un objectif de sensibilisation en permettant aux participants d'affronter la crise. Enfin, une dernière partie a été consacrée à l'approche de simulation iCrisis, le support de nos études. En particulier, les détails de l'approche de simulation de crise développée et son utilisation ont été présentés.*

*Afin d'apporter des réponses quant à la capacité de l'approche iCrisis, le chapitre 4 a présenté une étude empirique pour observer les caractéristiques de la crise dans le contexte des simulations iCrisis. Cette étude a permis de vérifier qu'il était possible d'observer les caractéristiques de la situation de crise ainsi que celles de l'état dans lequel se trouvent les gestionnaires de crise. Bien qu'on ne puisse pas parler d'un processus de validation, cette étude est innovante dans la mesure où il s'agit de la première tentative de vérification. Nous avons vu que les approches de simulation de crise ne sont pas validées bien qu'il semble très important de vérifier la capacité de*

*ces approches en raison des objectifs qu'elles visent à atteindre. Comme perspective, cette recherche vise à fournir une première base d'un processus plus complet avec des protocoles d'observation plus précis et peut-être des outils d'évaluation plus adaptés tels que pour la mesure de l'anxiété. Pour apporter des améliorations, d'autres simulations devraient être effectuées afin de continuer à vérifier que les caractéristiques peuvent être observées et d'autres outils d'investigation devraient également être testés. Une autre perspective consisterait à évaluer la capacité d'autres approches de simulation de crise à recréer des crises. Cela pourrait également être l'occasion de vérifier si les caractéristiques de la crise peuvent être observées avec d'autres types d'approches de simulation de crise.*

*Dans le dernier chapitre, deux études de cas sur l'utilisation d'iCrisis pour enquêter sur des problèmes dans un contexte de crise ont été présentées. La première étude a montré que la charge mentale des gestionnaires de crise augmente dans les situations de crise. La deuxième étude a été l'occasion de montrer que la plate-forme iCrisis pouvait être utilisée pour tester l'utilisation des outils en situation de crise. Ce chapitre montre que nous nous sommes limités seulement à 2 études de cas. Cependant, elles sont fondamentalement différentes avec une première étude centrée sur l'état des gestionnaires de crise (charge de travail mentale) et une seconde plus orientée sur la situation de crise (effets en cascade). Ces deux études différentes montrent la capacité de l'approche de simulation iCrisis à étudier, au moins partiellement, les situations de gestion de crise.*

*Enfin, le choix d'iCrisis comme outil de soutien à la recherche est intéressant en raison d'au moins une de ses qualités. Le système permet de conserver la mémoire des échanges afin de construire une base de données. Ces bases de données de tous les échanges sont utiles pour de nombreuses études possibles dans un contexte de crise, telles que le traitement de l'information, les processus décisionnels, etc.*

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# APPENDIX

## Appendix 1. Crisis characteristics perception questionnaire

**Questionnaire sur le ressenti de certaines caractéristiques au cours de votre séance de travail**

Dans le cadre de mes recherches sur les situations de crise, dirigées par Thierry Verdel, je cherche à obtenir des valeurs témoins quant aux caractéristiques suivant : *l'étonnement, les changements relationnels, le désordre, la pression temporelle et l'anxiété*. Le but étant de les comparer avec les valeurs obtenues dans le cadre des simulations iCrisis, que vous expérimenterez dans le cadre de l'atelier cindynique.

Merci de répondre à la fin de votre séance de travail de manière honnête, aucun jugement ne sera fait. Vous pourrez déposer le questionnaire auprès de Thierry Verdel, Mimi Edjossan ou moi-même.

Je reste à votre disposition pour d'éventuelles questions : clement.judek@univ-lorraine.fr

1. Vous étiez vous fixé un/des objectif(s) à réaliser au cours de la séance ?

|__| OUI |__| NON

2. Evaluer le taux d'accomplissement de vos tâches en fonction de objectifs définis.

.....%

3. Au cours de la séance, le déroulement des évènements a suscité de l'étonnement et de la surprise

A aucun moment 1 2 3 4 5 6 7 Tout le temps

4. Au cours de la séance, j'ai pu remarquer des changements relationnels entre les membres de mon groupe

A aucun moment 1 2 3 4 5 6 7 Tout le temps

5. Au cours de la séance, j'ai ressenti un désordre

A aucun moment 1 2 3 4 5 6 7 Tout le temps

6. Au cours de la séance, quelle pression temporelle avez-vous ressenti durant l'exécution de la tâche? Fallait-il gérer la réalisation de la tâche de manière lente (0 = pression temporelle faible) ou de manière rapide (100 = pression temporelle forte) ?

.....%

7. Anxiété : Test STAI-Y1

*Un certain nombre de phrases que l'on utilise pour se décrire sont données ci-dessous. Lisez chaque phrase, et cochez la case appropriée qui correspond le mieux à ce que vous ressentez à l'instant, juste en ce moment. Il n'y a pas de bonnes ni de mauvaises réponses. Ne passez pas trop de temps sur l'une ou l'autre de ces propositions, et indiquez la réponse qui décrit le mieux vos sentiments actuels.*

| MAINTENANT | Non | Plutôt non | Plutôt oui | Oui |
|---|---|---|---|---|
| 1. Je me sens calme. | | | | |
| 2. Je me sens en sécurité, sans inquiétude, en sûreté. | | | | |
| 3. Je suis tendu(e), crispé(e). | | | | |
| 4. Je me sens surmené(e) | | | | |
| 5. Je me sens tranquille, bien dans ma peau. | | | | |
| 6. Je me sens ému(e), bouleversé(e), contrarié(e). | | | | |
| 7. L'idée de malheurs éventuels me tracasse en ce moment. | | | | |
| 8. Je me sens content(e). | | | | |
| 9. Je me sens effrayé(e). | | | | |
| 10. Je me sens à mon aise. | | | | |
| 11. Je sens que j'ai confiance en moi. | | | | |
| 12. Je me sens nerveux (nerveuse), irritable. | | | | |
| 13. J'ai la frousse, la trouille (j'ai peur). | | | | |
| 14. Je me sens indécis(e). | | | | |
| 15. Je suis décontracté(e), détendu(e). | | | | |
| 16. Je suis satisfait(e). | | | | |
| 17. Je suis inquiet(e), soucieux (soucieuse). | | | | |
| 18. Je ne sais plus où j'en suis, je me sens déconcerté(e), dérouté(e). | | | | |
| 19. Je me sens solide, posé(e), pondéré(e), réfléchi(e). | | | | |
| 20. Je me sens de bonne humeur, aimable. | | | | |

# Appendix 2. Individual and collective mental load assessment questionnaire

**Enquête sur la charge mentale individuelle et collective**

Dans le cadre de mes recherches sur les situations de crise, je cherche à obtenir des valeurs témoins quant aux caractéristiques suivantes : *la charge mentale*. Le but étant de les comparer avec les valeurs obtenues dans le cadre des simulations iCrisis, que vous expérimenterez dans le cadre de l'atelier cindynique.

Je reste à votre disposition pour d'éventuelles questions : clement.judek@univ-lorraine.fr

**Date :**
**Age :**
**Homme** ☐ **Femme** ☐
**Rôle :**
**Cellule :**

**MESURE SUBJECTIVE DE LA CHARGE MENTALE INDIVIDUELLE : ECHELLE NASA-TLX (HART & STAVELAND, 1988)**

Les questions suivantes font référence à votre expérience pendant la tâche. Sur l'axe situé au-dessous des questions, qui va de 0 à 100, où 0 correspond à très faible et 100 à très forte, placer un curseur (un trait) pour répondre aux différentes questions.

1. EXIGENCE MENTALE : Quelle quantité d'activité mentale et perceptive a été nécessaire pour réaliser la tâche (ex : penser, décider, calculer, se rappeler, être concentré, chercher, etc.) ?

0_____100

2. EXIGENCE PHYSIQUE : Quelle quantité d'activités physiques a été nécessaire pour réaliser la tâche (ex : pousser, tirer, tourner, contrôler, activer, etc.) ?

0_____100

3. EXIGENCE TEMPORELLE : Quelle pression temporelle avez-vous ressenti durant l'exécution de la tâche? Fallait-il gérer la réalisation de la tâche de manière lente (0 = pression temporelle faible) ou de manière rapide (100 = pression temporelle forte) ?

0_____100

4. EFFORT : Quel effort (mental ou physique) avez-vous dû fournir pour atteindre votre niveau de performance ?

0_____100

5. PERFORMANCE : Comment estimez-vous votre performance en ce qui concerne a réalisation de la tâche ? (Quel est votre niveau de satisfaction concernant votre performance ?)
(Pour ce critère, l'échelle est inversée : élevé = 0 faible = 100)

0_____100

1

6. FRUSTRATION : Vous êtes-vous senti satisfait, content, relaxé (0 = niveau de frustration faible) ou plutôt ennuyé, irrité, stressé (100 = niveau de frustration élevé) pendant la réalisation de la tâche?

0_____100

**MESURE SUBJECTIVE DE LA CHARGE MENTALE COLLECTIVE : ECHELLE TWLQ (SELLERS & AL., 2014)**

Les questions suivantes font référence à la performance de votre groupe pendant la tâche. vous devez y répondre en considérant le groupe comme un tout. Sur l'axe situé au-dessous des questions, qui va de 0 à 100, où 0 correspond à très faible et 100 à très forte, placer un curseur (un trait) pour répondre aux différentes questions.

7. COMMUNICATION : Quelle quantité d'activités de communication a été nécessaire pour votre groupe (ex : discuter, négocier, envoyer, recevoir des messages, etc.) ?

0_____100

8. COORDINATION : Quelle quantité d'activités de coordination a été nécessaire pour votre groupe (ex : changer, ajuster, planifier, etc.) ?

0_____100

9. GESTION ET ORGANISATION TEMPORELLE : A quel niveau de difficulté avez-vous été confronté dans la gestion et l'organisation entre la part dédiée à vos tâches personnelles et celles du groupe ?

0_____100

10. EXIGENCE EMOTIONNELLE : Dans quelle mesure le travail en équipe a été exigeant sur le plan émotionnel ?

0_____100

11. SUIVI DE PERFORMANCE : Dans quelle mesure la tâche a t-elle nécessitée que vous « suiviez » la performance de votre groupe ?

0_____100

12. SOUTIEN : A quel point a-t-il été difficile d'apporter une aide/un soutien aux membres de votre groupe ou d'en recevoir (ex : aide, instruction, appui, etc.) ?

0_____100

## Appendix 3. Cascading effects consideration during a crisis situation questionnaire

Pilotage d'une situation virtuelle de crise

*Vous avez participé à une simulation de crise. Au cours de cette simulation, des groupes de décisions auxquels vous avez appartenu ont été placés dans une situation virtuelle où vous eu à faire face à la complexité et aux incertitudes, caractéristiques inhérentes à la situation de crise. Ces simulations permettent généralement aux participants de ressentir la difficulté à piloter de telles situations de crise et d'apprendre quant à leurs réactions dans de tels contextes. Pour contribuer à une meilleure compréhension de la façon dont les participants vivent et perçoivent ces situations, nous menons actuellement une étude sur les réactions en chaîne et la prise de décision en situation de simulation de crise. C'est pourquoi nous vous sollicitons afin de vous demander de remplir ces questionnaires. Il n'y a pas de bonnes ou de mauvaises réponses. C'est votre sincérité qui compte avant tout.*

Veuillez compléter ces informations et ensuite lire les instructions ci-dessous. TOUTES LES INFORMATIONS RESTERONT STRICTEMENT CONFIDENTIELLES.

**QUESTIONNAIRE DE PRESENTATION DU PARTICIPANT**

Initiales du sujet : |__|__|__| |__|__|__|
*(les trois premières lettres du nom et les trois premières lettres du prénom)*

Sexe |__| masculin |__| féminin

Age |__|__| ans

Date de passation : |__|__| |__|__| |__|__||__|__|

*Lors de la simulation*

A quelle cellule appartenez-vous ?

|__| Préfecture de l'Isère
|__| Mairie de Jarrie
|__| Arkéma

Au sein de la cellule, quelle était votre fonction :

.....

.....

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Pour les trois questions qui suivent placer un trait sur l'axe qui va de 0 à 100, ou 0 correspond à très faible influence et 100 à très forte influence

1. Les décisions prises par la cellule ont influencé le cours des évènements

0 100

2. Les décisions prises par la cellule ont influencé **favorablement** le cours des évènements

0 100

3. Les décisions prises par la cellule ont influencé **défavorablement** le cours des évènements

0 100

4. De manière générale, au cours de la simulation, diriez-vous que l'IET a été utilisé :
   |__| Jamais |__| Rarement |__| Souvent |__| Tout le temps

5. L'IET a t'il été utilisé pour :
   - Visualiser les systèmes impliqués dans la situation ?
     |__| Jamais |__| Rarement |__| Souvent |__| Tout le temps

     Pour cette tâche l'IET vous a t'il aidé ?
     |__| Non |__| Un peu |__| Moyennement |__| Grandement

   - Identifier des dépendances entre des systèmes ?
     |__| Jamais |__| Rarement |__| Souvent |__| Tout le temps

     Pour cette tâche l'IET vous a t'il aidé ?
     |__| Non |__| Un peu |__| Moyennement |__| Grandement

   - Identifier le premier niveau d'effets potentiels ?
     |__| Jamais |__| Rarement |__| Souvent |__| Tout le temps

     Pour cette tâche l'IET vous a t'il aidé ?
     |__| Non |__| Un peu |__| Moyennement |__| Grandement

   - Identifier le second niveau d'effets potentiels ?
     |__| Jamais |__| Rarement |__| Souvent |__| Tout le temps

     Pour cette tâche l'IET vous a t'il aidé ?
     |__| Non |__| Un peu |__| Moyennement |__| Grandement

   - Identifier le $n^{ième}$ niveau d'effets potentiels ?
     |__| Jamais |__| Rarement |__| Souvent |__| Tout le temps

     Pour cette tâche l'IET vous a t'il aidé ?
     |__| Non |__| Un peu |__| Moyennement |__| Grandement

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6. Diriez-vous que l'IET a été utilisé pour :
   - Initier une décision
     |__| Jamais |__| Rarement |__| Souvent |__| Tout le temps
   - Confirmer une décision
     |__| Jamais |__| Rarement |__| Souvent |__| Tout le temps
   - Contester une décision
     |__| Jamais |__| Rarement |__| Souvent |__| Tout le temps
   - Corriger une décision prise préalablement
     |__| Jamais |__| Rarement |__| Souvent |__| Tout le temps

MERCI POUR VOTRE PARTICIPATION

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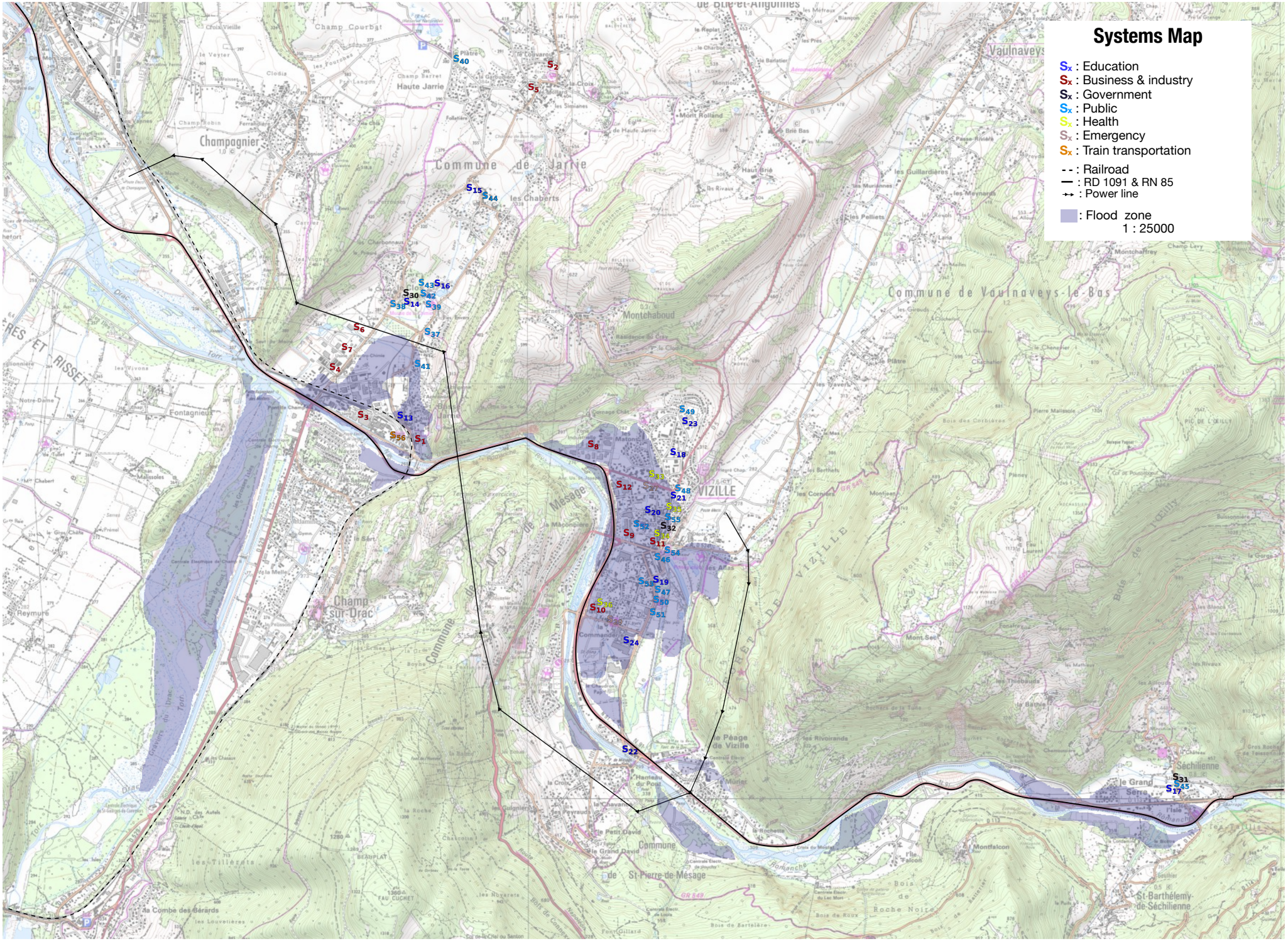
## Appendix 4. Cascading effects knowledge package

Table representing all systems, their vulnerability, their potential effects and the systems they can affect. Map localizing systems.

| ID | category system | System | Localization | Sensitive to | Potential created effects | Potential impacted systems |
|---|---|---|---|---|---|---|
| S1 | Business and Industry | Zone commerciale Basse Jarrie | Jarrie | GM,RA,TE,PRW,PRI,WA,FI, TO,SO,WFS,ES,TS | FI | Neighboring buldings S56 S13 S57 |
| | | | | | EP | Population |
| | | | | | FS | Population |
| | | | | | PRI | Neighboring buldings S56 S13 |
| | | | | | MI | Neighboring buldings S56 S13 S57 |
| S2 | Business and Industry | Zone commerciale Haute Jarrie | Jarrie | GM,RA,TE,PRW,PRI,WA,FI, TO,SO,WFS,ES,TS | FI | Neighboring buldings S5 S59 S60 |
| | | | | | EP | Population |
| | | | | | FS | Population |
| | | | | | PRI | Neighboring buldings S5 S59 S60 |
| | | | | | MI | Neighboring buldings S5 S59 S60 |
| S3 | Business and Industry | Arkéma | Jarrie | GM,RA,TE,PRW,PRI,WA,FI, TO,MI,WFS | TE | Neighboring buldings S1 S4 S7 S13 S56 S57 S59 S58 S60 |
| | | | | | PRI | Neighboring buldings S1 S4 S7 S13 S56 S58 S60 |
| | | | | | FI | Neighboring buldings S1 S4 S6 S7 S13 S41 S56 S57 S58 S59 S60 S63 |
| | | | | | TO | Population S1 S4 S6 S7 S13 S14 S15 S16 S30 S37 S38 S39 S41 S42 S43 S44 S56 S58 S60 |
| | | | | | MI | Neighboring buldings S1 S4 S6 S7 S13 S41 S56 S57 S58 S59 S60 S63 |
| S4 | Business and Industry | Areva-Cezus | Jarrie | GM,RA,TE,PRW,PRI,WA,FI, TO,MI,WFS | RA | Neighboring buldings S3 S6 S7 S58 S60 |
| | | | | | TE | Neighboring buldings S3 S7 S59 S60 |
| | | | | | PRI | Neighboring buldings S3 S7 S58 S60 |
| | | | | | FI | Neighboring buldings S3 S7 S57 S58 S59 S60 |
| | | | | | TO | Population S3 S6 S7 S57 S58 S59 S60 S63 |
| | | | | | MI | Neighboring buldings S3 S6 S7 S57 S58 S59 S60 S63 |
| S5 | Business and Industry | RSAle Rubis | Jarrie | GM,RA,TE,PRW,PRI,WA,FI, TO,MI,WFS | TE | Neighboring buldings S2 S59 S60 |
| | | | | | PRI | Neighboring buldings S2 S59 S60 |
| | | | | | FI | Neighboring buldings S2 S59 S60 |
| | | | | | TO | Population S2 S59 S60 |
| | | | | | MI | Neighboring buldings S2 S59 S60 |
| S6 | Business and Industry | Cofely-Axima | Jarrie | GM,RA,TE,PRW,PRI,WA,FI, TO,MI,WFS | TE | Neighboring buldings S7 S59 S60 |
| | | | | | PRI | Neighboring buldings S7 S59 S60 |
| | | | | | FI | Neighboring buldings S3 S7 S59 S60 |
| | | | | | TO | Population S7 S59 S60 |
| | | | | | MI | Neighboring buldings S3 S4 S7 S38 S59 S60 |
| S7 | Business and Industry | Air liquide | Jarrie | GM,RA,TE,PRW,PRI,WA,FI, TO,MI,WFS | TE | Neighboring buldings S4 S6 S3 S59 S60 |
| | | | | | PRI | Neighboring buldings S4 S6 S3 S60 |
| | | | | | FI | Neighboring buldings S4 S6 S3 S60 |
| | | | | | TO | Population S4 S6 S3 S60 |
| | | | | | MI | Neighboring buldings S4 S6 S3 S59 S60 |
| S8 | Business and Industry | Zone commerciale Intermarché | Vizille | GM,RA,TE,PRW,PRI,WA,FI, TO,MI,SO,WFS,ES,TS | FI | Neighboring buldings S60 S62 S63 |
| | | | | | EP | Population |
| | | | | | FS | Population |
| | | | | | PRI | Neighboring buldings S60 |
| | | | | | MI | Neighboring buldings S60 S62 S63 |
| S9 | Business and Industry | Zone commerciale Lidl | Vizille | GM,RA,TE,PRW,PRI,WA,FI, TO,MI,SO,WFS,ES,TS | FI | Neighboring buldings S52 S60 S62 S63 |
| | | | | | EP | Population |
| | | | | | FS | Population |
| | | | | | PRI | Neighboring buldings S52 S60 |
| | | | | | MI | Neighboring buldings S52 S60 S62 S63 |
| S10 | Business and Industry | Zone commerciale Carrefour | Vizille | GM,RA,TE,PRW,PRI,WA,FI, TO,MI,SO,WFS,ES,TS | FI | Neighboring buldings S36 S60 S62 S63 |
| | | | | | EP | Population |
| | | | | | FS | Population |
| | | | | | PRI | Neighboring buldings S36 S60 |
| | | | | | MI | Neighboring buldings S36 S60 S62 S63 |
| S11 | Business and Industry | Zone commerciale Centre ville | Vizille | GM,RA,TE,PRW,PRI,WA,FI, TO,MI,SO,WFS,ES,TS | FI | Neighboring buldings S32 S34 S46 S54 S55 S60 S62 |
| | | | | | EP | Population |
| | | | | | FS | Population |
| | | | | | PRI | Neighboring buldings S32 S34 S46 S54 S55 S60 |
| | | | | | MI | Neighboring buldings S32 S34 S46 S54 S55 S60 S62 |
| S12 | Business and Industry | Zone commerciale Neto | Vizille | GM,RA,TE,PRW,PRI,WA,FI, TO,MI,SO,WFS,ES,TS | FI | Neighboring buldings S60 S62 S63 |
| | | | | | EP | Population |
| | | | | | FS | Population |
| | | | | | PRI | Neighboring buldings S60 |
| | | | | | MI | Neighboring buldings S60 S62 S63 |
| S13 | Education | Ecole Victor Pignat (maternelle, primaire) | Jarrie | GM,RA,TE,PRW,PRI,WA,FI, TO,MI,WFS,ES,TS,WS,FS | PRI | Neighboring buldings S60 |
| | | | | | FI | Neighboring buldings S57 S59 S60 |
| | | | | | MI | Neighboring buldings S57 S59 S60 |
| S14 | Education | Ecole le Louvarou (maternelle, primaire) | Jarrie | GM,RA,TE,PRW,PRI,WA,FI, TO,MI,WFS,ES,TS,WS,FS | PRI | Neighboring buldings S30 S38 S60 |
| | | | | | FI | Neighboring buldings S30 S38 S57 S59 S60 |
| | | | | | MI | Neighboring buldings S30 S38 S57 S59 S60 |
| S15 | Education | Ecole les Chaberts (primaire) | Jarrie | GM,RA,TE,PRW,PRI,WA,FI, TO,MI,WFS,ES,TS,WS,FS | PRI | Neighboring buldings S44 S60 |
| | | | | | FI | Neighboring buldings S44 S57 S60 |
| | | | | | MI | Neighboring buldings S44 S57 S60 |
| S16 | Education | Collège Clos Jouvin | Jarrie | GM,RA,TE,PRW,PRI,WA,FI, TO,MI,WFS,ES,TS,WS,FS | PRI | Neighboring buldings S43 S60 |
| | | | | | FI | Neighboring buldings S43 S57 S60 |
| | | | | | MI | Neighboring buldings S43 S57 S60 |
| S17 | Education | Ecole municipale (maternelle, primaire) | Séchilienne | GM,RA,TE,PRW,PRI,WA,FI, TO,MI,WFS,ES,TS,WS,FS | PRI | Neighboring buldings S45 S60 |
| | | | | | FI | Neighboring buldings S45 S60 S61 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | MI | Neighboring buldings | S15 | S60 | S59 | | | |
| S45 | Public | Bibliothèque | Séchilienne | GM, RA, TE, PRW, PRI, WA, FI, TO, MI, WFS, ES, HU | PRI | Neighboring buldings | S17 | S31 | S60 | | | |
| | | | | | FI | Neighboring buldings | S17 | S31 | S60 | S61 | | |
| | | | | | MI | Neighboring buldings | S17 | S31 | S60 | S60 | | |
| S46 | Public | Centre Communal d'Action Sociale | Vizille | GM, RA, TE, PRW, PRI, WA, FI, TO, MI, WFS, ES | PRI | Neighboring buldings | S54 | S60 | | | | |
| | | | | | FI | Neighboring buldings | S54 | S60 | S62 | | | |
| | | | | | MI | Neighboring buldings | S54 | S60 | S62 | | | |
| | | | | | SO | Population | | | | | | |
| S47 | Public | Gymnase du Parc | Vizille | GM, RA, TE, PRW, PRI, WA, FI, TO, MI, WFS, ES | PRI | Neighboring buldings | S19 | S50 | S60 | | | |
| | | | | | FI | Neighboring buldings | S19 | S50 | S60 | S62 | | |
| | | | | | MI | Neighboring buldings | S19 | S50 | S60 | S62 | | |
| S48 | Public | Gymnase de l'école Jean Jaurès | Vizille | GM, RA, TE, PRW, PRI, WA, FI, TO, MI, WFS, ES | PRI | Neighboring buldings | S21 | S60 | | | | |
| | | | | | FI | Neighboring buldings | S21 | S60 | S62 | | | |
| | | | | | MI | Neighboring buldings | S21 | S60 | S62 | | | |
| S49 | Public | Gymnase Guy Mocquet | Vizille | GM, RA, TE, PRW, PRI, WA, FI, TO, MI, WFS, ES | PRI | Neighboring buldings | S23 | S60 | | | | |
| | | | | | FI | Neighboring buldings | S23 | S60 | S62 | | | |
| | | | | | MI | Neighboring buldings | S23 | S60 | S62 | | | |
| S50 | Public | Tennis du Parc | Vizille | RA, TE, PRI, WA, FI, TO, MI | | | | | | | | |
| S51 | Public | Stade Municipale du Parc du Château | Vizille | RA, TE, PRI, WA, FI, TO, MI | | | | | | | | |
| S52 | Public | Piscine municipale | Vizille | GM, RA, TE, PRW, PRI, WA, FI, TO, MI, WFS, ES, WS | PRI | Neighboring buldings | S60 | | | | | |
| | | | | | FI | Neighboring buldings | S60 | S62 | | | | |
| | | | | | MI | Neighboring buldings | S60 | S62 | | | | |
| S53 | Public | Cinema | Vizille | GM, RA, TE, PRW, PRI, WA, FI, TO, MI, WFS, ES | PRI | Neighboring buldings | S19 | S60 | | | | |
| | | | | | FI | Neighboring buldings | S19 | S60 | S62 | | | |
| | | | | | MI | Neighboring buldings | S19 | S60 | S62 | | | |
| S54 | Public | Château | Vizille | GM, RA, TE, PRW, PRI, WA, FI, TO, MI, WFS, ES, HU | PRI | Neighboring buldings | S11 | S46 | S60 | | | |
| | | | | | FI | Neighboring buldings | S11 | S46 | S60 | S62 | | |
| | | | | | MI | Neighboring buldings | S11 | S46 | S60 | S62 | | |
| S55 | Public | Médiathèque | Vizille | GM, RA, TE, PRW, PRI, WA, FI, TO, MI, WFS, ES, HU | PRI | Neighboring buldings | S11 | S35 | S60 | | | |
| | | | | | FI | Neighboring buldings | S11 | S35 | S60 | S62 | | |
| | | | | | MI | Neighboring buldings | S11 | S35 | S60 | S62 | | |
| S56 | Rail Transportation | Gare Jarrie-Vizille | Jarrie | WA, GM, PRI, PRW, TO, TE, TS | PRI | Neighboring buldings | S3 | S1 | S60 | S57 | | |
| | | | | | FI | Neighboring buldings | S3 | S1 | S60 | S59 | S58 | S57 |
| | | | | | MI | Neighboring buldings | S3 | S1 | S60 | S59 | S58 | S57 |
| | | | | | WFS | Local Business, industries and services | | | | | | |
| | | | | | TS | Local Business, industries and services | S58 | S57 | | | | |
| S57 | Rail Transportation | Voie ferrée | Zone entière | WA, GM, TE, TS, MI, FI | TS | Local Business, industries and services | S58 | S56 | | | | |
| | | | | | WFS | Local Business, industries and services | | | | | | |
| | | | | | FS | Local supermarkets | | | | | | |
| S58 | Rail Transportation | Trains | Zone entière | GM, RA, PRW, PRI, WA, FI, TO, MI, ES, TS | TS | | S57 | S58 | | | | |
| | | | | | WFS | Local Business, industries and services | | | | | | |
| S59 | Road Transportation | Reseau routier urbain (Jarrie) | Jarrie | WA, GM, TE, TS, MI, FI | TS | | S60 | S63 | | | | |
| | | | | | WFS | Local Business, industries and services | | | | | | |
| | | | | | FS | Local supermarkets | | | | | | |
| S60 | Road Transportation | Réseau TAG + Trans'Isère (bus de transport en commun, transport | Zone entière | GM, RA, PRW, PRI, WA, FI, TO, MI, ES, TS | TS | Population | S59 | S61 | S62 | S63 | | |
| | | | | | WFS | Local Business, industries and services | | | | | | |
| S61 | Road Transportation | Reseau routier urbain (Séchilienne) | Séchilienne | WA, GM, TE, TS, MI, FI | TS | | S60 | S63 | | | | |
| | | | | | WFS | Local Business, industries and services | | | | | | |
| | | | | | FS | Local supermarkets | | | | | | |
| S62 | Road Transportation | Reseau routier urbain (Vizille) | Vizille | WA, GM, TE, TS, MI, FI | TS | | S60 | S63 | | | | |
| | | | | | WFS | Local Business, industries and services | | | | | | |
| | | | | | FS | Local supermarkets | | | | | | |
| S63 | Road Transportation | RD 1091 et RN85 | Zone entière | WA, GM, TE, TS, MI, FI | TS | | S59 | S61 | S62 | S60 | | |
| | | | | | WFS | Local Business, industries and services | | | | | | |
| | | | | | FS | Local supermarkets | | | | | | |


Systems Map
Sx : Education
Sx : Business & industry
Sx : Government
Sx : Public
Sx : Health
Sx : Emergency
Sx : Train transportation
: Railroad
: RD 1091 & RN 85
: Power line
: Flood zone
1 : 25000
Champagnier
Commune de Jarrie
Montchaboud
Commune de Vaulnaveys-le-Bas
VIZILLE
Champ sur-Drac
Commune de St-Pierre-de-Mésage
St-Barthélemy-de-Séchilienne
Séchilienne
Fontagnieux
Haute Jarrie
Champ Courbat
les Chaberts
Mont Rolland
Mont Seel
le Péage de Vizille
Montchaffrey
Vaulnaveys
Champ Robin
Champ Barret
Champ Langon
Champ Vieille
le Veyter
Clodis
Croix Vieille
Plâtre
le Replat
le Charlier
le Barlatier
Haut Brié
Brié Bas
les Guillardières
les Muriannes
les Meynards
les Pelliets
Laria
les Girouds
Chachatier
Pierre Malissole
Pleney
les Cornières
les Barthets
les Thiebauds
le Bathie
les Rivoirands
Mont Seel
Séchilienne
le Grand Serre
l'Isle Blanche
Montfalcon
Roche Noire
Bois de Roux
Bois de Barlatière
Bois de Vizille
Bois de Pleney
Bois de Suisonnière
Bois de Montjean
Bois de Montchaffrey
Bois des Corbières
Bois de Connex
Bois de Chaillol
Bois de Chaillol Vieux
Bois de Chaillol Neuf
Bois de Chaillol Haut
Bois de Chaillol Bas
Bois de Chaillol Moyen
Bois de Chaillol Nouveau
Bois de Chaillol Ancien
Bois de Chaillol Petit
Bois de Chaillol Grand

## The contribution of virtual crisis simulations to the study of crisis management situations: the case of iCrisis crisis simulation approach

The emergence of major crises illustrates, on the one hand, the high intensity of these events, but also the increasing complexity and interdependence of systems, which are resulting in a larger number of affected organizations. Nowadays, many events are considered as crises, whereas they can only be emergencies. This use of the term «crisis» can be counterproductive because, due to its unique nature, the crisis requires special capabilities such as adaptation, unlike events in the field of emergency management that require the application of a procedure. To reduce the risk of major crises, prevention and protection are necessary. However, not all situations are predictable and for this reason, the organizations exposed must be prepared. To prepare and improve the experience of crisis managers, simulation appears to be a solution. Stress simulations raise awareness of crisis situations and allow organizations to gain experience by placing them in a virtual environment that tries to reproduce real conditions as much as possible. The objective of reproducing the situation as accurately as possible is necessary, but there is no verification/validation method to ensure that the simulation method is really effective. In addition, the majority of existing crisis simulators aim to achieve an educational objective for people involved in emergency or crisis situations. However, due to the complex nature of crisis situations, it is in the interest of conducting stress tests to investigate the crisis itself. In this context, we propose to question the ability of the iCrisis crisis simulation approach to place strategic managers in a situation with similar characteristics to those of a «real crisis». This interesting approach within the framework of the given pedagogical objectives also makes it possible to open up to objectives less known for crisis simulators: to achieve scientific objectives. Indeed, does such a system also make it possible to study certain aspects of the crisis? Through this manuscript, we will try to contribute to the reflection on these two aspects. To provide some answers to these questions, this manuscript proposes 5 chapters: - Chapter 1 aims to understand the positioning of the concept of crisis in relation to the concept of urgency. - Chapter 2 is devoted to the definition of the crisis that is used in research. - Chapter 3 discusses the research methodology with an emphasis on iCrisis simulation. - Chapter 4 presents the study that examined whether participants in iCrisis simulations experienced the characteristics of a real crisis. - Chapter 5 presents two studies that have been conducted. One concerns the assessment of mental workload and. The second is to test the use of a tool that evaluates cascading effects. The research made it possible to clarify the difference between emergency and crisis, and then to propose a definition of the crisis based on its characteristics. It also made it possible to implement the iCrisis crisis simulation approach, which is precisely described. The second important result is the presentation of the study the study which aimed to observe that the characteristics of the crisis are well observable during an iCrisis simulation. Finally, we demonstrate that studies on issues applied to the crisis can be conducted with iCrisis and yield results.

*Keywords: crisis situation, crisis simulation, scenario building, crisis perception, iCrisis, mental workload, cascading effects*

## La contribution des simulations virtuelles de crise à l'étude des situations de gestion de crise : cas de l'approche de simulation de crise iCrisis

L'apparition de crises majeures illustre d'une part la forte intensité de ces événements, mais aussi la complexité et l'interdépendance croissantes des systèmes, qui se traduisent par un plus grand nombre d'organisations touchées. De nos jours, de nombreux événements sont considérés comme des crises, alors qu'il ne peut s'agir que d'une urgence. Cette utilisation du terme «crise» peut être contre-productive car, en raison de sa nature unique, la crise nécessite des capacités spéciales telles que l'adaptation, contrairement aux événements dans le domaine de la gestion des urgences qui nécessitent l'application d'une procédure. Pour réduire le risque de crises majeures, la prévention et la protection sont nécessaires. Cependant, toutes les situations ne sont pas prévisibles et pour cette raison, les organisations exposées doivent être préparées. Pour préparer et améliorer l'expérience des gestionnaires de crise, la simulation apparaît comme une solution. Les simulations de crise permettent de sensibiliser les organisations aux situations de crise et de leur permettre d'acquérir de l'expérience en les plaçant dans un environnement virtuel qui essaie de reproduire au maximum les conditions réelles. L'objectif de reproduire la situation aussi fidèlement que possible est nécessaire, mais il n'existe aucune méthode de vérification/validation pour s'assurer que la méthode de simulation est vraiment efficace. De plus, la majorité des simulateurs de crise existants visent à atteindre un objectif pédagogique adressé aux personnes impliquées dans des situations d'urgence ou de crise. Toutefois, en raison de la nature complexe des situations de crise, il est dans l'intérêt de procéder à des simulations de crise pour enquêter sur la crise elle-même. Dans ce contexte, nous nous proposons de nous interroger sur la capacité de l'approche de simulation de crise iCrisis à placer les managers stratégiques dans une situation aux caractéristiques similaires à celles d'une «crise réelle». Cette approche intéressante dans le cadre des objectifs pédagogiques donnés permet également de s'ouvrir à des objectifs moins connus pour les simulateurs de crise : atteindre des objectifs scientifiques. En effet, un tel système permet-il aussi d'étudier certains aspects de la crise ? A travers ce manuscrit, nous tenterons de contribuer à la réflexion sur ces deux aspects. Pour donner des éléments de réponse à ces questions, ce manuscrit propose 5 chapitres : - Le chapitre 1 vise à comprendre le positionnement du concept de crise par rapport au concept d'urgence. - Le chapitre 2 est consacré à la définition de la crise qui est utilisée dans la recherche. - Le chapitre 3 traite de la méthodologie de recherche en mettant l'accent sur la simulation iCrisis. - Le chapitre 4 présente l'étude qui a consisté à observer si les participants aux simulations iCrisis ont vécu les caractéristiques d'une crise réelle. - Le chapitre 5 présente deux études qui ont été réalisées. L'une concerne l'évaluation de la charge mentale et. Le second concerne le test d'utilisation d'un outil qui évalue les effets en cascade. La recherche a permis de clarifier la différence entre urgence et crise, puis de proposer une définition de la crise à partir de ses caractéristiques. Elle a également permis de concrétiser l'approche de simulation de crise iCrisis qui est décrite avec précision. Le deuxième résultat important est la présentation de l'étude l'étude qui avait pour but d'observer que les caractéristiques de la crise sont bien observables lors d'une simulation iCrisis. Enfin, nous démontrons que les études sur les questions appliquées à la crise peuvent être réalisées avec iCrisis et donner des résultats.

*Mots-clés : situation de crise, simulation de crise, construction de scénarios, perception de la crise, iCrisis, charge de travail mentale, effets cascade*