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Contribution To A Design Methodology For Crisis And Emergency Training On Hazardous Industrial Sites

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CONTRIBUTION TO A DESIGN METHODOLOGY FOR CRISIS AND EMERGENCY TRAINING ON HAZARDOUS INDUSTRIAL SITES

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Summary

As shown by annual industrial major accidents statistics in Europe, despite progress of risk prevention in hazardous companies, disaster still appears and these organizations cannot overlook the need to organize to manage such situation. Yet, crisis and emergency management in hazardous industries rely on a particular organization which modifies the companies' normal operating mode. This kind of organization requires, both from operatives and decision-makers, specific knowledge that cannot be acquired through theoretical course or real-life practice only. Simulation exercises can be a training solution to allow the practice of crisis management. However, developing and implementing adapted exercises for agents and their needs is time and resource-consuming, especially when the system where they operate is complex. Therefore, in order to make these trainings more affordable for companies, their development and exploitation must be simplified.

Between the ends of 2015 and 2018, the Expert'Crise project, funded by the European Social Fund, provided emergency and crisis trainings to 19 hazardous companies or critical infrastructure, including 14 immersive simulation exercises on industrial sites. Based on this recurrent exercise development process, a scriptwriting methodology was developed, integrating Expert'Crise project's experience as well as existing methodologies and literature.

During such kind of simulation, trainees play their own role in their usual working place. Hence, only some emergency functions are simulated and, for instance, physical intervention with firefighter's tool are rarely set up.

Then, because some parts of the emergency organization are not tested, arrangements must be made to isolate trainees from real environment and establish the framework in which participants can interact with each other and with the facilitation interface. Because such organization strongly relates to Live-Action Role Playing Games, with a special focus on interaction between participants, improvements coming from the LARP literature were integrated in the methodology and contribute in making it more interactive, making such trainings close to serious games.

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List of Acronyms

BCP	: Business Continuity Plan
CC	: Coordination Committee in Belgium emergency planning
CBE	: Belgian Federal Occupational Health Department (<i>Direction générale Contrôle du Bien-Etre au travail</i>)
CLP	: Classification Labeling and Packaging Regulation of hazardous chemicals in the European Union
CRM	: Crew Resource Management, a kind of emergency training
CTT	: Critical Thinking Training, a kind of emergency training
D1/D2/.../D5	: Discipline 1/Discipline 2/.../Discipline 5, Generic name for emergency services
DCRC	: Belgian Federal Occupational Health Department for SEVESO companies (<i>Division du contrôle des risques chimiques</i>)
DIKW	: Data, Information, Knowledge and Wisdom, a model for the learning process
DIR-INFO	: Director of Information services (=D5)
DIR-MED	: Director of Medical services (=D2)
DIR-LOG	: Director of the Logistics services (=D4)
DIR-PC-Ops	: Director of the PC-Ops
DIR-POL	: Director of the Police services (=D2)
DIR-Si	: Director of the Firemen services (=D1; <i>Services Incendie</i>)
DPC/DPE	: Regional Environment Police Services (<i>Département de la Police et des Contrôles/Direction de la Police de l'Environnement</i>)
EBAT	: Event-Based Approach Training, a kind of emergency training
ESAR	: Exercice/Symbolique/Assemblage/Règles, a classification system for games
ESF	: European Social Fund
GCCC/CGCCR	: Belgian Federal Government Crisis Coordination Center (<i>Centre Gouvernementale de Coordination et de Crise</i>)
GPS	: Gameplay/Purpose/Scope, a classification system for games
HR	: Human resources function in organization
IPFH	: Institut Provincial de Formation du Hainaut
KMSKM	: Kan-man-så-kan-man (=If you can, you can). A LARP's philosophy.

KSA	: Knowledge-Skill-Attitude, a model for describing competence
LARP	: Live-Action Role Playing (Games)
(L)RPG	: (Learning) Role Playing Games
MSEL	: Main Scenario Event List, a method for representing crisis or emergency scenario
NaTech	: Natural-Technological. Technological Accident induced by natural disaster
NDA	: Non-Disclosure Agreement
NPC	: Non-Player Character
NPUI 1 to 5	: Name of the Ministerial Circular related to how each discipline must organize in Belgium
PC-Ops	: Operational Command Post
PGUI	: Local General Emergency and Contingency Plan (<i>Plan Général d'Urgence et d'Intervention</i>)
PMA	: Medical Outpost (<i>Poste Medical Avancé</i>)
PPUI	: Particular Emergency and Contingency Plan (<i>Plan Particulier d'Urgence et d'Intervention</i>)
PIU	: For companies and, organization, Internal Emergency Plan (<i>Plan interne d'urgence</i>)
RAM	: Regional department of industrial risk management (<i>cellule Risque Accident Majeur</i>)
SHE/(Q)HSE/EHS	: (Quality), Safety, Health and Environment manager
SMART	: Specific, Measurable, Achievable, Relevant and Time bounded. Method for properly setting a target or objective.
SMEM	: Social Media in Emergency Management

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General introduction

As Western populations get more and more aware of the risks they daily face, societies become increasingly risk-averse. Thus, in order to meet populations' expectation, political and administrative authorities at national and supranational levels try to improve both risk management policy and transparency on this topic.

However, all risks are not rejected with the same intensity by populations and chosen risks are more accepted than imposed ones (Bennett, 1999). Industrials negative externalities are especially not accepted and this is the reason why they are subjected to dedicated regulations aiming to reduce risk for surrounding populations. Hazardous chemical industries – because they can cause major accidents impacting numerous people – are notably aimed by regulation and have several safety requirements, adapted to the important risk level they generate. Nevertheless, even with restrictive regulations and administrative controls, major accidents may still occur and both political authorities and companies must be able to deal with such events on plants identified as being particularly dangerous and causing anxious responses from the population. Therefore, hazardous companies' managers as well as authorities' officials must be prepared to cope with a crisis and required to be trained for this kind of situation.

Crisis and emergency management trainings aim to meet this need. However, because it is a relatively new pedagogical field, several improvements can be brought to this domain which is the purpose of this work, with a special focus on Seveso companies' management. Indeed, subsequent to a 3-year project providing trainings to hazardous chemical companies and designing crisis and emergency on-site exercises, it appeared that existing design methodologies for such trainings are very heavy and time as well as resource-consuming. Then, through feedbacks from this project and literature review from several fields, this document aimed to contribute in making such training more reachable for companies.

However, before describing proposed enhancements, it matters to define what is a crisis and discuss this particular topic. Indeed, because the word “crisis” became polysemic with the increase of crises all along human and society life, it became difficult to understand its actual meaning and how it is used in the context of major accidents. Moreover, beyond semantics topics, how emergencies are managed, especially by authorities and emergency services, is a critical input data for trainings discussed in this document.

Therefore, the **first part** of the document – and, more precisely, its first chapter – deals with these topics and introduces several elements related to crisis. Then, the Expert'crise project, supporting this work, is described in the second chapter.

Indeed, because crisis and emergency management trainings are required by political and administrative authorities as well as by companies' management, projects funded by several organizations and aiming to develop such trainings are led and contribute to develop this pedagogical field while providing needed training. Hence, Expert'crise project funded by the European Social Fund, was held between the end of 2015 and the end of 2018, provided crisis and emergency management trainings to all emergency and crisis stakeholders. This project was split in two cooperating sub-projects based on audience targeted: a first one, held by UMONS, aiming industries and private organizations and a second one, held by the Institut Provincial de Formation du Hainaut, aiming emergency services and authorities. Unfortunately, for several reasons, these two sub-projects moved away and little coactions were possible. This work mainly focusses on trainings provided to the 19 companies in the UMONS' Expert'Crise subproject. Note that, while this project is at the genesis of this work, it was originally a training project aiming no specific research purpose. Then this work uses a posteriori approach, using data, feedbacks and experience gathered during experiments not designed with this intent.

Therefore, it matters to describe how trainings were provided during this project. Indeed, the setting of trainings impacts some conclusions of this work, especially through devices and equipment used during exercises. On the other hand, when this project started, it was based on others previous experiences lead in several countries but it had no proper pedagogical foundations. Yet, these bases – especially pedagogical concepts needed to understand trainings features – require to be clarified and are presented at the end of this first part, in the third chapter, concluding the background of this work. Therefore, this work relies on three pillars introduced in this first part: crisis management, pedagogy and feedbacks from Expert'Crise project.

Then, **the second part** of this work deepens both fields of crisis management and pedagogy by describing, in its first chapter, the state of the art of crisis and emergency management trainings, especially related to simulation and how to design scenario for crisis exercises. Indeed, most of trainings provided in this domain rely on active pedagogy and involve trainees in crisis simulations where they have to take decisions under stress and with little information. Such exercises aim to develop dedicated crisis competences and illustrate situations introduced during anterior lectures. Methods and guides for designing and performing this kind of exercises exist and state the different steps a design process must go through. Briefly, such process must include a conception phase, a performance phase concluded with a hot debriefing, and an analysis phase. This work focus on the conception phase of this framework consisting in designing the scenario for the simulation exercise, while letting aside exercises conduct and their analysis. However, existing methods for designing such simulation exercises are on one hand complex and time-consuming and, on the other hand, are usually designed from a pedagogic-only point of view. Then, they do not consider feedbacks from similar

serious games – known as Learning Role Playing Games – and its related game, (live-action) roleplaying games. These two topics are extended in the second chapter and introduce the research themes developed in the third and last part of this document. Therefore, based on existing crisis simulation design methods, feedbacks from Expert'Crise project as well as game-design and role-playing game literature review, a scriptwriting methodology for emergency and crisis trainings is proposed aiming to improve such design process to make them more affordable for companies and more interactive and playful for trainees.

The **third and last part** of this document does not directly start with a description of proposed improvements but with an Expert'Crise's exercises analysis. Indeed, since an important part of the added value of this work relies on feedbacks from this project, it matters to start with this analysis. Therefore, the first chapter of this third part consists in an analysis of most common companies' needs encountered during the project and, on the other hand, an analysis of companies' emergency plans aiming to raise most common features and arrangements in industrials' emergency organization. These elements support the methodology presented in the two following chapters. This method is split into two main parts, each one in a dedicated chapter. The first one, the Chapter 7, consists in defining a framework for the scenario, including both limits – in time, space or involved functions/workers – that must not be exceeded, and “rules” describing how the environment works, how trainees and facilitators interact during the exercise and what each of them can and cannot do. The second main part consists in scriptwriting a pedagogical and interactive scenario in the previously defined framework. The scriptwriting process proposed in Chapter 8 aims to be the less complex and resources-consuming as possible. This method is illustrated by an example taken from exercises prepared during Expert'Crise project and kept from a step to another in order to picture the progression of the scriptwriting. In the end of this part, because using a methodology can be too complex or time-consuming to be implemented in an industrial plant, a generic exercise framework is presented in Annex 6. Based on most common needs of Walloon Seveso companies and processing the scripting methodology, this framework aims to provide a very simple way to implement a crisis or emergency exercise in a Seveso company and only required little adaptations to be functional. Moreover, it can also be a base that any company can improve in order to adapt it and make it meet more its specific needs.

Besides this first linear way to go through the document, several **other reading paths** are possible according to the reader's profile. First, because it is one main purpose of this work, an industrial manager wanting to implement an exercise in one's organization can directly work based on Annex 6 scenario. Moreover, readers who want to adapt this generic scenario to make it meet more their specific needs, those who have to scriptwrite an original scenario or those who are interested in the methodology and have enough experience in crisis and emergency training design – or who does not want read the literature review – can read Chapter 7 then Chapter

8 while using internal references to find all required information for designing a scenario in the rest of the document. Readers interested in arrangements used during Expert'Crise project in order to compare several crisis simulation experiments can directly read the chapter 2. In the end, readers interested in the analysis of companies' pedagogical needs or emergency planning focus their attention on chapter 6.

Part 1: Crisis and Emergency Trainings for Hazardous Chemicals Industries

Contributing to a design methodology for crisis and emergency training on hazardous industrial sites requires first to define what fields of study are concerned. Yet, such contribution is at the crossroad of several domains: crisis management, pedagogy, exercise design and scriptwriting. Moreover, it relies on a training project, held between 2015 and 2018, which was the start point of this PhD thesis, allowing to gather information and test exercises. Therefore, this first part aims, on one hand, to introduce and describe main domains related to this thesis and, in other hand, to present the training project – called Expert'Crise project – its target audience, its goals and describe conditions where it was held.

Therefore, this first part introduces and describes what a crisis is and how it is managed. Crisis management organization including its heart – the crisis cell – as well as emergency planning are then described with a particular focus on Belgian regulations and organization. How emergency services work and intervene on site is introduced and functions of other organization, especially hazardous industries which represent high risk potentials, are specified. In the end, the **Chapter 1** concludes on bias and other dysfunctional process that may occur in a crisis team to show that the main solution to deal with such problems is trainings. This conclusion opens on trainings done during Expert'Crise project.

The Expert'Crise project describes Expert'Crise project along with its goals and target audience. The complete training's framework and content are also presented with a special focus on exercises held during the project together with a presentation of arrangements set up onsite and how exercises were conducted. The description of Expert'Crise's simulations and training infrastructure, besides describing the experimental arrangement used during this project, aims to present how to use acquired devices for later experiments directed by UMONS teams. This chapter ends on goals achieved during the project and deals with reasons why they all cannot be reached. Note that this chapter only presents the project and does not discuss the design process used which is the main topic of the second part of this document.

The **Chapter 3** completes the literature review started in by dealing with the pedagogical dimension of designing crisis exercises and by providing main concepts used in the following of this work. Knowledge and competences are discussed besides pedagogical approaches that may be used in teaching in order to justify the method set up in the third part of this document. Moreover, an important focus on competences corpus required to ensure a crisis and emergency management is done. As these competences support trainings designed by the proposed methodology, their proper definition is critical and required to be examined.

Chapter 1 **Crisis and Major Technological Accident**

Despite the progress of major accident prevention since the 1970's and accidents such as those of Flixborough or Seveso, there are still industrial disasters. As very simple examples, while these lines were written, at the end of January 2019, two major accidents occurred: the Enbridge gas pipeline explosion in Noble County, Ohio, USA (Chow, 2019), where two peoples were injured on 22/01/19 and a massive nitrogen dioxide release at Groupe Chimique Tunisien plant in Gabès, Tunisia (Grira, 2019), inducing several workers intoxications on 24/01/19, and these accidents are a sad commonplace. Indeed, during the last century, industrial safety mainly improved after major accidents or those receiving massive media attention. Therefore, Seveso (1976), Chernobyl (1986), AZF (2001), Katrina (2005) or Fukushima (2011) impacted safety culture around the world and remains both milestones and case studies for hazard management. Then hazard management is mostly a “reactive” process where previous accidents help to avoid next ones and it is perilous. Indeed, all accidents occurring only represent a small part of all possible disasters, especially in more and more complex systems, and it is bold to wait that each kind of accident happens one time to deal with their causes, that may be multiple (Lagadec, 1991). Moreover, crisis and, to a lesser degree, emergencies, always include an unexpected and/or unknown part and, considering human, social, environmental and economical stakes, our modern societies cannot wait every disaster to learn how to react. Therefore, resilient emergency systems must be implemented and workers must be trained for them.

This chapter aims to provide an overview of what a crisis is, how it is “managed” and trainings existing in this field. First, definitions of terms used is proposed, especially clarifying what a “crisis” is, then a description on how crisis and, more generally, how emergency situations are managed in companies and by the society, in the specific scope of Belgium. At the end of this chapter, a status report of crisis and emergency training is proposed to introduce the context within Expert'Crise project was launched. Note that some topics are only introduced in this chapter and receive an extensive description on Chapter 3 and Chapter 4.

1.1 Introduction to crisis management

Our modern society's mediatic flows have been invaded by "crisis": from adolescent psychology to economic fields, every field has its own "crisis". These "crisis" situations are feared – it is especially the mediatic purpose – because they supposedly lead to chaotic and destructive situations but are barely explained: Why are they "crisis" instead of "evolution", "change", "accident" or just "news"? It is mainly because the word "crisis" acquired a polysemic meaning that we need to clarify in this document. The word "crisis" wandered off its first meaning from the Greek word κρίνω – "krisis" meaning to decide, to choose or to judge – and evolve to describe the moment when a disease is at its paroxysm and when nature decide of the patient's fate. This medical meaning stand-alone from the XIV to mid-XX then evolve – by analogy – to explain a strong and disruptive moment in society when a critical change occurs (Godefroy, 1881).

In our context, a crisis is a serious (Bundy, Pfarrer, Short, & Coombs, 2017), complex, disruptive, unexpected and uncertain situation (Flin, 1996) (Sniezek, 2001) that needs fast decision-making to avoid the destruction of the impacted system (McKinney, 1997). Crisis may refer to different types of events according to the nature of the hazard, endogenous or exogenous (Dautun, 2007), threatening the system. That is why crisis management is often related to risk management which deals with these hazards prior they become perilous. Nevertheless, crisis overtake risk and are the critical transitional moments which can lead to a permanent rupture between two states, needing to take urgently but with discernment important decisions (Heiderich, 2010). Despite the fact crisis are single event, they still have common points in their structure and how humans proceed it.

First, crisis is characterized by a strong uncertainty which may be considered (Kebair, 2009), (Autissier, 2012) as one of its main attributes. This uncertainty is pervasive (Passè, 2015) and extreme (Lagadec & Guilhou, 2002). It means the management team gets incomplete, imprecise, inconsistent information and may remain in a state of ignorance strengthened by the misunderstanding of complex systems composed of lot of shareholders and organizations (Lagadec, 1995), divergence of experts' points of view or the inconceivability of the worsening of the situation (Heiderich, 2010). Then crisis is a serious and urgent phenomenon involving important human, environment and/or economic consequences and that may induce domino effect leveraging destructive impact. Interconnectedness and interdependence of modern systems may cause or amplify dysfunction and spread crisis from a system to another (Boin, Hart, & McConnell, 2008). On the other hand, crisis reveals suddenly with several simultaneous problems appearing at the same time, taking everyone by surprise, and requiring a quick and efficient response. Considering that, as Lagadec mention it (Lagadec, 1995), a crisis is close to an emergency situation but with higher uncertainties on the situation.

Therefore, the crisis is a specific environment for decision-making, characterized by uncertainty (Kebair, 2019), important stress and anxiety (Heinzen, 1995). Then, organizations impacted activate exceptional procedures (Heiderich, 2010) and set up a particular management: a crisis management within a crisis cell, even if operating modalities varies from a company to another as developed in Chapter 6.

1.1.1 The crisis cells

Important organization such as government, administration and (some) companies, plan emergency and forecast possible crisis by assigning their management to a dedicated team: the crisis cell. Crisis cells consist in “a limited number of persons previously chosen for their experience and expertise as well as their psychological and micro-sociological skills” (Crocq, Huberson, & Vraie, 2009). Crisis cell must be reactive, efficient, adaptable and cohesive (Combalbert & Delbecque, 2012) then if a core management team is planned, this unit may still be completed by other people who are then requisitioned and may not have the possibility to refuse it, according to the nature of the impacted organization. A crisis cell is composed of several persons according to the size of the organization, and a range from ten to fifteen members is mentioned in the literature (Libaert, 2001) but depend on the phase of the crisis and its needs (see Figure 3): 2 or 3 persons may be enough during the pre-crisis phase but not in acute phase.

Crisis cell is a temporary organization, both open, at the center of information flows and strategic decision-making process, and close to let crisis managers process this information and make decisions (Heiderich, 2010). It must quickly set up and be fully operational as fast as possible, but does only exist to deal with the critical situation and is disbanded once hazards are under control. Therefore, crisis cell mission is to decide and apply anticipatory, vigilance and response measures to bring the situation back under control (Lachtar & Garbolino, 2011) as well as limit crisis consequences and protect system, people as well as assets (Coombs, Holladay, & Thompson, 2010).

Crisis cell's members are trained to achieve crisis management solving task, such as: “Situation survey, severity and emergency assessment, decision making and taking, monitoring and adjustments of actions, identifying the end of the crisis and assess post-crisis situation” (Lagadec, 2001). Crisis cells are divided into sub-cells performing dedicated tasks and support strategical decision making in their expertise field. To achieve these tasks, they may have to communicate with a wide scope of targets (media, population, public organization) and may be located in a dedicated room, especially in case of long or severe situation requiring dedicated communication means for example.

Crisis cell sub-cells composition is widely discussed in literature (Heiderich, 2010), (Lagadec, 1995), (Gaultier-Gaillard, Persin, & Vraie, 2012), (Tran Thanh Tam & Pesloüan, 2004) that agree more or less on crisis cell composition (see Figure 1):

- **Management sub-cell** which leads the crisis process, decides actions to do, validates suggested actions and communicates.
- **Coordination sub-cell** supporting management sub-cell and which centralizes the information, coordinates means and human resources involved in crisis cells, ensures crisis cell's decision implementation, their follow-up and feeding the crisis cells back with information.
- **Operational follow-up sub-cell** which makes the connection between on-site teams and crisis cells, transmits orders and deals with logistics and providing resources needed.

- **Legal and financial sub-cell** which ensures account and financial monitoring for human and material means involved, issues order bond, agreement, decrees and other credential documents needed.
- **Communication sub-cell** which communicates with external organizations, especially media and population, support management sub-cell for official communication, and ensures a media monitoring to get needed information for crisis management.
- **Anticipation and foresight sub-cell** which assesses and monitor the situation (event, response, asset), anticipates possible evolutions, then informs and supports management sub-cell in decision-making.
- **Secretariat sub-cell** which writes the log of activities ensuring registration of all information and decision, centralizes the information, follow the schedule, receives fax and transmit them.

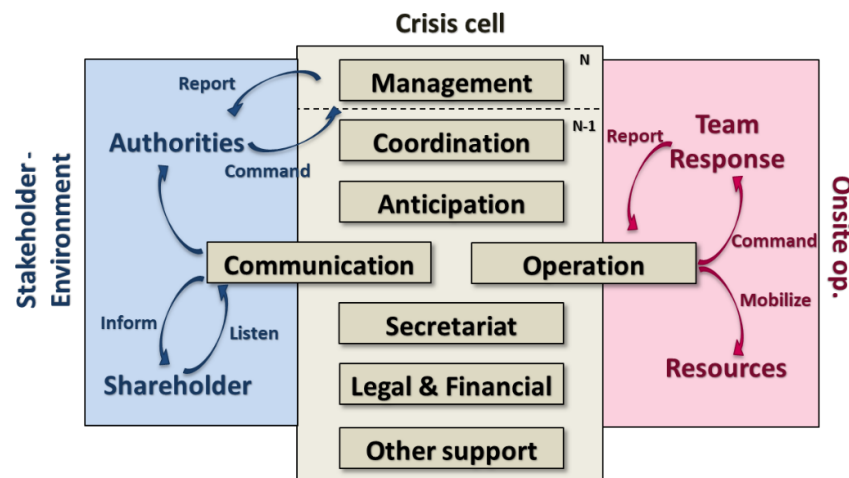


Figure 1: Crisis cells composition

The previous list – resume in Figure 1– is not comprehensive and other sub-cells may also compose crisis cells to provide a specific support such as technical maintenance sub-cells or environment sub-cells, especially in chemical industrials companies. Moreover, crisis organization is dynamic and adapt to face the situation in a new and turbulent environment requiring some “improvisation” (Passè, 2015). Then these organizations set up according to the size and nature of the organization (or organizations if several entities are involved), current crisis nature and process (Altemaire & Renaudin, 2007), (Pardini, 2010), and the severity of the situation (Dautun, 2007).

The crisis management team is responsible for developing a crisis response strategy that takes into account either short and long-term impact and may be adapted to the evolutions of the situation and which then requires to anticipate possible worsening of the situation (Limousin, 2017). Its mission is not onsite but as support of operations response by leading them, provide support in resources, information or instruction, and ensure communication

with stakeholders. This goal results in several missions that may be classified into three main categories (Tena-Chollet, 2012) as shown in Figure 2:

- **Leading the strategic response** which consists in gathering information and assess the situation, especially the severity of involved phenomena, to protect identified stakes and set an operational response with adapted resources. Coordination, logistic and anticipation are also an important part of this function as they aim to deal with the current situation by taking into account its possible worsening (Lachtar & Garbolino, 2011), (Tena-Chollet, 2012)
- **Ensuring the strategic crisis cell functioning** meaning ensuring a good internal coordination, communication and leadership in the team. It also includes activation of crisis cell, its setup, information gathering and display, actions monitoring, and decision-making (Tena-Chollet, 2012).
- **Leading crisis communication** which consists in spreading regulated information to external organizations (authorities, stakeholders) and populations (Restoueix, 2014), monitoring the media and correct their information through a press statement or social media for example.

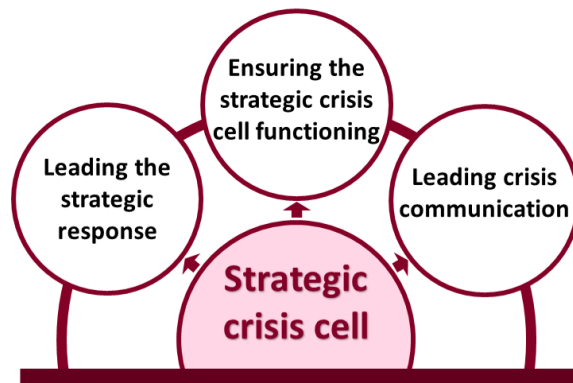


Figure 2: : Crisis cell missions' categories (Lapierre, 2016)

These fundamental missions are completed by one or several internal or external expert committees that can support decision, provide information or forecast possible evolution of the situation and their impact, especially on legal, mediatic, environment or public health matter (Tena-Chollet, 2012)

These missions require several competences from team member in addition to opportunities, environment and resources needed, to apply them. For Flück, four kinds of competences are involved in professional situations, alone or in a team (Flück, 2001):

- **Technical competencies** related to theoretical knowledge, methods, tools, rules, procedures and professional skills. Sharing a common technical knowledge background and the same understanding of the system (Chebbi & Pereira Pündrich, 2009) is important to efficiently collaborate with different professional bodies and hierarchical level and run operational feedback mechanism.

- **Organization competencies** related to spatio-temporal organization and dealing with information flows. They consist especially in mobilizing team crisis members and activate crisis unit (Lagadec, 1995), organizing crisis cell with dedicated method and tools such as regular situation report (Gaultier-Gaillard, Persin, & Vraie, 2012) (Chebbi & Pereira Pündrich, 2009) and, more globally, spreading efficiently and synthetically information inside crisis cell.
- **Interpersonal and social competencies** related to oral and written expression, relationship and managerial skills, as well as network skills.
- **Adaptation competencies** related to abilities to adjust to new and changing situation and apply knowledge or skills in a different scope that where they were learnt. Adaptation is the first – chronologically – competency use in a crisis unit where first moments may be overwhelming and require to manage violent and unusual situations and emotions to overcome stunning effect (Heiderich, 2010). This competency relies on flexibility, improvisation and on individual, team and social creativity (Autissier, 2012).

As said before, these competencies are generic professional competencies. Yet these competencies apply in the crisis management field (Lapierre, 2016). Then crisis management requires several individual, collective and organizational competencies. These competencies are technical as well as non-technical and take a more or less important part in crisis management according to the situation phases.

1.1.2 Crisis characteristics and emergency disambiguation

A crisis may be divided in three phases: a dynamic phase characterized by important evolution, high uncertainty and important stress level, this phase is followed by an instable static state where the nature of the crisis appears to crisis management who have the opportunity to regain control the situation, and a stable static situation where disaster cannot worsen. These three phases are represented in Figure 3.

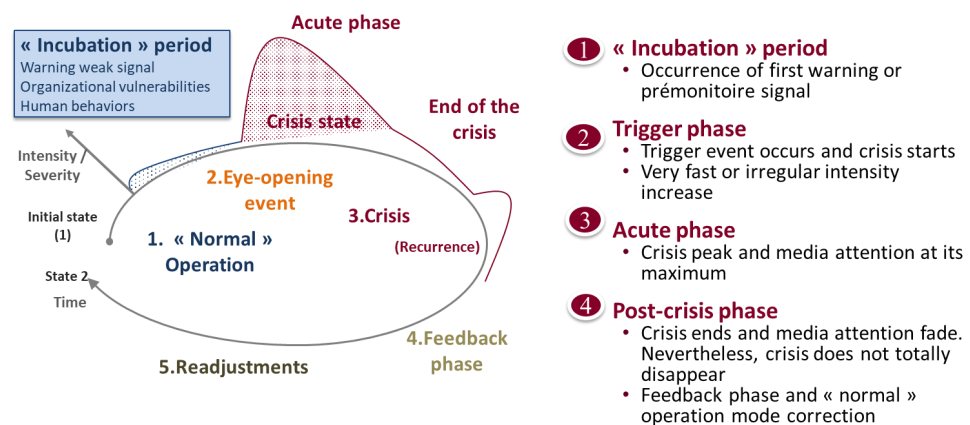


Figure 3: Crisis phases from (Roux-Dufort, 2003) and (Dautun, 2007)

During these phases, crisis cell may experience different characteristics phenomena induced by stressing situation such as the lack of information and resources (Bronner, 2008), the inadequacy between actions taken – when they are – and the gravity of the situation (Dautun, 2007), the high number of stakeholders involve, the “action-lock” where decision-makers are overwhelmed then do not know how to react so do not act at all or get uselessly agitated, the lack of consensus (Denis, 1993) between decisions-makers that may result in an action-lock, the failures in decision-taking and decision’s implementation (Persson, 2002), and cumulative accidents (Crocq, 2003) or contingencies. Also, during the dynamic phases until the instable static state, crisis management may experience what Lagadec call the triple impact with (1) a flood of information and input which (2) disrupt the operation of crisis management until (3) the rupture of the crisis cell which become useless, without any impact on the resolution of the disaster (Lagadec, 1995).

Therefore, a theoretical framework to characterize crisis and explain their mechanism exists and training to improve decision-makers’ competencies on this topic can be developed on the basis of these knowledge.

Crisis may be caused by various events and relates to different hazards. Risk analysis – or cyndinics (Kervern & Rubise, 1991), hazard study – classify hazards in two groups: natural ones and anthropic ones. Technological and, more precisely, industrial risk related to anthropic risk even if some technological accident may also be caused by a natural disaster so called NaTech accident. This work focuses on hazardous chemical industries which are part of technological risk. Industrial risk management has significantly improved this last 50 years. Indeed, populations and politicians became especially aware of this problem after the Seveso disaster and decided to regulate the risk management in chemical industries. The main consequence of this collective awareness is an integrated European regulation called SEVESO directive (European Parliament and Council, 2012) that tries to ensure the same level of protection for every European citizen against the chemical industrial hazard. This directive, and regulation associated, is periodically modified and adapted to take into account new accidents feedbacks or evolution in risk assessment paradigm. The SEVESO directive official name is actually *Directive [...] on the control of major-accident hazards involving dangerous substances, [...] where “major accident” is the European taxon for dangerous substances release, fire or explosion related to chemical companies*. On the topic of crisis and emergency management, articles 12.1 and 12.6 of this directive are the most relevant. The first one, implies upper-tier Seveso companies – those having higher amount of dangerous chemicals – must have an internal and external emergency plan, respectively co-designed with employees and emergency services, and the second one implies these Seveso companies must test, review and evaluate their emergency plan every three years.

Nevertheless, all accidents are not a crisis and there is a main difference to make between emergency and crisis. The first criteria to differentiate an emergency from a crisis is the gravity of the consequences. Three categories of consequences may be used to evaluate the severity of an accident: the number of casualties and their state, an evaluation of ecological damage and financial and material loss. However, this approach allows to make an observation ex-post only and does not reflect reasons that explain why a situation

is a crisis while another an emergency. Especially, it does not reflect the impact of forecasting and readiness in a crisis development.

Indeed, a crisis is always related to an unexpected aspect which forces decision-maker to adapt in order to propose new solutions adapted to the situation. On the other hand, emergency related to a sudden situation harmful to the society that required immediate and coordinated actions (Lachter, 2012) but that can be forecasted, with existing analysis and procedures. Decision-maker have to react fast but they know what to do. Furthermore, precisions can be made – as done by Rogalski (Rogalski, 2004) and Gundel (Gundel, 2005) – depending on the level of control on the event and how it is forecastable as shown in Table 1.

Table 1: Crisis or emergency according to predictability and control over the situation (Rogalski, 2004) (Gundel, 2005)

	High Control over the situation	Low Control over the situation
Low Predictability	Unexpected emergency (Knowledge and procedures available)	Fundamental crisis (No knowledge and available procedures)
High Predictability	Conventional emergency (Expected, knowledge and procedures available)	Overwhelming crisis (Expected but not prepared)

Crisis studies focus on very few probable events and that explains why there are situations in the overwhelming crisis box. It relates to events we know they can happen but, considering their probability, society “accept” (or “deny”) that risk – meaning no particular policy is taken and nothing is planned if such event occurs – because of limited resources. Nevertheless, decision-makers are aware of this vulnerability and investment are made to know how to react considering prevention is out of reach and improve this situation.

Considering that, the main goal of **emergency** planning is to reduce as much as possible the number of events in overwhelming crisis box, to know how to react in the case of a predicted event occurred. On the other hand, the goal of **crisis** management is to know how to organize if an event of the top line occurs to quickly find a solution and make it an unexpected emergency (upper left box). Then overwhelming crisis box management consists in setting up a reactive management system able to absorb every unexpected event.

Nevertheless, all organizations do not have the same readiness against crisis and emergency. First crisis readiness requires an efficient emergency management system all organizations does not have and, moreover, it requires strong investments to develop a crisis management system and train crisis manager, out of reach of some organization. According to organization readiness, they have different problems during crisis management Lagadec identifies (Lagadec, 1995). First, he stated level readiness levels – unprepared, little prepared and prepared – then he reviews companies according to three axes: alert and mobilization, Crisis unit processing and cultural aspect resumed in Table 2.

Table 2: Problems in crisis unit according to their preparedness level

	Alert and Mobilization	Crisis unit processing	Cultural aspect
Unprepared Organization	Ineffective alert system Nonexistent procedures	No dedicated means and Nonexistent procedures Heterogenous team Non-adapted actions and communication	Reluctant management Lack of preparedness
Little prepared Organization	Badly calibrated sensor and approximate alert Missing mechanism (enhance monitoring after acute phase, progressive reinforcement)	Unclear team composition and division of tasks Lack of framework leading to a degradation of function Approximate communication	Reluctance to use crisis dedicated means
Prepared Organization		Strategy hard to maintain in long-time Insufficient function meshing	Groupthink Lack of expertise

Organization preparedness is an important factor to take into account to set adapted exercise and it may help – as Lagadec do – to identify problems to solve and part of the organization to improve.

1.2 Crisis and emergency organization in Belgium

As mentioned, chemical companies have, in the European Union, specific obligations in matters of emergency planning according to the Seveso regulation. However, Emergency planning does not exclusively relate to Seveso companies. Indeed, societies in their globality need to be able to react quickly in case of disaster, whatever its nature. Then emergencies services and political decision-maker are organized in a way it seems relevant to describe as a context of this PhD thesis. The Belgian's emergency services organization went through a long reforming process from polices reform of 2001 to civil protection reform of 2017, it is almost all the emergency system which was revamped. The keystone of this new organization is the Royal Decree of 16 February 2006 (Moniteur Belge, 15.03.2006), completed by Ministerial circulars NPU-1 to NPU-5 (Moniteur Belge, Circulaire ministérielle du 26 octobre 2006 NPU-1 relative aux plans d'urgence et d'intervention, 2007), (Moniteur Belge, Circulaire ministérielle du 30 mars 2009 NPU-2 relative au plan général d'urgence et d'intervention du gouverneur de province., 2009), (Moniteur Belge, Circulaire ministérielle du 30 mars 2009 NPU-3 relative à l'approbation des plans d'urgence et d'intervention provinciaux, 2009), (Moniteur Belge, Circulaire ministérielle du 30 mars 2009 NPU-4 relative aux disciplines, 2009), (Moniteur Belge, 2009) and “Circulaire ministérielle NPU-5 relative au plan particulier d'urgence et d'intervention du gouverneur de province” (Service public fédéral Intérieur, 2009).

Emergency planning is a political matter then political organization of the country has its importance. Nevertheless, because this work is not a political science document, only the strict minimum of the complex political organization of Belgium will be presented. Therefore, because emergency planning relates to civil protection and civilian safety, it is a kingly function. As Belgium is a Parliamentary constitutional federal monarchy, this

function is assigned to king delegate in each state level: Mayors in municipalities, Governors in the provinces, and the Prime Minister for the federal level. Note that the regional level – between provincial and federal ones – is not involved in emergency planning despite competencies' regionalization process in Belgium.

Belgian regulation considers as an emergency situation "any event that cause or which could cause harmful consequences for social life, such as a serious problem of public safety, a major threat against people life or health and/or against important material interests, and which requires the coordination of emergency disciplines in order to make disappear the threat or to limit the harmful consequences". Emergency planning is then defined as "all the measures that prepare for an emergency situation" (Moniteur Belge, 15.03.2006). These measures should be taken by emergency services and appear in emergency and contingency plans that include either operational and strategic actions and coordination between different services.

1.2.1 The emergency and contingency plans (PUI)

Ministerial circular NPU-1 describes implementing modalities of the Royal Decree of 16 February 2006. It sets that the Mayor must establish, in one's municipality, a local general emergency and contingency plan (*Plan Général d'Urgence et d'Intervention*, also known as PGUI) which describes measures that should be taken and how emergency services should organize in case of calamitous event. This plan must be approved by Municipal Council and the provincial Governor. Similarly, Governor of each province – who is responsible for mapping risk on their area of jurisdiction and provide adapted prevention – should also establish provincial general emergency and contingency plan that must be approved by the Minister of the Interior.

General emergency and contingency plans are completed by specific provisions for specific risks, recorded in dedicated particular emergency and contingency plans (*Plan Particulier d'Urgence et d'Intervention*, also known as PPUI). Moreover, Governors must draft these particular emergency plans for industrial SEVESO activities (in accordance with the cooperation agreement of the 16 February 2016).

Emergency plans – general and particular – mentioned above are multidisciplinary. Indeed, different disciplines are involved, collaborating, in an emergency situation management – (1) emergency response services, (2) medical, health and psychosocial aid, (3) police, (4) logistical support, and (5) information – and the way they collaborate in a situation is described in these plans. Each discipline will be separately described in 1.2.4. Beyond this multidisciplinary part, each discipline needs specific operating procedures regulating their intervention methods under multidisciplinary general plan and possibly under some particular plans, these plans are called mono-disciplinary plan. Matters covered by mono-disciplinary plans are alert and departure, reinforcement, distribution of tasks, communication (between members of the same discipline), command, how commandment is transferred through phases (communal, provincial then federal phases detailed in 1.2.3), and how disciplines are represented in coordination bodies (detailed in 1.2.5). Finally, as a pseudo-discipline, companies are also required to provide their internal emergency plan which aims to limit the adverse consequences of an emergency by the setting of appropriate measures. Therefore, for SEVESO companies and some other case, PPUI, draft by the

Governor, are not to be confused with internal emergency plans of these companies called internal emergency plan (*Plan Interne d'Urgence* aka PIU).

All the above considerations and plans are summarized in Figure 4:

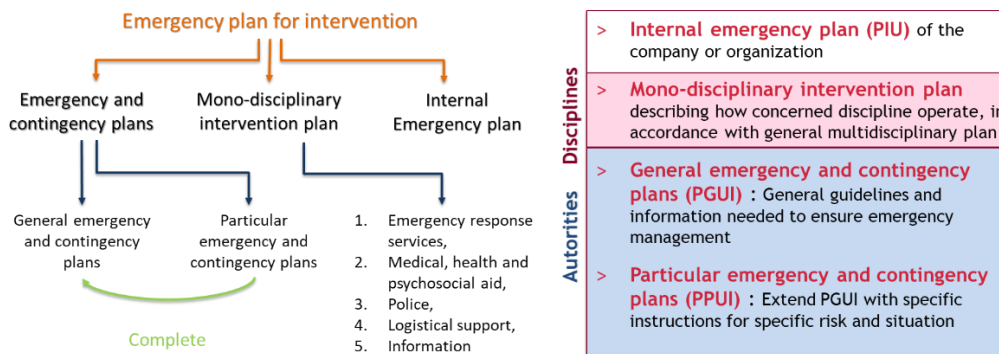


Figure 4: Emergency plan in Belgian emergency system

1.2.2 Content of emergency and contingency plan

In accordance with the Royal Decree of 16 February 2006, **general emergency and contingency plans** must deal with general information of the Province or the municipality concerned by the plan such as the directory of persons concerned by emergency planning, the risk mapping and the list of public services that can be mobilized and resources they can commit. But these plans must also contain the warning procedures of competent authorities, involved services and disciplines, means of communication, including the communication scheme, the procedure for calling the emergency system and how it should strengthen through emergency management. The operational and strategic coordination organization must also appear in general plan as well as the communication scheme for public and impacted population, how impacted population may be evacuated and accommodate, all reports and standard forms, and exercise organization arrangements and plan review.

Particular emergency and contingency plans, on the other hand, have different obligations depending if they refer to localized risk – Seveso sites, railyard, or cultural event – or non-localized risk, such as railway, road or geological hazard.

Particular plans relating to a non-localized risk must deal with a risk description, including an emergency planning area (areas that may be impact by a major accident), accidental scenarios and particular intervention methods for each scenario, how operations are coordinated, contacts information of people, especially concerned by the risk, specific people and property protection measures, potential location for the operational headquarter and assignment of the head of operational command post to one discipline according to the hazard.

On the other hand, particular plans related to a localized risk must deal with the site's geographical situation, general information related to the risk considered such as information on (hazardous) activities of the establishment, the list of hazardous substances used, the directory of managers or executives or information on the internal safety system. But these plans must also include emergency area, geographic, demographic or relevant

economic data as well as other hazard potential such as facilities or activities outside the site. Then, the establishment or the site operators must provide to authorities all the necessary information for the development of these particular plans. For Seveso companies, the particular emergency and contingency plan is drafted by the Governor and its office composed of members of communal and provincial safety office and may be help of several external resources (other Governor cabinet, emergency services, other companies or services...).

As written above, mono-disciplinary plans deal with the alert and departure, reinforcement, distribution of tasks, communication, command and command succession through phases and how disciplines are represented in coordination bodies. Moreover, they specify resources that may be immediately commit or that stay in backups. Mono-disciplinary plans may be – and actually are – trigger by disciplines leaders when a major accident occurred regardless of emergency and contingency plan.

1.2.3 Emergency planning phases in Belgium

Emergency situations come in different size and seriousness regardless of their cause. A massive toxic leak has different gravity depending surrounding territory: little if there is no inhabitant around or very grave if it is in the middle of a city. Then, these different severities of accidents will not require the same deployment in men and resources and the same coordination. Therefore, an emergency phase system was set up to provide proper resources for each situation and avoid both over and under-deployment. These three phases are: the municipal, provincial and federal phase. This system allows to organize emergency management, according to its magnitude of the situation and strengthen organization if the situation exceed the scope of the initially triggered phase.

The communal phase is under the responsibility of the Mayor who decides to trigger it, lift it and informs the Governor who assesses the need of strengthen organization with a higher phase. The mayor decides to trigger the phases according to operational emergency service feedback (often from firemen officer) when the consequences of the situation are restricted to the municipal territory. In that case, emergency management is ensured with municipal resources or resources that the municipality can mobilize from other services or agencies, such as those of civil protection. This phase matches with the local general emergency and contingency plan implementation including the operational (with the operational command post aka PC-Ops) and strategic (with the Coordination Committee) coordination structures setup. It can last as long as resources needed – both human and equipment – can be provided or mobilized by the municipality.

The provincial phase is triggered by the Governor in two cases: when the magnitude of the situation requires management by the Governor because the municipality is overwhelmed or when direct situation's consequences go beyond the territory of one municipality. The Governor decides to trigger this phase – which is under its responsibility – according to information he gets from Mayor (or directly from emergency services), to lift the phase and informs the Minister of the Interior through the Government Crisis Coordination Center (GCCC). This phase matches with the provincial general emergency and contingency plans implementation and emergency management is then ensured with provincial resources or resources that Province can mobilize from other services or

agencies, such as those of civil protection. Note that, in practice, some event may directly trigger provincial phase such as Seveso major accident or dangerous good road accident.

The Federal phase is triggered and coordinated by the Minister of the Interior. As for provincial phase, it may be trigger in two cases, based on information from the Governor (or directly from emergency services) : after a provincial phase if resources needed exceed what the Province can provide or mobilize or, directly, if a major event occurs such as two or more province impacted by an event, in case of an event requiring more resources than what a province can provide or requiring federal coordination with numerous casualties, major impact (or threat) on environment or the food chain, or major impact (or threat) on vital national interest or population critical need.

Phase level, situations that required them and who is in charge of the phase is resume Table 3.

Table 3: Emergency level summarized

Level	Situation and needs	Responsible
Communal	Communal management needed	Trigger and manage by the Mayor who notifies the Governor
Provincial	Provincial management needed <u>or direct consequences impacting several municipalities</u>	Trigger and manage by the Governor who notifies the federal Prime Minister
Federal	Federal management needed <u>or direct consequences impacting several provinces</u>	Trigger and manage by the federal Prime Minister

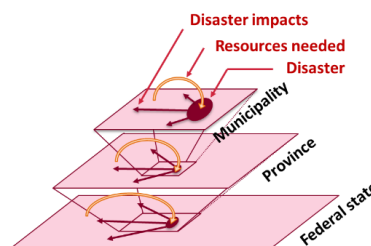


Figure 5: Belgian emergency level

1.2.4 Disciplines of emergency planning

Belgian emergency services consist of 5 disciplines: (1) emergency response services, (2) medical, health and psychosocial aid, (3) police, (4) logistical support, and (5) information. Disciplines are defined as a functional set of mission done by several stakeholders. Nevertheless, in practice, they tend to define specific professional bodies. As each discipline is usually named after its number, it is usual to designed firemen by D1 or civil protection by D4. This paragraph aims to describe missions and tasks of each discipline.

Discipline 1: Emergency response services

Discipline 1 includes firemen service and civil protection. Since the 2015 firemen organization reform, firemen services work in interlinked areas that provide resources according to availability inside the area or request surrounding area to provide needed resources. This organization by area – involving several cities – replaces the older local organization which was more local often involving only one city. Civil protection is currently under reorganization because of the 2017 reform. The 5 operational units spread in Belgium will become 2 highly specialized units and current equipment (and persons) will partially merge with firemen. These services are charged to take under control emergency situations and mitigated associated risks. They must also find, free, rescue, save and safe people and protect their property. If needed, they may requisition resources available to achieve their mission. Head of operation is held by fire brigade director (*Directeur des*

Services Incendies also known as DIR-SI). This function is ensured by the fireman ranking officer (the senior one in case of rank equality). The head of the operation cannot also hold the head of the operational coordination. D1 mono-disciplinary plan are developed by area technical commission president with firemen area command and civil protection operational unit command. Nevertheless, in practice, these plans are often internal firemen plan.

Discipline 2: Medical, health and psychosocial aid

Medical, health and psychosocial aid discipline's mission consists in providing medical and psychosocial aid to casualties, setting up the medical chain to evaluate and dispatch victims, transporting them to hospitals, and taking public health protection measures to preserve the population. These tasks are carried out by emergency medical aid services – not clearly describe in regulation – and those referred in mono-disciplinary plan. In practice, this discipline includes hospital-affiliated nurses – some specialized in emergency practice – and emergency doctor, paramedics (some are also firemen) and other services or organization such as Red Cross organization. During an emergency situation, the medical discipline work under the administrative authority of the federal Inspector of hygiene. On the other hand, the operational management is assumed by the head of medical aid (*Directeur de l'aide médicale* also known as DIR-MED) nominated in the mono-disciplinary plan.

Discipline 3: Local police

Discipline 3 includes local and federal police members according to the current emergency phase. As for firemen, police services go through a reform process merging prior communal and territorial police into area police and keeping common supra-local and specialized federal police for support missions. Main missions of this discipline are to maintain and restore law and order, clear access roads, install, keep and monitor emergency perimeters. On the other hand, the police are responsible for confinement order and evacuation of the population. Operational management of administrative police missions is the head of the police (*Directeur de la Police* also known as DIR-POL). This role is held by the commanding officer of the local police or the coordinating director according to the mono-disciplinary plan also called police intervention plan (also known as PIP)

Discipline 4: Logistical support

Logistical support's mission is to provide staff and equipment reinforcement, set up communication and supply impacted people as well as emergency services. These support missions are carried out by several services: civil protection (which are automatically mobilized in a provincial or federal phase), firefighter service or specialized public and private services referred in mono-disciplinary plan or commandeered if needed. This discipline is managed by the head of logistics (*Directeur de la logistique* also known as Dir - Log). This role is held by the civil protection ranking officer or decided on-site by the head of operational coordination.

Discipline 5: Information.

Discipline 5 has different mission depending on the time of the emergency management. During the emergency, it must alert concerned people through adapted means, monitor the population, media and stakeholder perception of the situation, provide information on the situation, action taken and recommendation to impacted population, and ensure communication through adapted means to population and identified stakeholders. On the

other hand, after the emergency, this discipline must inform the population on recommendation to restore a normal situation and ensure a continuous and coherent communication at the end of the situation. This discipline is under the responsibility of the head of information (*Directeur de l'information* also known as Dir-INFO) nominated by the Mayor or the Governor according to the phases. In case of a situation that required a federal phase, Minister of Interior is in charge of the coordination of the overall population information, while being assisted by concerned Governors and Mayors.

Figure 6 represents disciplines' different activities around disaster. Because, there are numerous activities, interaction between disciplines and coordination needed, all disciplines are supervised by several coordination levels, at operational level: the operational headquarter (*Poste de Commandement Opérationnel* also known as PC-OPS).

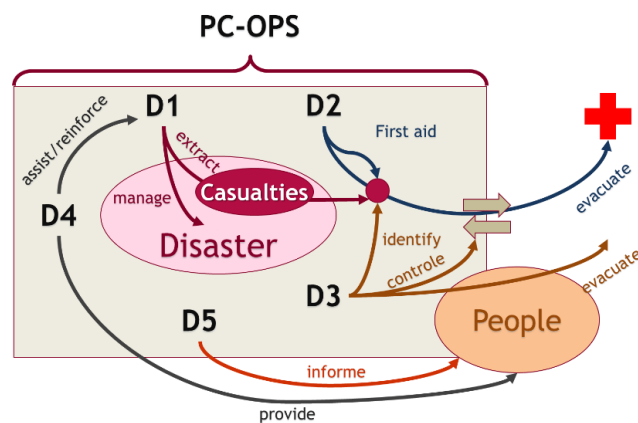


Figure 6: Disciplines activities

1.2.5 Coordination of emergency services

As previously discussed, emergency management involved a lot of different services and organization. Then coordination appears as necessary both at operational level to coordinate every stakeholder and at strategic level to take critical decision. On the other hand, both of these coordination levels must anticipate evolution or aggravation of the situation to be ready to involve staff and equipment reinforcement.

Operational coordination is held in the operational headquarters (*Poste de Commandement Opérationnel* also known as PC-OPS). This headquarter is located onsite, according to the situation, close enough from the event and in a safe place. It also must be easily visible as a command post. PC-OPS is composed of all head of disciplines – DIR-SI, DIR-MED, DIR-POL, DIR-LOG and DIR-INFO – involved in the emergency situation and an officer in charge of coordination of these disciplines and so-called head of PC-OPS (*Directeur du Poste de Commandement Opérationnel* also known as *DIR-PC-OPS*). This function is ensured by the senior fireman ranking officer (in that case, DIR-SI is then the second in rank fireman officer). However competent authority may choose a head of another discipline as Dir-PC-Ops depending on the nature of the emergency. Therefore, in some situation, DIR-PC-OPS may be a policeman for a security emergency or a medic for public

health matter. Nevertheless, DIR-PC-OPS may not be the head of a discipline at the same time and must be replaced at this function. PC-Ops may also include a representative of the impacted organization, especially for Seveso companies which may merge crisis cells and PC-Ops when it is possible and as long as this one is not overcrowded.

PC-OPS has several missions. It must draft and transmit a report of the situation to the competent authority (according to the current phase) and provide regular feed-back of onsite evolutions, assist and advise the authority at strategic level then implement strategic decisions at operational level, and organize on-site intervention area. PC-Ops relies on 100/112 provincial emergency call center to centralize communication and alert every emergency service, authority and service and/or organization required.

Depending the current emergency phase, the competent authority ensures strategic coordination and support operational actions. DIR-PC-OPS ensure strategic coordination until competent authority takes it over. As said in 1.2.3, strategic coordination is ensured by the Mayor the local phase, the Governor for the provincial phase and the Minister of Interior for federal phase. Strategic coordination is held in strategic headquarter (*Comité de coordination* also known as CC) which is a crisis center set up by authority team. This crisis center is at least composed of emergency planning official, a strategic head of each discipline involved (called DIR-D1, DIR-D2, DIR-D3, DIR-D4 and DIR-D5) and, for a provincial phase, concerned Mayors or their representant.

Strategic coordination has several missions. It must ensure a coordinated implementation of strategic decisions with operational measure, evaluate socio-economic impact of strategic decision, mobilize or commandeer staff and equipment reinforcements, and, in the end of the situation, ensure a transition to a back to normal phase.

1.2.6 Organization around the intervention area

Organization of different disciplines around disaster requires to set up different perimeters to ensure operators can work in safety and population stay away enough to not be in danger and does not bother emergency workers. The area must be defined according to danger for health or life within at the moment of the evaluation but also according to potential negative evolution. Then, depending on the area, individual protection may be needed to work within and, in other hand, population living there may be alert but not necessarily evacuate. This zoning does not only serve to protect people but also allows to protect elements needed for judicial investigations.

The first emergency perimeter is the first perimeter set up, when first operators arrive on the scene. When the risk is localized and a particular plan exists, this area is pre-determinate and directly set up by D3 (when it is possible, regulation fixing these pre-determinate areas may give very wide area and not being operationally applicable). On the other hand, when the risk is un-localized a first emergency perimeter is defined by the first arrived fireman officer or by the first arrived policeman Chief. In that case, reflex perimeter is from 100m to 200m depending on terrain, or 300m to 500 if there is a risk of explosion. This perimeter is quickly replaced by a more relevant zoning called intervention area.

Intervention area is divided into three areas following the orders of the Dir-PC-Ops, designated by colors: red, orange and yellow. Each area is bounded by specific perimeter, explaining their function: exclusion perimeter, isolation perimeter and dissuasion perimeter.

The red area, surrounded by the exclusion perimeter, is the point of operation, only accessible to emergency response services, experts and technicians with the Dir-PC-Ops' express agreement and following safety and operational instructions given. This area replaces and modifies the first reflex emergency perimeter, according to the emergency situation, and is immediately adapted in case of worsening of the situation.

The orange area, surrounded by the isolation perimeter, is dedicated to logistical support and disciplines' actions. Its main purpose is to avoid that the area around the disaster were overcrowded by curious bystanders and to clear free space for emergency services work. Therefore, this area may be accessible to residents, workers and possibly the press depending of the Dir-PC-Ops' decision and in accordance with instructions given. PC-Ops, potential mono-disciplinary headquarter, the medical outpost (*Poste Medical Avancé* aka PMA) together with casualties gathering and evacuation.

As shown in Figure 7, the yellow area, surrounded by the dissuasion perimeter, aims to free access to disaster and to let dedicated space either for evacuation and reinforcement reception and parking. This area should be avoided by people who do not live or work there and dedicated access measures are taken by D3 to free access.

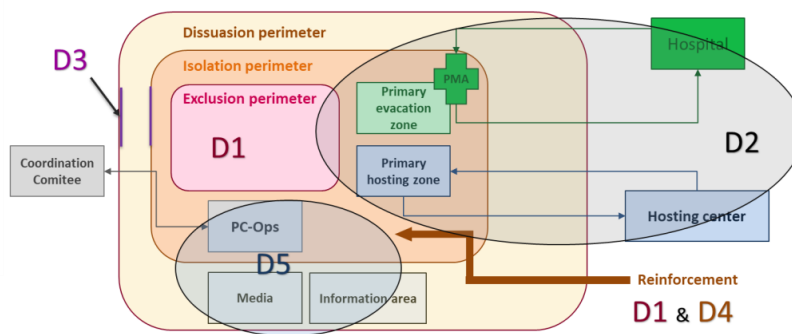


Figure 7: Intervention perimeter and disciplines

The judicial area overlies the intervention area and become effective after D1 activities. This area aims to protect clues for judicial inquiry and is bounded by caution ribbon. Access to this area is controlled by policemen to limit as much as possible contamination of the disaster scene.

1.3 Crisis and emergency training for crisis team management

Previously described system is complex and that is why it needs to be regularly tested and evaluate to ensure a good functioning state. Moreover, public as well as private organizations related to emergency planning have specific regulations that required them to set up such tests. Then, as already mentioned, article 12.6 of the Seveso directive states that upper-tier companies – and competent public authorities – fully test their emergency planning system at least every 3 years. On the other hand, article 3.2.5 of the Royal Decree of 22 May 2019 requires that communal and provincial emergency planning team organize regular exercises with at least one exercise per year. Therefore, these teams may be reluctant to set non-mandatory exercise and, in Belgium, we may doubt that every municipality and provinces totally comply with emergency planning requirement.

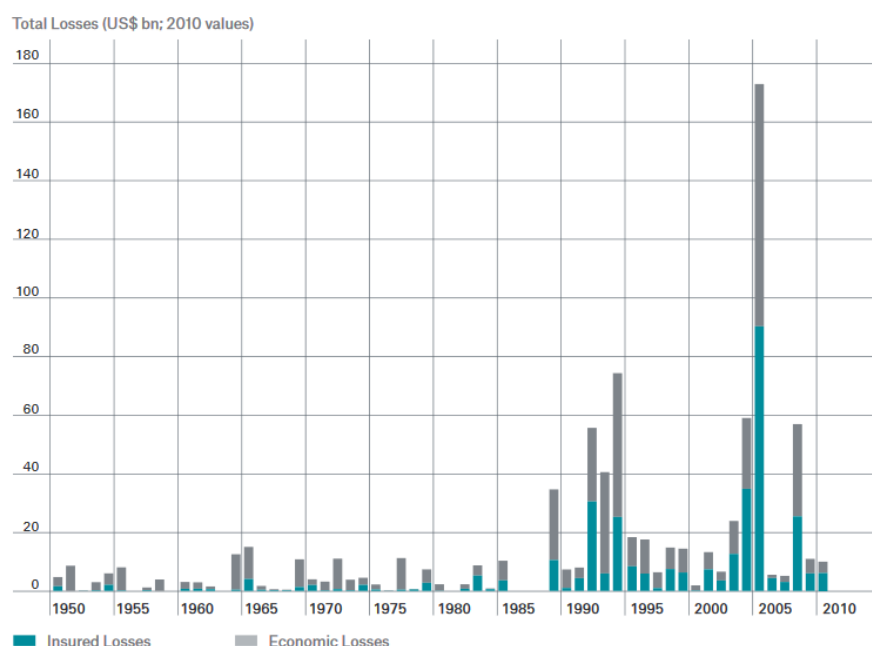


Figure 8: Annual Loss caused by natural disaster in USA between 1950's and 1990's (Munich Re, 2011)

These obligations align with increasing loss due to major accident since the 1950's. The following graph – from Much Re, a reinsurer company (Munich Re, 2011) – represents financial and material loss occurred since the 1950's in USA during natural disasters. These loss skyrocket since 1990's and, even if natural hazard may have increased in frequency and in intensity during this period, the increasing vulnerability of our societies, especially with the escalation of human systems complexity powered by globalization process had probably something to do with that. Note that, if Figure 8 only considers financial and material loss in an insurance-related approach, human and environmental loss should also be taken into account.

Then, moreover regulation, private decision-makers have to choose between different path to protect assets under their responsibility. Generally, there are four main paths to deal with risk: Prevention (including hazard reduction/suppression that may see as a fifth path), protection, transfer through insurance in this case, for example, and – and it is not a possible path if the risk is too important – acceptance.

As said in the introduction, prevention in hazardous chemical industry significantly improved these last decades and, even if there are always ways of improvement, further advance in prevention may be expensive. In the same way, transfer through insurances may be costly especially because insurance companies reassess periodically their risk evaluation and adapt their fare according to their customers' risk level. On the other hand, some hazards, because they may cause too much damage, simply cannot be insured, meaning no insurance company would take the risk to insure those risks. Only remains protection systems to improve major accident management, more precisely protective human organization, because technical active or passive protection systems are often – as preventive system – already implemented. This specific human organization, emergency organization, is the only one likely to be able to deal with new random complex and hazardous situation.

Then crisis and emergency management in hazardous industries rely on a particular organization which modifies the companies' normal operating mode. This kind of organization requires, from both operatives and decision-makers, specific competences that cannot be acquired through theoretical courses or real-life practice only (Lagadec, 2001). Indeed, because they experiment a high amount of stress during an emergency situation, involving all their available cognitive resources, members of crisis cells cannot fully capitalize competences during real situation. They are in "danger zone" as defined in the aviation pedagogical field (Cook, 2010) that does not allow any (or a minor) learning. Difficulty and stress level determine how persons involved in a problematic situation may learn something. Aviation pedagogy identifies four learning areas according to the difficulty of the situation: comfort zone where trainee applies competencies learned without stress, stretch zone where trainee experiment an unknown situation which little exceed one's usual competences, risk zone where trainee experiment a difficult situation which clearly exceed one's competencies and danger zone where trainees do not have competencies at all to deal with this situation. Learning is optimal in stretch zone which put into difficulties the trainee but without goals being out of reach. The learning is less efficient in comfort area – because there is no challenge for trainees – or in risk area which may overwhelm trainees and stop the learning process. This graduation of difficulty influencing learning efficiency, represented in Figure 9, will be discussed in Chapter 5, especially by defining the notion of flow state.

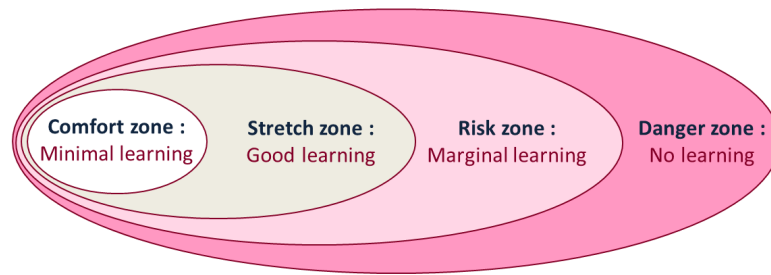


Figure 9: The four Learning zones

Besides, as said before, a theoretical framework describing and explaining how crisis cells work and problems they usually meet has been developed and underlies this work.

1.3.1 Team process in a crisis cell: How a crisis cell work

A crisis cell, as a team formed to accomplish a mission, is driven by team process. Team processes are “interdependent acts that convert inputs into outputs through cognitive, verbal and behavioral activities directed to organizing taskwork to achieve collective goals” (Marks, Mathieu, & Zaccaro, 2001). Indeed, even though team members have different role, they share common goals. Because each role depends on other ones, individual and team target are closely related (Smith & Dowell, 2000), (Schaafstal, Johnston, & Oser, 2001) and imply a continuous collaboration. Therefore team processes may be related to two kinds of work (Guzzo & Salas, 1995), (Marks, Mathieu, & Zaccaro, 2001), (Hussain, Feurzeig, & Cannon-Bowers, 2010), (Weil, Hussain, Diedrich, Ferguson, & Macmillan, 2004) : the taskwork directly related to the achievement of the task to do and involving either technical and non-technical individuals competencies, and, on the other hand, the teamwork related to interaction, coordination and communication between team members to achieve the taskwork. Teamwork efficiency is linked to the members’ ability to know and predict other members needs and act according to these needs then share a common picture of the situation (Noe, Mcconnell Dachner, Saxton, & Keeton, 2011).

From all different team’s processes used to achieve goals, three of them explain mainly how a team works (Marks, Mathieu, & Zaccaro, 2001): (1) Group behavior related to goals evaluation and planification of milestone to pilot and achieve the global mission, (2) actions or behavioral activities – support, control, behavioral monitoring of other – aiming to accomplish goals, and (3) interpersonal processes such as conflict prevention and management, motivation or collective confidence.

Emergency management deficiency, as a team work activity, usually involved team process, either task or team work. Then, because emergency management may be said as the solving of activities interdependency between different organization involved in the situation (March & Simon, 1958), (Simon, 1978) the main deficiency usually lies on the lack of coordination between each entity that are not used to work together. It is then the lack of teamwork between organization – seen as team of team – that is shown up but this is the more obvious failure and other ones can be identified, particularly in the decision-making process.

1.3.2 Decision making process in a crisis cell

Team decision making is a key process in crisis and emergency management which consequences, if decisions are inadequate, may be permanent or hard to recover. This process is a team cognitive process involving information gathering, transformation, integration and communication to take a decision related to the concerned task (Cannon-Bowers, 1993). Even though numerous researches, especially in the military field, aimed to provide a framework to understand the decision-making process, no relevant formalization was produced. Indeed, there is no unique framework to explain decision making progress because of plentiful of heterogenous factor involved that may impact a choice instead another. Moreover, this process – especially under stress – rely on individual cognitive process then is hardly generalizable (Crichton, 2002)

Nevertheless, these processes may be classified into families in a continuum going from processes used in situation where stress is limited – little impact, long thinking time – to situation where stress is important (Bryant, Webb, & McCann, 2003). This continuum reveals 4 main decision-making processes (see Figure 10): creative ones related to the creation of new solutions and mainly involving cognitive processes (Crichton, 2002), analytic ones related to logical evaluation of different solutions according to the weighting of different criteria (Hogarth, 1980) but limited by individual memory and cognitive resources that cannot deal with rigorous evaluation of all criteria of a complex situation (Bryant, Webb, & McCann, 2003), procedural ones related to existing rules or procedures linked to the problem and intuitive (also known as *Naturalistic Decision Making*) which is a recognition process (Klein, 1997) aiming to identify significant model (Shanteau, 1987) then associate them to adapted reaction (Means, 1993).

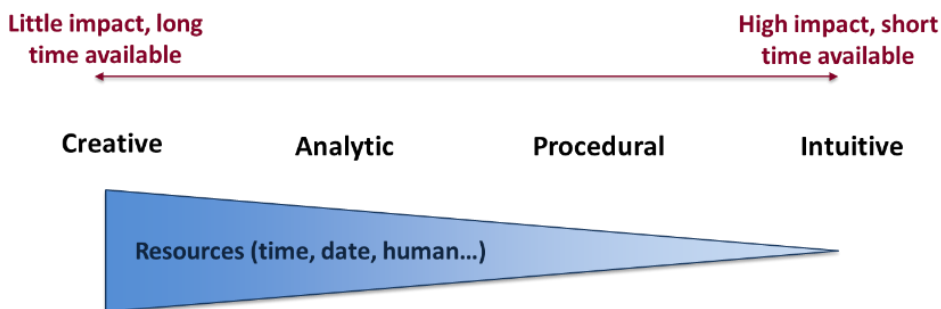


Figure 10: Decision making continuum (Tena-Chollet, 2012)

Time pressure in the decision-making process induces stress for executives, but it is not the only cause of stress that may impact how a decision is made. Three main stressors categories may burden this process: environment-related stress, task-related stress such as time pressure or important impact of the decision and team-related stress related to motivation, coordination or communication (Kontogiannis & Kossiavelou, 1999)

These processes schemes directly impact how trainee learned under stress situation. Indeed, the more a situation is stressful, the more intuitive the trainee's answer is. Then it does not allow to involve a cognitive process implied in learning. Nevertheless, and with differences between individual or team, stress may also be positive (Kowalski-Trakofler, Vaught, & Scharf, 2003) by strengthening individuals focus, thinking or identification of major information and, at the team level, by keeping cohesion and hierarchy, and helping to take a decision.

Decision-making in emergency or crisis occurred in a specific place that may easily be compared to a headquarter bunker (Maisonneuve, 2010). This situation may impact representation of the situation – as detailed in 1.3.3 – but also the decision-making. Indeed, studies in isolated and confined spaces – in polar station, during space mission or isolated medical teams – shown that these conditions impact teams with tension between persons, cohesion reduction, lack of leadership and development of anxiety, discouragement, anger or irritation (Kanas, 2004), (Sandal, 2001). As decision-making is a team activity, consisting in considering each member opinion to build an “optimal” decision accepted by every member, it may be both irrational and biased because of these stress factors. Two forces notably influence the decision-making process under a stressful situation: normalization and polarization.

Normalization (Schachter, 1951) consists in the convergence of opinion and belief to a consensual opinion resulting from the inclusion of opinion of every group member. It results in a median opinion, the barycenter of point of view of every member, gathering approval of each member because not too far of everyone's belief and strengthening the group cohesion. On the other hand, opposed to normalization process, **polarization** consist in the emergence of extreme opinions that does not reflect the medium opinion and is finally accepted by the group. The emergence of such opinion may be explained by the “risk shift” (Stoner, 1961), describing the difference between individual and team risk taking. Indeed, people trends to make more hazardous choice in a group than alone because risk taking is socially valued and potential consequences are shared in the group causing a responsibility dilution. Moreover, it appears that polarization is related to the implication of the group in the management of the situation: the more this one is involved, the more polarization is likely to appear.

Extreme opinion that emerges with polarization may lead to a situation where this opinion definitely settles and crush other emerging opinions, this phenomenon is called group-thinking (Janis, 1982). Groupthink describes situations where an idea or a belief settle in a decision-making process without being contradicted all along the situation. After it appears, the belief spread in the group in a standardization process that may be strengthened by an illusion of control or of invulnerability (see 1.3.3) then, in a second phase, group exerts an active censorship on every member with divergent arguments that contradict the common belief or idea. This collective comportment aims to maintain group cohesion at the

expense of justified contradiction and then decision-making quality (and morality). The more the group is self-centered and isolated, with a strong leader and high external threat – such as in a crisis cell – the more this phenomenon is strong. The same way this phenomenon affects the decision-making process, it may also affect how the crisis cell evaluates the external situation with the development of an incorrect representation of the situation reinforced through the group-thinking.

1.3.3 Representation process in a crisis cell

Decision making relies on a set of information that describe more or less efficiently the external situation. Based on this information each group members build a mental picture, a representation, of the situation. If there is no need to have a perfect picture of the situation, a minimal set of information is needed with at least more useful information than useless one (Todd, 2007). The amount of information needed is anyway limited by amount of data decision-making group may process and register and, in this regard, two parameters of the situation must be considerate: its uncertainty and its complexity. The first parameter implies members fill gaps of the description due to the lack of information and the second one implies they have to simplify their picture of the situation by limiting and hierarchizing this information.

Because crisis cells are isolated places where decisions are made without direct contact and feedback from external environment, they may experiment distortion in their representations of the external situation. This condition may be described as a “bunkerisation” (Lagadec, 1995) where crisis cell members get more and more isolated alongside the situation with intense activities that make feel the passage of time as it was accelerated (Vraie, 2010). Therefore, crisis cells may be disconnected geographically, temporally, and have totally incorrect representation of the situation.

Building of incorrect representation is mainly caused by a lack of internal and external communication, and differences in individual representation of the situation (Lagadec, 1995) that lead to a dysfunctional Shared Mental Model (Cannon-Bowers, 1993). Indeed, building such model, each member's mental picture of the situation must be coherent. Dysfunction in this Shared Mental Model implies that people collaborate inefficiently because they do not figure correctly what other expect (Rouse, Cannon-Bowers, & Salas, 1992). Moreover, collaboration is not efficient but decision-making process is heavily impacted by an inadequate representation because decisions are made according to representation of the situation (Bulunge, 2013). Representation process in 4 phases – perception, processing, picturing and statement – and several factors may influence each step. Perception depends on individual characteristics such as ability to select relevant information and process it. Therefore, more than memory, experience or knowledge, perception is related to individual parameter set by culture, norms or education. Then processing of perceive information mainly depends of cognition abilities of members and some cognitive bias are well known through disaster feedback and resume in Figure 11:

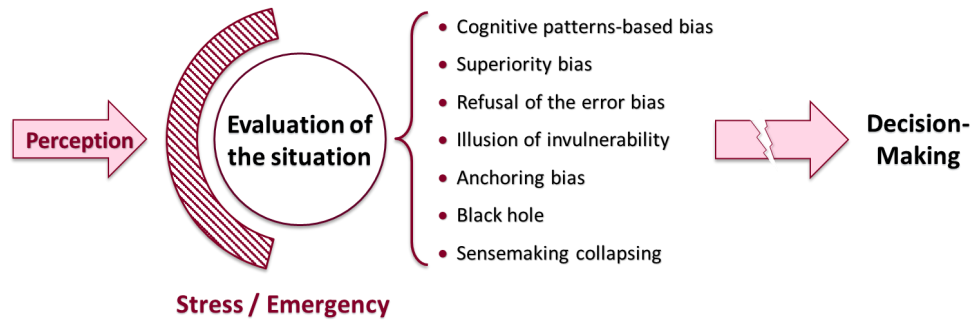


Figure 11: Impact of cognitive bias on perception and decision-making (Lapierre, 2016)

- **Cognitive patterns-based bias:** for routine actions, executives may proceed with a minimal set of tasks according to existing pattern that does not totally comply with procedures and lead to forget action or information (Orasanu, 2010).
- **Availability and superiority bias:** decision-maker may over-exploited easy to access information providers (availability bias) or be over-confident regarding some information (superiority bias) (Kouabenan, Cadet, & Sastre, 2006).
- **Refusal of the error bias:** this bias related to inconsistent analyses pursued by decision-makers that does not admit possible errors (Bulinge, 2013).
- **Illusion of invulnerability:** this bias consists in an unrealistic optimism that let decision maker believe they control the situation (Kouabenan, Cadet, & Sastre, 2006).
- **Anchoring bias** describing situation where decision-maker keep their first inadequate picture of the situation (Daniellou, Boissières, & Marcel, 2010)
- **Black hole:** High stress in the first phase of emergency situation may cause memory loss when precisions on disaster are needed (Llory, 2000).
- **Sensemaking collapsing:** this phenomenon describes a situation where there are important differences between crisis members' representation and reality. New elements incoming in crisis room have no consistency with existing representation and dissonance appears until the mental picture of the situation collapse (Weick, 1993)

1.3.4 Other Dysfunctional process

If representation and decision-making processes are the two most important potentially dysfunctional processes in a crisis cell identified in literatures, other dysfunctions may appear as Lapierre resumed it (Lapierre, 2016).

Table 4 brings together and classifies dysfunctions gather from the literature and disaster feedbacks in four groups: information transmission dysfunction, situation representation dysfunction, stress dysfunction, and organizational dysfunction.

Table 4: Crisis cell possible dysfunctions (Lapierre, 2016)

Information transmission dysfunctions	
Problem in sharing information	(King, et al., 2008)
Unclear communication	(Crichton & Flin, 2004)
Loss of information, keeping only the major ones	(Kowalski-Trakofler, Vaught, & Scharf, 2003)
Major information blank	(Guarnieri, Travadel, Martin, Portelli, & Afrouss, 2015)
Lack of validation and control on decisions	(Guarnieri, Travadel, Martin, Portelli, & Afrouss, 2015)
Problem in sharing information between crisis cell and onsite headquarter	(Lefrou, 2000)
Situation representation dysfunctions	
Difficulties to build a shared mental model of operational situation	(Seppänen, Mäkelä, Luukkala, & Virrantaus, 2013)
Collapsing of sensemaking	(Weick, 1995)
Control illusion	(Kouabenan, Cadet, & Sastre, 2006)
Poor risk assessment, deviation normalization	(Vaughan, 1996)
Groupthink in crisis cell	(Guarnieri, Travadel, Martin, Portelli, & Afrouss, 2015)
No taking a step back on the situation	(Lagadec & Guilhou, 2002)
Deny of contingencies	(Lagadec, 2012)
Inappropriate or wrong assessment of the situation	(Crichton & Flin, 2004); (Guarnieri, Travadel, Martin, Portelli, & Afrouss, 2015); (Orasanu, 2010)
Inconsistent, inappropriate or impracticable request	(Guarnieri, Travadel, Martin, Portelli, & Afrouss, 2015)
Stress-induced dysfunctions	
Deny, action lock	(Kouabenan, Cadet, & Sastre, 2006)
Illusion of invulnerability	(Kouabenan, Cadet, & Sastre, 2006)
Stunning	(Crocq, Huberson, & Vraie, 2009)
Confusion of members	(Heiderich, 2010)
Reduction of alertness and memory	(Kontogiannis & Kossivelou, 1999)
Organizational dysfunction	
Collapsing of coordination arrangements	(Weick, 1995) (Lagadec, 2012)
Poor division of task	(Kanki, 2010)
Self-effacing leadership	(Kanki, 2010)
Leader unfollowed	(Guarnieri, Travadel, Martin, Portelli, & Afrouss, 2015)
Blind confidence to procedures or misapplication	(Crichton & Flin, 2004) (Lagadec, 2012)
Isolation crisis cell members	(Guarnieri, Travadel, Martin, Portelli, & Afrouss, 2015)
Internal tension and conflict	(Van Vliet & Van Amelsfoort, 2008)
Lack of available resources	(Guarnieri, Travadel, Martin, Portelli, & Afrouss, 2015)
Poor support from leaders	(Dautun, 2007)

Considering all these potential dysfunctions, trainings for workers appears as a solution to improve crisis management. Indeed, because global organizational reaction is complex to improve because of human and all uncertain factors involved (Dautun, 2007), crisis decision-making improvement may be done through the development of individual abilities to mobilize knowledge and develop an efficient thinking process at short or long terms with dedicated trainings (Fredholm, 1999).

Such trainings improve particularly how crisis members deal with decision making and situation representation: experimented emergency decision-makers take less time to take decision and more time to assess and evaluate situation whereas unexperimented ones take more time in decision-making and need more raw scattered information to take decision. Yet this last comportment is not compatible with hindsight needed to take strategical decisions and induces a tiredness then a performance decrease. Therefore, trainings and advices may help unexperimented crisis managers to better handle such situations and more easily share common mental pictures of the situation to quickly take collective decisions (Randel, Pugh, & Reed, 1996).

On the other hand, these trainings aim to test emergency management tools – such as maps, documentation or procedures usefulness – evaluate mobilized staffs' reactions (Gaultier-Gaillard, Persin, & Vraie, 2012), and highlight problems and means of improvement (Heiderich, 2010).

Therefore, several kinds of crisis management trainings have been explored. These ones are designed to provide global knowledge, regardless of the nature of the crisis and its consequences. Indeed, if every major event requires specific actions closely depending on the crisis environment and its circumstances, executives who must manage these situations, assume all similar functions: decision-makers. Then crisis management education focuses on the transmission of non-technical knowledge to prepare efficient crisis decision-makers, regardless of their technical skills. Nevertheless, although this target is shared by all existing programs, the way they are led differs significantly. This may be explained by the recent development of such trainings and by the need to address them to a wide panel of professionals, from management to operational level. Indeed, an emergency system may operate correctly only if all its actors, individually, know what to do and are, collectively and regularly trained to unusual accidental situations (Lagadec, 2001).

Nevertheless, even if trainings' nature may be very different, because the target aims stay the same, the global structure remains the same from a training to another.

1.3.5 Emergency and crisis training usual frame

Whatever the training, the purpose is the same: every trainee should be able to apply what they learnt in real situations. Moreover, it should improve teamwork, including shared mental picture, decision-making process, team management and leadership, and communication. Therefore, training aims to simulate a situation close enough to a real situation and set up a learning process (Galvão, Martins, & Gomes, 2000).

The development of such training is a four main steps process: (1) planification, needs statement and training goals description, (2) conception by training developers, (3) leading exercise and observing trainees' reactions, and (4) analyze how the exercise proceed (Morin, Jenvald, & Thorstensson, 2004). Furthermore, these trainings are usually

integrated in a continuous improvement cycle in the organization then development of a training rely on previous exercises' feedback that raised new topic to be tested or improvement domains as represented in Figure 12: (Fagel, 2014), (McCreight, 2011), (Heinzen, 1995) (Limousin, 2017) :



Figure 12: Emergency and crisis training improvement process

Planification is the first step of the process and set how each stakeholder would be involved in a first work session. Then, this first meeting aims to coordinate main partners, set meeting planning, milestone and exercise date.

Defining exercise's goals and its nature aims to set main characteristics of the training such as its timing, when and where it will set, who is involved in it and its scope (Gaultier-Gaillard, Persin, & Vraie, 2012). Depending of organization, theme may be defined in this step, especially when it is related to exercise's goals.

Moreover, choosing pedagogical goals is an important part of this step. Indeed, this choice will drive all the design process and determine the final exercise quality (Heiderich, 2010), (Fagel, 2014), (Alberta Emergency Management Agency, 2012), (Bernard, 2014) that cannot exist without relevant pedagogical goals (Gaultier-Gaillard, Persin, & Vraie, 2012). These goals must be clear and indicators must be defined to be integrated in exercise observation, especially to adapt exercise according to these indicators (Morin, Jenvald, & Crissey, 2002). First, trainees' pedagogical needs must be assessed, distinguishing competencies already acquired from those that must be enhanced through exercise (Jan & Muthuvelayutham, 2012), (Goldstein, 2002). This needs evaluation can be done by several means: meeting with trainees, previous exercise feedback, survey, or they may be directly expressed either by trainees or their management. Note that pedagogical goals are not

learning activities, they answer the question “what trainees must be able to do?” (Anderson, et al., 2000) but does not state what they have to do during the exercise. They may be formulated as a sentence with a verb, related to the action following the cognitive process, and an object describing competencies aims by the pedagogical goal. Pedagogical goals in crisis and emergency system will be described in Chapter 3.

Once exercise's goals and scope are defined, **exercise arrangement and scriptwriting** may start. Scriptwriting is closely related to goals definition because scripted events must lead trainees to develop competencies aimed by them (Center for Health Policy, 2006). Exercise scriptwriting describe event chronology or exercise management through these events which may be likely or, on the other hand, highly improbable (Walker, Giddings, & Armstrong, 2011). For crisis exercise scriptwriting, script may be triggered by one event which is the main problematic of exercise or by several events (Heinzen, 1995), potentially matching with different pedagogical goals. Therefore, scriptwriting consists in carefully choosing an event to both allow trainees to enhance their competencies and to credibly simulate a crisis situation (Crichton & Flin, 2004). For this, crisis scenario must be design taking into account following parameters (Gaultier-Gaillard, Persin, & Vraie, 2012) (Heiderich, 2010) (Lagadec, 2012): probability and realism of events involved, trainee awareness of such events, information accuracy provide by stakeholders on events, ease to communicate with other stakeholders simulated, tools provided by the simulation environment to trainees, crisis organization set up and how trainees are used of it, and emergency and unexpectedness of events that may be real-time driven (Walker, Giddings, & Armstrong, 2011).

The same way scriptwriting is related to pedagogical goals, the arrangement is related to the scope of the exercise. It consists in equipping the crisis room if it is needed and set up immersive devices used to simulate a realistic situation (Gaultier-Gaillard, Persin, & Vraie, 2012). The realism of simulation will be discussed extensively in Chapter 4. These arrangements come with several files that must be prepared to be exploited by facilitators and observers during exercise including sound, messages and communication, alert, fictional newspaper, data, support and other documents. Therefore, a wide range of files could be needed for the preparation of such exercise (Major Emergency Management Project Team, 2016), (Alberta Emergency Management Agency, 2012).

Once preparatory phases end, exercise time comes and this one must be managed through an **exercise management**. First, right before exercise or some days before, a briefing explaining goals, rules and scope – especially simulation limits – is presented to trainees. It should also clarify timing, goals, what it is expected from the exercise, and criteria of evaluation (Alberta Emergency Management Agency, 2012), (Gaultier-Gaillard, Persin, & Vraie, 2012). Moreover, each participant's role and missions may be reminded. Even if briefing is an integral part, essential to explain the whys and wherefores of the exercises, it may occur that it is not possible to set up such a proper meeting, especially when crisis managers should be in a non-alertness state to correctly evaluate crisis cells setting up and stress reaction.

Then exercise management itself consists in facilitating the exercise with previously developed files and observe trainees' reactions (McCreight, 2011). Facilitation must be realistic and in accordance with pedagogical scenario whereas observation must be carefully

done, based on observation grid adapted to pedagogical target. During exercise, facilitators inject inputs related to scenario events gradually according to established chronology and keep all exercise information consistent to maintain a realistic framework for trainees (Direction Générale de la Sécurité Civile et de la Gestion des Crises, 2013).

After exercise comes what it is considered as the most important part of the training: **the debriefing** (Fanning & Gaba, 2007) (Salas, Rosen, Held, & Weissmuller, 2009). Debriefing principle is “to experience an event, to reflect on it, to discuss it with others, and learn and modify behaviors based on the experience” (Fanning & Gaba, 2007). Reflexivity is a main part of the process and aims to focus trainee’s attention on what they have done to improve learning in a cognitive mechanism. These mechanisms are described in Chapter 3.

Debriefing directly after exercise may be the end of the training for participants but debriefing may go further after an analyze of what happened during exercise. **Review and analysis of exercise** is a critical evaluation of exercise, trainees’ reaction and emergency system effectiveness and efficiency. This analysis may be focused on individuals or collective performances (McLennan, Pavlou, & Klein, 1999), and may follow three kinds of assessment: operational rating related to pre-set indicators that are expected to be fulfilled at the end of the simulation, pedagogical rating related to competencies expected to be used and developed in the simulation, critical assessment related to the identification and explanation of mistake done in the simulation during the debriefing, and corrective assessment related to ideas proposed during debriefing to improve behaviors experienced in simulation (Crampes & Saussac, 1998).

Following the analysis step, **improvements identified are integrated in emergency system**. Exercises are then both a learning process and a review. These improvements may be widespread in global organization functioning especially as good practices in communication, creativity or teamwork (Robert, 2002).

1.3.6 Training examples and limits

As said previously, besides having a globally common structure, crisis and emergency trainings are very different from each other and may be classified in different categories, according to resources required to design such training and their complexity. Federal Emergency Management Agency – which shown a profit of training exercises in emergency field – defined a classification for crisis management training as Figure 13 shows:

Then different methods exist to train on crisis management that may be divided in two groups: **debate-based exercise** (in yellow, on left) and **practice-based exercise** (in orange, on right) (Limousin, 2017). Nevertheless, even if these exercises form a pedagogical continuum, three kinds of exercise are mainly set up (Trnka & Jenvald, 2006): Table top exercise, functional exercise and full-size exercise.

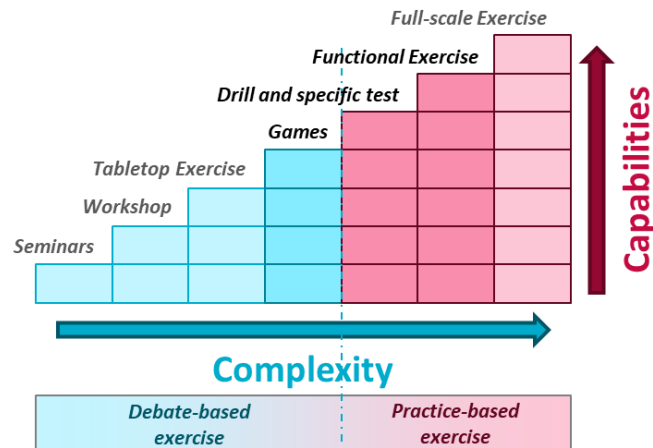


Figure 13: Building-block approach to exercise scheduling (Homeland Security and Emergency Services, 2014)

Debate-based exercises include workshop, seminars, table-top and role-playing games (Major Emergency Management Project Team, 2016), (Homeland Security and Emergency Services, 2014). They allow to easily accustom emergency and crisis stakeholders to emergency plans and introduce crisis management and how it is organized. Table-top exercises in particular are open situations where trainees freely developed a strategy based on their arguments and guides-lines or others resources. These exercises set as brainstorming meetings where participants progress step by step in developing their strategy.

On the other hand, they are not realistic enough to allow an effective immersion required to experienced emergency feeling (Borell & Eriksson, 2013). Then, as emergency timeline is usually unrealistic in these trainings, practical exercise is also needed to test technical equipment and validate how they are deployed in real time.

Moreover, these trainings imply a substantial work upstream from exercise designers to keep the table-top exercise under control. Indeed, because these exercises involve creativity, participants may propose new solutions if problematics are unknown or if existing procedures are inexistent or inappropriate. Then facilitators must be able to improvise to adapt script to these proposals while keeping exercise consistent and pedagogical. Therefore, it can lead to a complex and unstructured facilitation (Borodzicz & Van Haperen, 2002) with facilitators who may tend to replace script in a well-known situation.

Practice-based exercises include specific test, functional exercise and full-scale exercise aim to test both technical devices and actors' behaviors (Peterson & Perry, 1999). These exercises occur onsite, not in a simulator, and operations are usually fictitiously applied but transport and movement are really done and then give information on intervention delay time or time needed to evacuate a facility. Simulations may complete operations fictitiously applied to provide all correct input for crisis management. Moreover, in case of partial exercise involving only some stakeholders and/or focused on specific parts of the emergency plan, reactions of absent organizations are also simulated (Direction de la Défense et de la Sécurité Civiles, 2005).

Functional exercises are typical partial exercises that aim to test only some activities of the emergency plan (Peterson & Perry, 1999). They, however, take place in real time and must also integrate simulation (digital or not). Even if these trainings cannot reproduce all consequences and characteristics of a crisis that only a real situation can do (Bruinsma & De Hoog, 2006), they may simulate an important part of crisis processes then may be adapted to several pedagogical targets. Besides, because they do not involve all stakeholders, they are relatively easily set up.

On the other hand, direct or full-size exercises involve all (or almost all) stakeholders of crisis management to evaluate every function of emergency planning during a disaster (Peterson & Perry, 1999) and the coordination between persons, equipment and organization. Such exercises should be the ultimate step of a training or a review emergency system process, after several partial easier exercises (Fagel, 2014) that had previously tested every function separately (Major Emergency Management Project Team, 2016). Indeed, even if these exercises allow to train emergency planning actors in reality close situation (Direction de la défense et de la sécurité civiles, 2007), developing them is a complex and time-consuming task. Therefore, such exercises should only be used for main hazards and most important functions, especially because it is impossible to test or train on every possible – and infinite – disaster scenarios (Bruinsma & De Hoog, 2006). Full-size exercises are very instructive on how every service and organization react, work together, communicate or operate available resources, and according to what procedures they do it. Therefore, these procedures are also evaluated during exercises then may be improved, with complementary element or, on the other hand, by lightening them.

Therefore, because motivation is a main component of training efficiency, exercises must be adapted to the targeted public from awareness discussion-based easy exercises to more and more sophisticated and complete exercise. In the same way, external organizations must be progressively added to the simulation scope and should not be involved if there are still major internal dysfunctions in the target organization, it may be self-defeating for organization self-confidences and relation with these external organizations.

Aiming trainings progressiveness, Burtles (Burtles, 2006) classified exercises in five levels, according to the number of organizations involved and phenomena constituting an accidental situation:

- Level 1: One organization and one phenomenon
- Level 2: One organization and several phenomena
- Level 3: Several organizations and one phenomenon
- Level 4: Several organizations and several related phenomena
- Level 5: Several organizations and several unrelated phenomena

These five levels add up with the pedagogical continuum of trainings presented before and were resumed by Limousin (Limousin, 2017) with their advantage and inconveniences, as shown in Table 5:

Table 5: Pros and cons of training categories (Limousin, 2017)

Exercise category	Pros and cons of training categories
Seminaries / workshop	<ul style="list-style-type: none"> + Developing knowledge and allow to weigh different points of view (Borell & Eriksson, 2013). + Provide elements to recognize and conceptualize a crisis and identify possible responses (Milazzo, Bernier, Rosnet, Farrow, & Fournier, 2016). - Facilitators may have difficulties to ensure a consistent realism (Tena-Chollet, 2012). - Strong involvement and conceptualization abilities needed from learners (Limousin, 2017)
Table-top exercise	<ul style="list-style-type: none"> + Examine actions to do during a crisis and make use emergency plan (Sandström, Eriksson, Norlander, Thorstensson, & Cassel, 2014). + Question missions suggested by facilitators (Direction de la Sécurité Civile, 2008) and develop decision making process (Araz & Jehn, 2013). + Trainees are located in order to facilitate communication (Limousin, 2017) - Poor immersion and does not reproduce crisis characteristics (Tena-Chollet, 2012).
Role-playing games and simulation	<ul style="list-style-type: none"> + Collective thinking and emergency decision-making (Martin & Lhuillier, 2016). + Improved realism (Galvão, Martins, & Gomes, 2000). Safe environment, adapted for learning (Cannon-bowers & Bell, 1997) and allowing strengthened evaluation (Lapierre, 2016). Increase motivation by allowing trial-error process (Tena-Chollet, 2012). + Improve automatism (Pons-Lelardeux, Galaup, Segonds, & Lagarrigue, 2015) and teamwork (Tena-Chollet, 2012). - Only human system is tested, emergency technical system is not evaluated (Fagel, 2014).
Specific test	<ul style="list-style-type: none"> + Make use emergency dedicated tools and devices, and help to develop operational and perceptual skill. + Learning by doing and opportunity to repeat such exercise allow to strengthen skills and knowledge - Poor interaction with others organization and mobilize resources (Direction de la Sécurité Civile, 2008).
Functional	<ul style="list-style-type: none"> + Internal crisis cells coordination improvement (Bouget, Chapuis, & Vincent, 2009). + Realistic time-line and dynamics event (Tena-Chollet, 2012) thanks to control over input/output information flow (Direction de la Sécurité Civile, 2009). + Train to use crisis cells equipment (Homeland Security and Emergency Services, 2014). - Facilitation requires significant resources (Direction de la Sécurité Civile, 2008).
Full-size exercise	<ul style="list-style-type: none"> + Train to deals with situation evolution in a complex environment with a real time-line including transportation, set up and decision-taking (Direction de la Sécurité Civile, 2011). + Test and improve globally the coordination, interactions, control over the situation and performance of the crisis management system (Agence internationale de l'énergie atomique, 2010). - Minor modification of the scenario may appear and require heavy resources to simulate correctly crisis situations (Direction de la Sécurité Civile, 2008).

If each kind of exercises has its own pros and cons, they all aim the same target: train and prepare organizations to efficiently deal with a crisis (Borglund & Öberg, 2014) (Poumadere & Bertoldo, 2010). Nevertheless, the previous description only focusses on the scope of exercise – more or less complete – and does not explain pedagogical mechanisms they use and, consequently, how they are designed. Three main approaches exist to design crisis exercises: *cross-training* focused on individual skill, *Critical Thinking Training* based on the premise that extreme conditions make training more efficient, and *Event-Based Approach to Training* based on several discrete events as different learning situations.

Cross-training is a role-playing training where each trainee plays the role of another member of the team. The purpose of such inversion is that every member improves their global comprehension of the system by experiencing other function, point of view, needs and missions. Experimentation shown that this approach is efficient to improve anticipation of other team member needs, and comprehension of other works, utility and expectation. Even if this training is not dedicated to crisis management and need to be associated with

more specific training, it does not need a lot of resources to be efficiently set up. (Blickensderfer, Cannon-Bower, & Salas, 1998). On the other hand, even if anticipation and teamwork are critical in crisis management, cross-training occurs in an environment too different from crisis to efficiently train on crisis management competencies.

Critical Thinking Training (Cohen, Freeman, & Thompson, 1998) aims decision-making process improvement by flooding decision-making team with tactical information and make them solve a problem based on this massive amount information. That requires to reduce hypothesis and select relevant information without taking too much time in data management to keep time to actually solve the problem. Because crisis evolution strongly depends on the first step of crisis management and first decisions, this approach focus on how to deal with this emergency phase (Lagadec, 1993) (Flin & Slaven, 1995). This kind of training is similar to tactical decision-making games developed to improve tactical skills under the stress of emergency situations. CTT consists in the simulation of several emergency or crisis events that must be managed by a team up to ten trainees on the basis of this massive amount of scattered information dispatched between trainees that plays different predefined roles. They have to quickly decide what to do under unclear situation and with little useful information. CTT reproduces several characteristics of a crisis situation such as uncertainty, emergency or uncontrollability. Therefore, this approach seems relevant for crisis management but is too limited to cover all crisis competencies such as anticipation or teamwork (Tena-Chollet, 2012).

EBAT is based on naturalistic decision-making process (Fowlkes, Dwyer, Oser, & Salas, 1998), more common in emergency situations. It allows to develop trainees' skills in a realistic environment while providing a feedback on trainees' efficiency during simulation. EBAT consist in scripting two or three events that aimed specific pedagogical target, chosen during the preparation phase, and designing all the script based on these events that structure all the exercise. These events may vary in intensity during the exercise to match trainees' needs and keep them focused. Trainees evaluation is done during exercise with an observer taking note of trainee's performances on a list designed alongside exercise and events design and related to those events and what trainees are expected to do. At the end of the exercise, a debriefing occurs based on the filled list and behaviors observed during the training are discussed (Schaafstal, Johnston, & Oser, 2001). Therefore, EBAT offers a more "generic" framework for teamwork where every team member has its own features and seems adapted to developed strategic crisis management training (Tena-Chollet, 2012).

Note that other trainings exist, especially developed for aviation or medical, such as team coordination training (also known as Crew Resource management or CRM) (Eduardo, Bowers, & Wilson, 2001) aiming to improve teamwork, team self-correction (Smith-Jentsch, Johnston, & Payne, 1998) (Blickensderfer, Cannon-Bowers, & Salas, 1998) aiming to induce a reflective group-thinking on how the team work or stress exposure training aiming to acknowledge sensitize trainee to stress effect on performance (Driskell, Johnston, & Salas, 2001).

Therefore, considering pedagogical goals for strategic crisis management trainings and existing pedagogical methods, it seems relevant – as Tena-Chollet proposed – to merge EBAT and CTT in a hybrid methodology allowing both to support learners with dedicated

scenarios adapted to their needs and train them to decision-making under stressful situations, in close to real crisis and emergency situations (Tena-Chollet, 2012). The methodology Tena-Chollet proposed, based on “situation-task”, is presented in Chapter 4.

On the other hand, about the scope of strategic crisis management training, full-size exercise, even if they allow to simulate real-like situations, both at operational, tactical and strategic level, are difficult to set up because of cost, time, workers’ availabilities and external organization involvement. Table-top exercises, on the other hand, imply learners choose actions to do sequentially which is far away from crisis decision-making process and induce an important lack of immersion for trainee who are not under stress. In the end, functional exercises focus on some functions of crisis or emergency management system and then on one specific level that may be strategic as well as tactic or operational. They allow to induce a real-like dynamic in that level without involving other level or organization which reduces organizational difficulties but requires, on the other hand, simulation. Even if these simulations may be simplistic, it reduces the charge on facilitators and ease exercise design and facilitation. Then it appears functional exercises are the most adapted for strategic crisis management training.

Therefore Tena-Chollet, and IMT Mines Alès, choose an EBAT-CTT hybrid methodology on a functional exercise scope corresponding to pedagogical target and requirements related to these trainings. This methodology takes place in a dedicated simulator in IMT Mines Alès and is supported by a software platform: *Simulcrise*. Expert’Crise project – because it has to start its training right after its beginning – relied a lot on this existing simulator and these methods.

1.4 Chapter 1 Resume

A crisis is a serious, complex, disruptive, unexpected and uncertain situation that needs fast decision-making to avoid the destruction of the impacted system. It is a critical situation that overcomes protective measures set up and endangers surrounding environment. Even if specific installations such as Seveso companies have a dedicated regulation forcing them to plan several serious situations to be prepared for such circumstances, a crisis is always more serious than what the existing emergency planning and the team can handle. The team managing a crisis is called a crisis unit or a crisis cell and is composed of three main missions that may be affected to several functions: these missions are leading the strategic response, ensuring the strategic crisis cell functioning and leading crisis communication. A crisis unit composition is variable depending on the nature of the organization, its size and how strong it is involved inside or alongside emergency services. Indeed, because Belgian emergency work under a functional structure with services working together in five disciplines – Emergency response services, Medical, health and psychosocial aid, Local police, Logistical support, and Information – with a dedicated management, organizations highly involved in crisis management such as Seveso companies that must have dedicated resources to deal with major accident may work together with these services as a Logistical support (also known as D4).

Belgian regulation describes how every service must interact by defining a global framework in three levels according to the severity of the situation. Each level is related to

general and particular plan precising emergency planning organization. These plans describe each organization's functions as well as their mission and identify several crisis units where decisions are taken. Indeed, crisis and emergency organizations are a hierarchized system where operational decisions are taken close to the field of operation while strategic decisions are taken at a distant place, several hierarchal levels higher according to the situation. Therefore, as the crisis unit is the place where decisions are taken, cognitive process occurred and bias appears. Several biases well documented impact two important processes of the crisis unit: representation and decision-making. To prevent such biases to show during an actual situation, the best solution consists in training team members to face these conditions. Several kinds of exercise exist in literature focusing on different management levels and mobilizing more or less resources depending on targets aimed. After reviewing exercise's category, their pros and cons, it appears that functional Event-Based Approach to Training completed by Critical Thinking Training is a relevant approach, proposed in literature, for designing emergency and crisis training. Expert'Crise trainings are built on these first conceptual basis, completed with several elements detailed in the following of this document. Eventually, these trainings – including simulation exercises and theoretical courses – take a final form that is presented in the next chapter.

Chapter 2 **The Expert'Crise project**

Initially, the Expert'Crise project was not a research project but a training project, funded by the European Social Fund to achieve quantified targets and qualitative goals. Therefore, its main purpose consisted in producing emergency and crisis training for hazardous companies and critical infrastructures. Developing a design methodology was the most relevant and efficient thing to do but time and project constraints imposed to organized training from the very beginning of the project. That is the reason why, the design methodology was developed together with training and exercises production. Then, because the development of the design methodology relied on continuous improvement and feedback from exercises, Expert'Crise project can be seen as a starting point and as an end point. Therefore, considering this specificity, it seems relevant to present the context of this continuous improvement process which leads to the actual design methodology, i.e. describe the Expert'Crise project as a training project.

2.1 Target Audience and Goals of the Expert'Crise project

After the 2008 economic crisis, the European Union adopted a 10-year development strategy called Europe 2020. In this strategy, European Social Fund has a major role in achievement of employment promotion and social inclusion targets. The University of Mons (UMONS) and the Provincial Institute Training of Hainaut (IPFH) – respectively expert in chemicals risk management and emergency services training – submitted Project Expert'Crise aiming to found a joint training center for all crisis management stakeholders and develop immersive training modules. Indeed, crisis and risk management technical and regulatory evolutions have forced stakeholders to adapt to comply with new requirements. Expert'Crise project aimed to develop a crisis management training offer matching emergency stakeholders' needs to support them in these changes. Theses trainings, composed of traditional lectures and immersive serious game, should allow to practice the theoretical knowledge from lectures into simulations in order to evaluate collective and individual reactions under crisis.

The project was divided into two sub-projects each dedicated to one specific target audience to provide an adapted training to these stakeholders:

- A training developed by the IPFH dedicated to emergency services and local authorities based on reduced-model simulation around which different stakeholders interact to coordinate intervention.
- A training developed by UMONS dedicated to Seveso companies and critical infrastructure operator based on functional full-size simulation where

management must identify accident, coordinated first steps of intervention and communicate with emergencies services and authorities.

Due to the European funding, trainings could only take place in Walloon's "Transition" areas, excluding Walloon Brabant from this training program.

Therefore, UMONS' trainings target hazardous companies, critical infrastructure operators and, more broadly, companies that may have an important role in a major crisis because they are the cause of it or because they intervene with emergency services in crisis resolution. In these companies, the training specially focuses on workers directly involved in the safety of the installation and in emergency system: intervention team members, control room operators, prevention advisor, managers and directors, etc... Nevertheless, because trainings for intervention team members already exist in sufficient numbers and quality to satisfy demands, Expert'Crise project focusses on strategic emergency level, usually held in crisis cell by managements board of companies: site manager/director, SHE managers, production manager/director, technical managers, HR manager... Because functions involve in emergency planning (and how they are named) significantly change from a company to another, a companies' emergency system analysis is proposed in Chapter 6.

When Expert'Crise project was submitted to the ESF, besides target audience, goals of the project were discussed. These goals aim to answer to Europe 2020 and ESF problematics by teaching, training and improving employability of struggling industry workers. Five activities were identified: developing a simulating infrastructure, developing a pedagogical methodology, developing a scenario library, considering the human factor in crisis management, developing a training program. Each activity was defined with quantitative or qualitative target and deliverables.

A1. Developing a simulating infrastructure

This activity aims to develop a simulation platform replicating Belgian emergency planning decision centers in rooms including communication and multimedia devices: call center, radio, control screen, television and so on. Pedagogical activities should take place in Régie Provinciale Autonome (RPA) Hainaut Sécurité, an Expert'Crise partner on this project, providing building and rooms to set exercises and trainings. The platform should also include a facilitation room where facilitator would be able to interact with trainees through devices and with the support of a software platform allowing to display information, videos or other stimulus improving simulation realism. This software, Simulcrise, developed by the IMT Mines Alès, allows, through a multi-agent system, to simulate complex human and physical situations in real time while injecting trainee's decisions (or facilitator input: perturbation or help) in the digital simulation. This simulation framework would work together with a monitoring system composed of several technical devices (sensors, recorders, software...) and allowing to capture and process human activities during simulation. These sensors (ocular, heart rate) would aim to provide information on trainees' emotional and cognitive state during simulation. This activity had three deliverables: the training framework including rooms, multimedia devices, simulation software and others equipment, technical documentation explaining how to use the training framework, and a training of the trainers in the training framework.

A2. Developing a pedagogical methodology

A specific pedagogical methodology is needed to fully operate the training framework. This one must include traditional lectures, immersive training in simulation platform and a feed-back process to target deficiencies in emergency management, especially based on trainees' activities analysis.

Traditional lectures would focus on several point of emergency planning regulation especially internal and external emergency plan, specific Seveso regulation, and latest emergency services re-organization. Other points would be developed according to the needs statement of the companies. Immersive training would then validate theses knowledge, test them or reinforce emergency management skills. Then, thanks to human activities monitoring, a debriefing process with an individual follow-up would be suggested with, for instance, theoretical complements or new simulation focus on specific activities. Yet, individual analysis is only a part of the global analysis of the emergency management system involving individual reaction but also collective representation, decision-making and action. This analysis would lead to an emergency plan optimization, highlighting good (and bad) practices and, improving how simulations are made and how they are scripted. This activity had two deliverables: a pedagogical methodology merging technological and behavioral aspects of crisis management, and a set of performance indicators system to evaluate trainees.

A3. Developing a scenario library

One main purpose of Expert'Crise is to propose reality-like scenario, as close as possible to professional and operational environment. Based on technical documentation, safety report, and emergency plan of the company, one or several scenarios directly linked with accidentology would be developed then proposed to trainees. These scenarios should proceed automatically, integrating trainees' decision in the simulation through the interactive platform, but also allow facilitators to amend the simulation in order to emphasize a specific pedagogical aspect. Therefore, these scenarios should be modular, allowing to pass from an internal emergency to a major accident involving a lot more stakeholders such as emergency services, authorities or media. This modularity should lead to developing a scenario library composed of generic scenario easily adapted to trainees' needs. This activity had two deliverables: a documentary database of emergency planning and industrial accidentology and a generic scenario library that can be adapted to trainees needs.

A4. Considering the human factor in crisis management

The human factor has a significant role in each phase of crisis management from the realization of the gravity of the situation to the experience feedback. Nevertheless, psychological aspects are often only considered as aggravating factors and emergency or crisis analysis rarely focus on them. The Expert'Crise give a prominent place to analysis of human activities during crisis and aims to include human factor in the processing of the simulation framework in order to increase individual and organizational resilience. Therefore, exercises would simulate "out of focus" situation to confront trainees to situations where flexibility, improvisation and creativity are needed. Considering the human factor in scenario aims to make trainees face surprise and anticipate breaks in the organization, make them experience usual crisis psychological effect such as stress, fear,

tiredness or overwhelms then make them note their own mistake or psychological bias and, ensure important interaction between stakeholders in order to identify characteristic dysfunctions of crisis complexity. This activity had three deliverables: a human activities analysis methodology related to simulation event, a set of psycho-behavioral performance indicator system to assess trainees during exercises, and a follow-up process aiming to improve human efficiency in a crisis.

A5. Developing a training program

This activity is the core of the project and aims to propose high added value trainings in a developing field that rely on previous discussed project goals. As every training, it will need preconditions that will be provided in introduction lecture modules such as legislative context. The training by itself would be mainly practical through the simulation that will be adapted and customized to professional trainees' environment.

The simulation will focus on critical points of emergency management such as emergency alert, emergency procedures application, notification to the authorities, neighboring communities' information, coordination with internal firemen, reception of emergency services, post-emergency management and coordination of works to bring into conformity installation and restart operation. The simulation will be followed by a debriefing phase and trainees would be able to discuss about their performance in crisis resolution during a "hot" debriefing then in a "cold" debriefing, after exercise in deep analysis. These debriefing should allow to propose an individualization of the training and a personal coaching aiming specific competencies than would be tested in following exercise. This activity had five deliverables: a detailed training program on the different aspects of crisis management, a support for emergency planning development and implementation in the target organization, a set of adapted pedagogical support, an individual follow-up methodology for improvement and evaluation of individual competencies, and 3.360 man-hour of training given: 168 in 2015, 840 in 2016, 1008 in 2017 and 1344 in 2018.

It appears, at the end of the project, that some goals are either utopic, self-defeating or out of reach for a three-year project. The A1 activity was very ambitious, the A3 activity is almost not applicable because companies' organizations are too different and the A4 activity focusses on individual follow-up while it appears a collective analysis is more relevant and is less problematic. These activities were the start point of the Expert'Crise project and their limits will be discussed across this document.

2.2 Framework of Expert'Crise training and continuous improvement process

Expert'Crise project, as previously discussed, was a training project limited in time, resources and without connection with a research project. Because the project starts from scratch, first sessions were highly inspired by existing trainings – especially IMT Mines Alès' one – then were improved in a continuous improvement process. Therefore, this development method was experimental and that aspect was introduced to industrials as the counterpart of free trainings: they received free crisis and emergency management

formations and we used their feedbacks to improve next sessions. Also, this operating mode – stuck between the need to continuously produce trainings and starting from scratch – imposed to design a simulating platform a priori, assuming how it would be used.

Despite the continuous improvement process, the framework of the training proposed remained the same throughout the project as described: one to six theoretical course modules (cf. 2.3), briefing of some or all the trainees, simulation exercise, “hot” debriefing right after the simulation, analysis of the simulation and “cold” debriefing as represented in Figure 14.

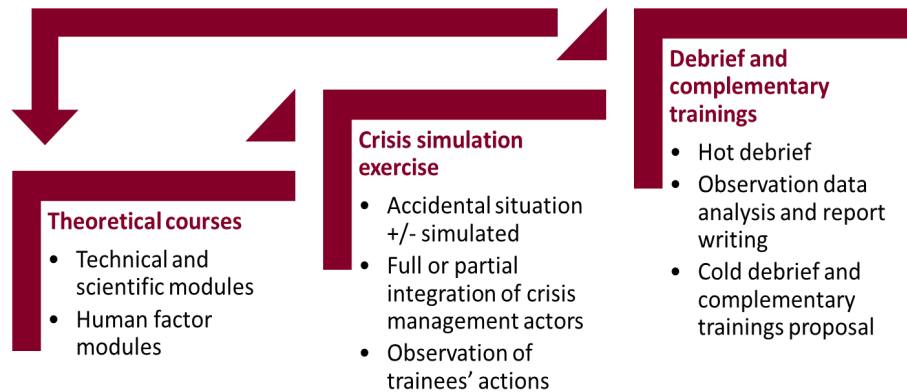


Figure 14: Structure of the Expert'Crise training

Nevertheless, inside this framework, each step has evolved thanks to the continuous improvement process taking into account previous mistakes, bias, limits and suggestions of improvement into account.

Expert'Crise worked in project mode and each training proposal was considered as a new project where every step proceeds: commercial prospecting of companies, lead qualification and needs analysis, training proposal and customization, theoretical courses, simulation preparation, simulation training, simulation analysis and debriefing. Each step was improved from a proposal to another implementing previous feedback and adapting to

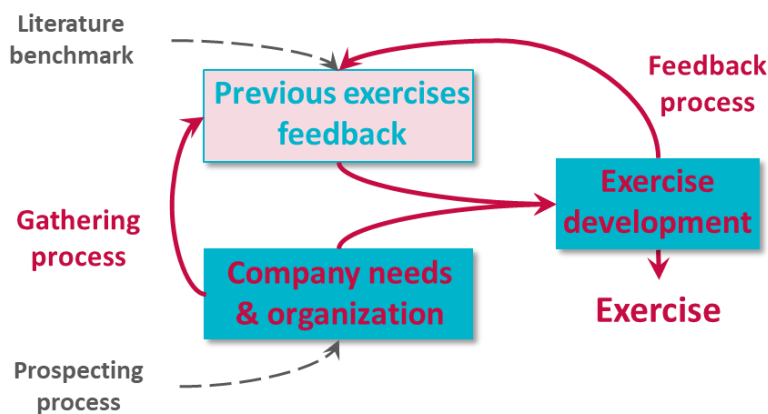


Figure 15: Continuous improvement process

different companies' organization, however only simulation design and conduct was collectively discussed.

The internal continuous improvement process – represented in Figure 15 – based on a first debriefing some days after exercises where facilitators and observers shared, on an informal basis, the good and bad points of the exercise and suggest how exercises could be improved for the next time. This debriefing usually follows the pooling of notes and commentaries needed for the study of the exercise. Then, during the analysis and the writing of the report, difficulties experimented by the company are identified and a special attention is given to those induced by exercises bias. In this way, the company was not blamed for simulation limits and failures.

Independently of this continuous improvement process, time and project constraints reduce exercises preparation time. Indeed, as indicated in the Table 6, one exercise was organized in 2015, two in 2016, four in 2017 and seven exercises in 2018. This exercise rhythm was possible thanks to the rationalization of exercise production with a flexible methodology that allowed to propose an adapted exercise to each company.

2.3 Lectures

Trainings started with theoretical lectures on crisis and emergency management in Seveso companies. These trainings were held by UMONS teachers in companies that allow to customize trainings to the particular needs of the targeted companies. Then trainee groups were relatively small from about five to fifteen persons which is a good environment for interactive courses including workers' experiences feedbacks or exchanges. However, these trainings stayed mainly ex-cathedra and were few interactive.

Teaching of crisis and emergency management specific knowledge was done through a seven-module program. Each module was about two/three hours long and cover a wide scope of topics needed in Seveso organization's crisis or emergency management including reglementary, scientific as well as psychological aspects. These modules were designed and taught by Chemical Engineering service of the Polytechnical Faculty for technical and scientific modules (in **blue**) and by Occupational psychology service of Psychology and Educational sciences Faculty for human factor modules (in **red**):

- **Module 1:** Crisis Management Introduction
- **Module 2:** Hazardous Substance: Properties, Classification and Transport
- **Module 3:** Human Factor and Safety: Individual Aspect
- **Module 4:** Accident Phenomenology and Experience Feedback
- **Module 5:** Human Factor and Safety: Collective and Organizational aspect
- **Module 6:** Emergency Planning in Belgium
- **Module 7:** Human Factor in crisis management: Key-points for implementation in emergency systems

These modules were designed to cover a wide scope of topics and were sometimes too advanced or inadequate for companies. Therefore, all modules were not given to every company but only those matching with previously identified needs.

Technical and scientific modules aimed to provide theoretical knowledge that may be needed in crisis management and focus on physics of chemical accidental phenomena as well as technical and organizational systems that should or may be set up by industrial organization – especially to meet regulatory requirement – or emergencies to mitigate these situations. **Human factor modules** aimed to introduce concepts and principles allowing to efficiently implement human factor in crisis management and communication and, more broadly, improving safety culture. These modules deal with both strength and weakness of human agents, the importance of teamwork, possible defects of crisis management and what makes a resilient organization.

Module 1: Crisis Management Introduction

Human societies are subject to a wide scope of risk, natural such as anthropic ones. To face this vulnerable state, peoples set hazards management and control systems in particular for hazards produced by their own activities that induce technological risk. This module aims to introduce that every society is subject to hazards and accept a risk level for each hazard if they are managed and have interesting counterparts such as job creation or territory wealth. Risk related regulation for SEVESO companies, especially in emergency and crisis management requirements, is also introduced in this module alongside with stakeholders involved in crisis and emergency.

Module 2: Hazardous Substance: Properties, Classification and Transportation

Technological risks are implied by human activities and are categorized accordingly human activity groups. Therefore, among technological risks, this module focusses on industrial risk relying on hazardous substances or activities exploitation by industries. Seveso regulation deals more specifically with hazardous goods and defined requirement depending amount of dangerous substances onsite. This module introduces main physico-chemical properties of dangerous substances, preferably used in the companies, that may be required in safety and risk management. Then a focus on substance classification, based on these properties, is done with a presentation of the CLP regulation (European Parliament and Council, 2008) and an introduction to dangerous good transportation, spotlighting main transport means used in the organization.

Module 3: Human Factor and Safety: Individual Aspects

The human factor plays an important role in the organization's safety both as a reliability and unreliability factor. This module focusses on individual human factor introducing the concept of human error and how these errors are managed in practice with the "threat and errors management" model. Main threats for human reliability are reviewed: stress, over-confidence, loss of situational awareness, defective decision-making etc. This course details measures that may be set to ensure human operator performance regarding system management, related to technical professional skills, situation management, related to non-technical skills and self-control, related to attitude (Chapter 3).

Module 4: Accident Phenomenology and Experience Feedback

Accident phenomenology is well known and documented. It usually proceeds in three phases: a trigger event releasing hazardous potential of an equipment, a central event related to physical phenomenon turning potential hazard in effective hazard with harmful consequences, and impacts of these consequences on target, human or not. This module aims to describe main physical phenomena through simplistic model that may be used in

emergency situations. These phenomena are illustrated with experience feedback, possibly related to organization history.

Module 5: Human Factor and Safety: Collective and Organizational aspect

This module introduces collective and organizational part of human reliability. It focusses on teamwork and its significance in system safety, especially through risk-related behavior such as perception and cognition bias, profession defensive ideology or caution skills. Group behaviors that may impact decision-making are discussed (see 1.3.2) and practical advices are exposed to avoid defective decision-making. On organization level, High Reliability Organization is introduced and main lessons that may be learned about risk management are discussed.

Module 6: Emergency Planning in Belgium

When a disaster occurs, dedicated process is triggered in organization to operate the safing of installation and, if needed, alert emergency services. These services follow their own procedures with dedicated requirements. Therefore, it may be relevant to know how each actor onsite work to ensure an adapted emergency management with an efficient communication between stakeholders. This module aims to present the Belgium emergency planning, organization both from a regulatory point of view and a practical point of view, explaining how services organize onsite (see 1.2).

Module 7: Human Factor in crisis management: Key-points for implementation in emergency systems

Crisis management burden human agents involved: uncertainty, stress, time distortion, surprise, fear... and some competencies are needed to face these situations. This module aims to present these competencies and their importance in each crisis phase, including feedback phase, with a spotlight on out of focus crisis. Crisis cells efficiency condition – such as management involvement – and communication good practice are then introduced.

Module 8: Companies dedicated module

An eighth module, customized for each organization – after or before exercise – was initially planned. Nevertheless, no companies were interested in such training modules and no resources were allocated to develop it. Then it was never taught.

2.4 Simulation and Training infrastructure of the Expert'Crise Project

Exercises – as well as lectures – were held on industrial sites and used rooms, tools and communication devices available to operatives and decision-makers both in their work-life and during emergencies. This configuration allows immersive situations for trainees without destabilizing them too much (Cook, 2010). In addition, it provides an emergency system test for companies in accordance to European regulations (European Parliament and Council, 2012). Exercises are mainly functional (Tena-Chollet, Tixier, Dandrieux, & Slangen, 2016), focused on decision-making functions (Lagadec, 1995). The operational part is often simulated through the control of information flows entering the crisis room. Therefore, these trainings aim members of the crisis management team and key persons in the warning chain.

Exercises rely on material arrangement and human organization. The human organization refers to facilitators regulating the exercise (Fréalles & Tena-Chollet, 2017) near trainees (or at distance) and observers consigning what happened during the event. Experimental device is composed of cameras, microphones, projectors and sound-speaker that allow immersing trainees in the fictional situation and, on the other hand, capturing multimedia flows that are lived-streamed to distant facilitators to help them adjusting the scenario and saved to complete observers' notes for later analysis.

These arrangements and this human organization are the result of both project or material constraints, and experience feedbacks from the IMT Mines Alès where a research team has been working since 2010 on a crisis simulator and inspired considerably this work. Indeed, because the timing of the project was tight, first organized training sessions could not be developed from scratch and needed a template. That is why, at first sight, pedagogical context was not totally clarified as well as materiel equipment was not neither acquired nor decided. It is only after first trials we were able to set a proper pedagogical and material setting. Therefore, one of the first steps of this PhD thesis was to understand this context and characterize the serious game provided in Expert'Crise project.

2.4.1 Expert'Crise material arrangements

Designing such infrastructure – even with important feedbacks from previous experiences – requires to use system conception methodology starting with a functional analysis. Reviewing emergency and crisis trainings has highlighted four main functions for Expert'Crise framework: ensure an immersive and realistic enough environment, allow to facilitate and simulate a pedagogical environment for trainees, allow to observe trainees, and record their behavior. These functions match with two kinds of data flow: input ones for immersion and facilitation, and output ones for observation and recording. These information flows have to be directly operable by human – without intermediate software treatment – then must be related to one of the human perception organs. Therefore, because they are both most “prominent” sense and because these senses may be easily covered with a technical solution, we focus on two senses: vision and hearing. These four functions lead to four dedicated systems, plus one support system providing technical resources to others ones: audio and video immersive system, audio and video recording system, exercise monitoring system, facilitation system and network system.

These systems should take place somewhere then, besides functional analysis, organization and localization of devices that composed the infrastructure must be defined before choosing them in order to make correct choice in size, mobility, autonomy, etc.... As said, exercises were held on industrial site so adaptation was required, including high mobility, little footprint and high autonomy in energy and network. Nevertheless, because exercises focused on crisis unit, main points of interest remain approximately the same from an exercise to another. It was usually a meeting room used as a crisis cell and connected to different others “minor” points of interest – similar to sub-cells – such as control room, guard post or onsite, in front of impacted installations. Then it requires to be able to split the material in different places while keeping them working together even if distance is important. On the other hand, because external environment was simulated by facilitators, it requires another room, so called « facilitation room » to install them without direct

interactions with trainees and equipped with mobile facilitation devices. Note that initially the Expert'Crise project should take place in Régie Provinciale Autonome (RPA) Hainaut Sécurité buildings, stakeholder of this project, but due to building delays, exercise infrastructure had to be developed independently of these future buildings. That is the reason why some parts of the infrastructure are more adapted to a static simulator as IMT Mines Alès's one and cannot be correctly valued in a full nomad setting.

Bringing technical solutions to develop each system was an iterative process based on the addition of new technical constraints, our first exercises' feedbacks, and news from RPA Hainaut Sécurité that made progressively move infrastructure from a semi-static one to a full-nomad one. Nevertheless, design time was relatively limited because of project accounting constraint. Solutions taken for Expert'Crise are presented here after and resumed in Figure 16.

Audio and video recording system

This system is composed by four JVC GY-HM200 cameras with their batteries and memory cards, associated with DIAT A203KS20 tripod when there is enough space or, if needed, small phone Manfrotto Pixi Smart tripod. Sound capture is ensured by hyper-cardioid Rode NTG2 or cardioid Rode NT4 directly plug in the camera XLR audio input and substituting internal camera micro with a mono sound capture with a better range for NTG2 microphone or a good spatialized stereo sound capture with NT4. These cameras may be covered by a rain-proof "wetsuit" to operate outside, even in case of bad weather. This system is fully autonomous but may require a battery changing operation during long exercises of three or more hours.

Audio and video flows recorded during exercises are processed during the analysis phase because they cannot be directly exploited right after exercise, during the hot debriefing. Nevertheless, even it is a heavy job, record analysis brings relevant information on crisis management process, especially when management stakeholders are dispatched in several places.

Monitoring system

Meanwhile, cameras record audio and video flows on a memory card, monitoring system focuses on providing to facilitators a representative picture of what happen at different points of the exercises. This system is composed by ten Samsung S6 smartphones on a Manfrotto Pixi Smart tripod and associated with Rode VideoMicMe to improve sound capture and battery extension to improve phones' autonomy.

Phones are connected on local Wi-Fi if available or on 3G network and live-stream capture on a Periscope software private room. Periscope is a free to use Android application allowing to live-stream video either publicly or to private groups, its main advantage is to allow freely to connect and disconnect to streamer flows without any actions needed from streamer device. Then this feature counteracts undesired disconnection due to network instability and allows to reconnect easily, in contrast to Skype or some other software. Observation of these flows is supported on phones or on laptops on Expert'Crise dedicated Periscope profiles. Nevertheless, because Periscope is not natively supported on Windows, Android is emulated – with a free to use software called Nox – on laptop to allow to run Periscope. Often, because relevant areas are the same for recording and monitoring, smartphone are mounted on camera-hand to reduce the footprint of the installation.

Smartphones of this system may complete recording system if more than four cameras are needed. In that case, smartphones record in their internal memory. Alongside they were also used in the facilitation system to control Bluetooth devices and get quick feedback on what happen onsite through Periscope monitoring, and be used in network system to provide a Wi-Fi connection instead of nomad 4G Modems.

Audio and video immersive system and Facilitation system

Immersive system was designed according to possible inputs that can be injected in a crisis simulation: outside call, chat message or mail, social network reaction, media feedback, fax or direct voice interaction (Fréalles & Tena-Chollet, 2017). Sound and image from the outside of the crisis room may be also relevant. Even if others sense could be involved such as the smell or the heat perception, equipment to simulate such feeling – as dedicated smoke machine or thermal panel – was both unpractical and financially out of reach. Therefore, only hearing and vision were exploited.

For the vision, facilitators can broadcast video, photography or any other picture on two kinds of support: two Surface Pro 4 tablets that may also simulate interaction with control panel, and projectors and their display. Tablets aims to broadcast or simulate punctual input or interaction such as the video of an area at one precise moment then they may be widely used by facilitators to accentuate trainee's immersion. Projectors, on the other hand, aims to provide a static and long terms presentation, such as informative or atmosphere display. This kind of equipment may also be used outside industrial site as said below. For the hearing, facilitators can use five Samsung Xcover 3 smartphones dedicated to simulating external stakeholders and four JBL Xtrem Bluetooth speakers that may broadcast several audio medias such as atmosphere sounds – such as rain – or discrete event sounds, as explosions or firemen horn. These speakers are controlled by Bluetooth with a laptop or Samsung S6 smartphone. Alongside, if the four speakers are not required for immersion and facilitation systems, they may also use as audio output for the monitoring system.

A mobile classroom composed of fifteen laptops, three projectors and their display also composed this system. It was designed to allow to realize exercise elsewhere than on an industrial site, inside the University or in RPA buildings. Laptops are still used to support other systems and projectors are used for lectures. Laptops work on the standard UMONS configuration and get installed by connecting all laptops on an UMONS network with a dedicated switch, presented in the network system, and starting the installation procedure on each laptop. Because reinstallation was not frequent, we did not improve this procedure, but a script could be written to automatize this one.

On the fifteen laptops, ten were dedicated to be used by trainees outside of industrial sites where they could not use – for several reasons – their own computers or devices and then these laptops must provide essential computing tools to simulate a standard office room. Therefore, these laptops must have a basic software suite – text processing, spreadsheet, configured mailbox, internet connection – and additional services could be added according to training needs with software chosen during exercise design.

Five other laptops of this system are dedicated to facilitation and aims several targets. First, they allow facilitators and observers to monitor multimedia flows without directly interacting with trainees. Then, they allow facilitators to run Mines d'Ales simulation software – so-called Simulcrise – that simulate crisis situations through a multi-agent

simulation and allow to modify in real-time evolution of the situation according to trainees' reactions (Tena-Chollet, 2012). Facilitators then can, according to simulation output, inject information in the crisis room through facilitation devices. These laptops may also be used to send e-mail to crisis room during the simulation. Nevertheless, despite promising outcomes, due to the difficulties to customize the software to Expert'Crise needs – especially the nomad aspect – it was not significantly exploited through the project.

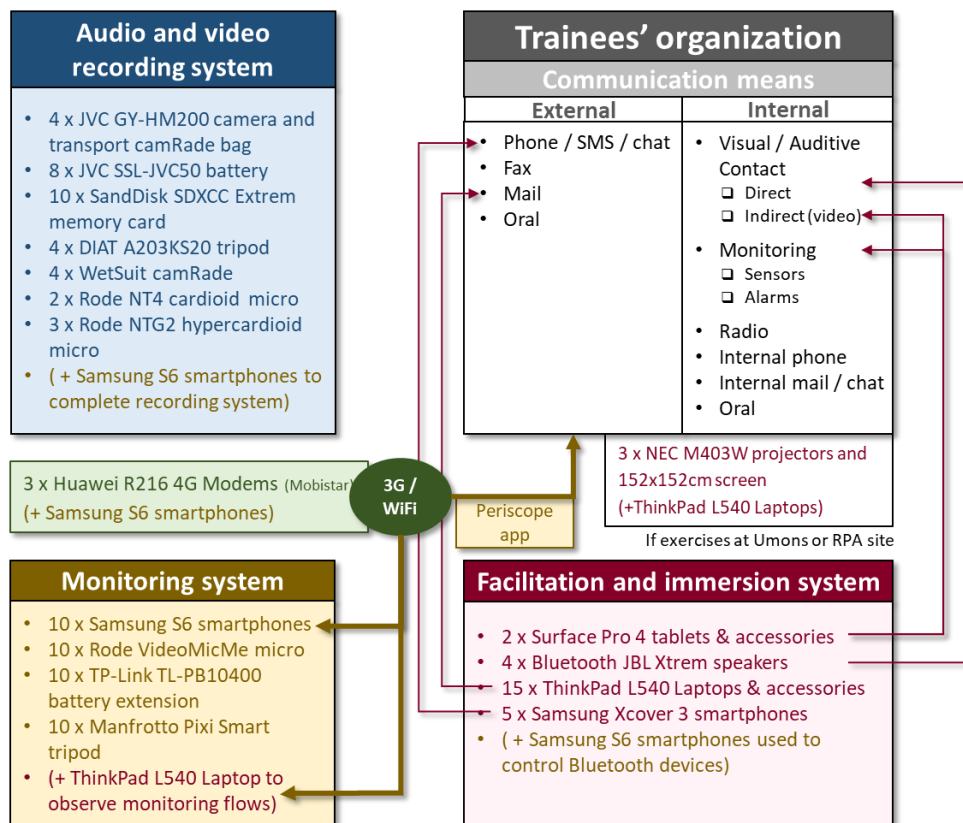
Network system

However, to be fully operational, laptops must be connected to the Internet either to get media flows from monitoring system or to send mail or run immersive devices. The easiest solution consists in connecting our devices on trainees' companies Wi-Fi. Nevertheless, because some companies have strongly restricted Wi-Fi, we had to consider cases where we have no Wi-Fi and be totally autonomous: it is the mission of the network system

This system aims to connect devices with each other and make them work together. As previously said, the framework is mainly supported by 3G or Wi-Fi network and does not rely on any external supply to be operated. The first designed framework draft was way more complex, integrating the RPA facility network as building requirements, but has to be simplified and reduce to a minimalist nomad infrastructure. This simplification was possible, especially by using versatile devices such as smartphone, which may match several needs. On the other hand, this way the designed system is more adaptable and may be either used for different needs or be easily dismantled for match other projects' needs.

This system mostly supports other system and is composed of 3G modem planned to provide 3G to different devices, especially laptop and a network switch used to configure laptop and, when it is appropriate, to connect laptop to a local network for exercise outside industrial site. Ten telephone subscriptions were required to operate with telephones and 3G network: five telephone subscriptions without data pack for each Samsung Xcover 3 smartphones and five data only subscriptions for support all 3G requiring devices.

All sub-systems and their interactions are resumed below in Figure 16.



+ Switch GS1100-16 10/100/1000 for configuring laptop and, eventually, build a local network.

Figure 16: Expert'Crise material arrangements

2.4.2 Expert'Crise exercise settings

Expert'crise exercise material setting is closely linked to trainees' organization and its specific statement needs then it may significantly vary from an exercise to another. Nevertheless, some parts of this setting remain constant alongside exercises then may serve as bases for a generalization of Expert'Crise setting.

First common element of exercises is the companies' emergency organization. Even if they vary as we will extend it in Chapter 6, main emergency functions remain the same as well as their spatial distribution. Emergency system usually relies on a crisis cell where management meets, several sub-cell "rooms" including the control room, guard post or maintenance office working on specialized tasks, and onsite intervention where two areas may be distinguished: very close to disaster to operate mitigation missions and a little behind, at a safe distance, where tactical decisions are taken by the intervention team chief. Note that sub-cell "rooms" are not always room strictly speaking and may be a corridor, a lodge or even outside. Moreover, another area completes these three kinds of point of interest: the facilitation room previously introduced that take place in an empty office or meeting room of the organization depending availability. Global room organization is represented in Figure 17.

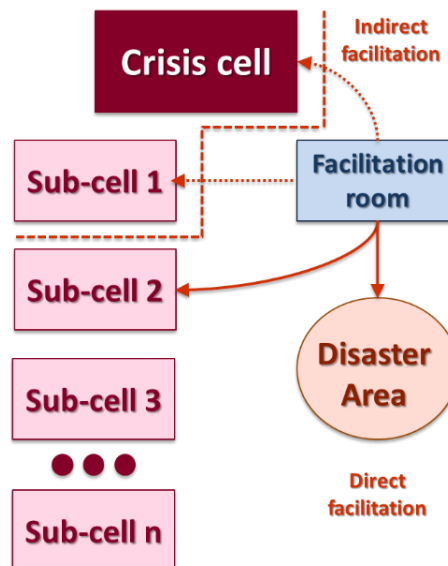


Figure 17: Exercise point of interest

According to this first scope and based on who is the target audience of the training, points of interest are split in two groups: those where facilitation will be indirect and with as little interaction with exercise staff as possible for target audience, and, on the other hand, those where facilitation will be direct and facilitators will interact with trainees as themselves, without playing any role. Then the relative importance of each point of interest is assessed to adjust equipment and human repartition. An important point of interest may be composed of worker that does not belong to target audience. This part of the exercise design is extended in 6.2

The more a point of interest is important – because a lot of emergency actors meet there, a lot of decision is taken there or there is important information flow in the room – the more equipped it is, meaning more captors are set in such location to capture what happens there for later analysis. The “standard” setting for an important point of interest consists in: a JVC camera on a DIAT tripod with a NTG2 micro if both outside and with distant trainees or with NT4 micro on a deployed Manfrotto tripod if both inside a room with several trainees, one or two Samsung S6 smartphones use as a monitoring camera either directly mounted on JVC camera or on Manfrotto tripod and with its dedicated accessories, and, if needed, a JVC speakers. Note that Rode VideoMicMe for Samsung S6, because of 3G interferences, only work with Wi-Fi or for recording.

If there is no need to have cameras elsewhere in other point of interest, more than one camera may be set, according to available footprint to not bother trainees.

Moreover, equipment set up, observers are also dispatched between important points of interest, depending UMONS and trainees’ organization's observer's availability. During exercises provided, expert UMONS observers and facilitators were privileged dispatched at the most important points of interest and company's facilitator/observer were dispatched in less important area. The same way as before, how facilitators and observers are dispatched will be extend in Chapter 7.

Less important areas are equipped with only one Samsung S6 smartphone use as a monitoring camera or, sometimes, as a recording camera to capture first emergency actions or to provide punctual information on what happens onsite. Immersive devices may although be set in these places to inject first emergency inputs and start the emergency chain for example. Observers as well as facilitator may be temporally assigned to these areas then move to more important areas.

On the other hand, facilitation room was equipped with one to three laptops allowing to observe monitoring media sometimes connected with projector and Bluetooth speaker to keep attention on the main points of interest, and Samsung Xcover3 smartphones to simulate external stakeholders. Note that to contact these phones, a directory is either display, communicate or deliver to the crisis center to avoid they contact real external stakeholder. This directory was one of the main practical reasons – besides pedagogical reasons – why a pre-exercise briefing was required, even if, when no briefing was possible, it was not too problematic.

Besides facilitation, these phones may be used by dispatched facilitator to get information on exercise progress and information transmission. These communications are usually brief and only aims to make a small point of situation, occasionally they also serve to take decisions required to adapt the scenario to trainee reaction. They may be planned in the scenario or unplanned and occurring when needed.

2.4.3 Expert'Crise exercise conduct

Even it is not possible to give a complete and representative picture on how an Expert'Crise exercise is conducted onsite, it is essential to provide a global description of them otherwise the previously described system remain an empty shell. Therefore, this paragraph aims to summarize how this kind of training process, especially focusing on exercise by itself without detailing all briefings, debriefings and lectures.

First of all, a facilitator either onsite or in a control room near a first witness of the simulated disaster describe partially the situation. This description only focusses on points seen or felt by the operator according to position, devices used or wind. This trainee then triggers warning system according to procedures and the facilitator precise if some actions are not simulated (such as shutting down all the installation for real) and the warning signal spread the emergency system and its actors get mobilized. First emergency information may also be sent from facilitation room, where a facilitator may call trainees' organization to alert there is a problem at some place, although the consequence is the same: emergency system is triggered.

During the alert phase, every person involved in emergency management is taking its place – after several movements, eventually accompanied by a facilitator and/or observer – on crisis cells, in sub-cells or in front of the disaster. Note that disaster intervention may be simulated in a table-top exercise, not realistic but only aiming to provide inputs to crisis cell while involving intervention team chief in the exercise, even if this one is not focused on intervention. Then, when every emergency protagonist is mobilized, a facilitator may inject scenario inputs to different cells, either directly – for out of focus trainees – or indirectly for the target audience.

Direct facilitation consists in describing the situation to trainees and asking them how they react and what actions or decisions they take. It is then a discussion between facilitator and trainees on the development of the disaster, possibly relying on maps or schemes. Indirect facilitation, on the other hand, consists in simulating several stakeholders impacted by the disaster and calling (or contacting by other means) cells to deal with their issues.

Therefore, there is communication between facilitator and trainees but also between trainees themselves to discuss different information they get and make decisions. Onsite intervention team chief may for example provide regular feedbacks to crisis cell and ask for resources or technical information while media sub-cell may inform crisis cell of media and politic pressure to gather direct information on the situation from the crisis cell.

Each facilitator has a facilitation sheet explaining inputs that have to be injected, when or after what sequence of events and how. These sheets may have conditional inputs depending of events on another point of interest, under the responsibility of another facilitator, then coordination may be needed. Facilitation instructions are deliberately open enough to allow facilitators to adapt them to trainee's reaction. Therefore, injection time may be flexible mentioned as “about 15h10” or strict as “at 14h03”. Nevertheless, main modifications have to be transmitted to the Game Master that is in charge of the simulation consistency. Game Master is a facilitator that may either have for only mission to follow exercise and take decision to keep simulation consistent or, if there is not enough facilitator, also mentoring trainees as other facilitator. This mission requires to know well the scenario played and was usually ensured by the scenario designer.

This setting allows to test several pedagogical targets, see in 6.3, and may be completed by punctual trainee movements from a point of interest to another as in real life. In that case a trainee from target audience may directly interact with facilitator then go back to the crisis room. This particular situation must be clearly identified and trainees must be warned if a point of interest – typically the disaster area – is simulated and where it is simulated to avoid that they move to the actual disaster area and find nobody without having any directions.

End of the simulation is usually time-dependent, exercise last about 2 hours, but may either shorter if the emergency management system is not developed in the company or longer if a lot of topics have to be discussed and according to participants availability. Therefore, the end of the exercise is written on facilitator sheet and a dedicated one have to warn other of the end of the simulation. Then every trainee is led to a room to debrief on the exercise.

2.5 Expert'Crise exercises and training provided in 2015-2018

Expert'Crise was a three-year project and significantly evolve from October 2015 to December 2018. Indeed, at first, the project has no syllabus, no methodology and – with one exception – no “customer” organizations neither lead. Then, for about the first year, project focus on designing a global methodology for this training, including its syllabus, preparing lectures, building – and buying – material architecture for exercise and developing a pattern for exercises. This important preparational work explain the few exercises provided during the first year of the project.

Then, because project focused on developing the content of the training during the first year, marketing aspect was a bit neglected and first half of 2017 was mainly dedicated to prospection of Seveso companies interested in the project for next years. From this point, marketing work was fully integrated into the training design process, including a first needs gathering matching with the beginning of this process. Second half of 2017 was dedicated to improving exercise design methodology with the previously presented continuous improvement process, while providing planned trainings.

The last year of the project was almost fully dedicated to providing trainings planned even if exercise design methodology continued to be improved exercises after exercises. This year was particularly touched by “giving-up” organizations and four fully prepared exercises could not be provided because of these organizations' internal problems.

Fifteen Walloon SEVESO companies participated in one of the fourteen exercises organized between 2015 and 2018, **Erreur ! Source du renvoi introuvable.** resumes these exercise as well as companies involved. Companies, number of employees, their environment and the type of exercises (Tena-Chollet, Tixier, Dandrieux, & Slangen, 2016) proposed vary from an exercise to another and cover a wide scope of situations. This number does not allow to be representative of the 103 Walloon Seveso companies but allows to picture the situation of companies willing to set up this kind of training. Indeed, conclusions of company comparison have an inherent bias because only companies interested in this kind of training were studied.

Table 6: Companies and exercises: size, environment and nature of the exercise

Company	Number of employees ¹	Place	Date	Exercise & Environment	Type of exercise
A	250 to 499	St-Ghislain	01/12/15	Coordinated exercise with three companies in a multi-operator industrial site Accidental scenario: Tank truck acrylonitrile leakage	Full size
B	20 to 49				Functional (crisis unit and control room)
C	100 to 249				Evacuation exercise
D	100 to 249	Ecaussines	27/09/16	Single exercise in a multi-operator industrial site (the other company was not involved) Accidental scenario: Fire of a cyclohexane tank truck and leak of hydrochloric acid tank truck	Functional (crisis unit)
E	20 to 49	St-Ghislain	21/12/16	Single exercise in an isolated site Accidental scenario: Heat transfer fluid leakage and fire	Functional
F	500 and more* ²	Frameries	11/05/17	Exercise in a regional office center of a critical infrastructure of gas and electricity distribution Accidental scenario: Massive gas leakage underground of a city	Functional (crisis unit) and reduce-scale model based
C 2 nd exercise	100 to 249	St-Ghislain	22/08/17	Single exercise in a multi-operator industrial site (other companies were not involved) Accidental scenario: Massive ammoniac leakage	Functional (warning chain and first intervention)
G	20 to 49	Seneffe	27/09/17	Single exercise in an isolated site Accidental scenario: Fire of a liquid oxygen tank truck and leakage	Functional (warning chain and first intervention)
H	20 to 49	Seneffe	24/10/17	Single exercise in an isolated site Accidental scenario: Chemical runaway in a chemical waste tank	Functional (crisis unit)
I	50 to 99	Lessines	11/06/18	Single exercise in an isolated site close to city center Accidental scenario: Chemical runaway, explosion and fire	Functional (warning chain and crisis unit)
J	100 à 249*	St-Ghislain	04/09/18	Single exercise in an isolated site Accidental scenario: Massive liquid oxygen leakage followed by a liquid nitrogen leakage	Functional (warning chain and crisis unit)
K	100 to 249	Mouscron	05/09/18	Single exercise in an isolated site Accidental scenario: Reactor explosion and fire	Functional (warning chain and crisis unit)

¹ <https://be.kompass.com/>, for guidance only² <https://www.ores.be>

Company	Number of employees	Place	Date	Exercise & Environment	Type of exercise
L	20 to 49	Charleroi	01/10/18	Exercise in a business and industrial zoning Accidental scenario: Fire caused by incompatible waste	Functional (warning chain and crisis unit)
M	500 and more	Braine-l'Alleud	15/10/18	Exercise in a production and R&D campus Accidental scenario: Natural gas leakage underground a lab.	Functional (crisis unit)
N	10 to 19	Amay	03/12/18	Exercise in two distant locations: administrative office and production isolated site Accidental scenario: Fire in a maintenance hall containing explosive substances	Functional (warning chain, evacuation and crisis unit)
O	500 and more*	St-Ghislain	11/12/18	Exercise for railway infrastructure manager on a railyard near a city center with dangerous substances. Accidental scenario: Ammoniac massive leak on a wagon	Functional (warning chain, local coordination and intervention)
P	100 to 249	Seneffe	Cancelled	Single exercise in an isolated site Accidental scenario: Diethyl amine leakage on a transfer rack followed by a fire	Functional (warning chain and crisis unit)
Q	50 to 99	Verviers	Cancelled	Exercise in a business and industrial zoning near storage area Accidental scenario: Ethylene oxide jet fire in a storage rack and domino effect	Functional (warning chain, evacuation and first coordination with emergency services)
R	500 and more*	St-Ghislain	Cancelled	Exercise in an internet critical infrastructure, in an isolated site. Accidental scenario: Fire of a medium sized fuel tank and limited propagation	Functional (warning chain, first coordination and crisis unit)
S	20 to 49	Namur	Cancelled	Single exercise in an isolated site Accidental scenario: Electric fire in a naphthalene storage area leading to a generalized fire	Functional (warning chain, local coordination and crisis unit)

*Number of employees in Belgium, not representative of the number of workers on the plant.

Note that the four last exercises of Table 6, planned in 2018, were cancelled by industrials. Nevertheless, even if they were cancelled, theoretical courses were already provided and exercises were fully prepared.

Providing exercises in such various organizations lead us to some conclusions on how Walloon Seveso companies organized and planned emergency. These conclusions – even if they are not representative of the global situation – provide guidelines and invariants which help us in designing exercises. These conclusions and how they were used are extended in Chapter 6 and Annex 6.

2.6 Expert'Crise goals achieved

As said previously, Expert'Crise had several quantitative and qualitative targets to reach and some of them were either out of reach or irrelevant. Especially, developing this PhD thesis conducts to reconsider some goals to get more relevant outcomes for further development.

Then, the **A1 goal “Developing a simulating infrastructure”** was mainly fulfilled: the training framework was delivered even if it has no dedicated room as expected, this framework is described and explained in this work as a technical documentation.

The **A2 goal “Developing a pedagogical methodology”** was also almost completely fulfilled: Exercise pedagogical methodology is the core of this work and, even if there are still some questions on what indicators use, several of them were identified.

The **A3 goal “Developing a scenario library”** is the less implemented Expert'Crise project goals. Two reasons explain that situation. First, because we had to sign non-disclosure agreement with organizations we work with, we could not use emergency documents they provide to complete the project documentary database of emergency planning. Then, because each exercise was significantly different with various scenarios, each strongly dependent on the company's emergency organization, no generic scenario library could be developed. Nevertheless, an alternative is proposed in the Part 3 of this document to partially meet with this goal.

The **A4 goal “Considering the human factor in crisis management”** was moderately accomplished during the project with a human activity analysis methodology related to simulation event used during exercise analysis and several psycho-behavioral performance indicators set, although, as for A2 target, there are still some questions on what indicators use and when. On the other hand, because of how the project processed, with very punctual one-shot intervention trainings, a follow-up process aiming to improve human efficiency in crisis could not be developed.

The **A5 goal “Developing a training program”** was the main focus of the day to day project management, especially because it has a quantified objective. Despite that it was only partially achieved and if a detailed training program on the different aspects of crisis management was completely developed, with a set of adapted pedagogical support, the project little focus on individual follow-up methodology for improvement and evaluation of individual competencies preferring deals with group evaluation. Besides these pedagogical goals, support for emergency planning development and implementation was mainly done in a case by case basis and do not lead to a global methodology, as for pedagogical engineering.

2.7 Chapter 2 Resume

The Expert'Crise project is a training project funded by the European Social Fund between 2015 and 2018 aiming to provide innovative trainings to Seveso companies and critical infrastructures' operators, at strategical level, helping them to comply with regulations related to emergency planning and their scheduled tests. The global framework of trainings proposed to these companies remains the same along the project, including a set of theoretical course held by UMONS trainers on site and covering up to the seven available topics with the option to prepare dedicated courses according particular companies' needs and, on the other hand, immersive serious game simulating crisis situations where trainees must deal with problems that may occurred in such conditions, playing their own role in a dedicated infrastructure. This infrastructure was especially designed for the Expert'Crise project, based on literature review and feedback from others crisis simulators. It consists in five systems - Audio and video recording system, Monitoring system, Audio and video immersive system, Facilitation system and Network system – working together to immerse trainee in a crisis-like situation. Expert'Crise trainings were held in 19 companies, including 4 that only attended theoretical courses and cancelled their prepared exercises, meaning 19 different emergency plans were reviewed to design exercises. Fourteen of these crisis management exercises were held in 15 different companies. These trainings, even if they do not allow to picture correctly all Belgian Seveso companies, provided a large amount of information on how companies are prepared for crisis, what they need to improve their emergency and crisis management system and how to improve trainings to meet their needs.

After 3 years, Expert'Crise project reach most of its goals: (A1) a training infrastructure was designed, implemented and tested, (A2) a global pedagogical process was conceived – as introduced in this chapter – and used along the project, (A4) human factor was taken into account, especially during the debriefing phase by a dedicated human activity analysis even if precise indicators lack to complete this methodology, and (A5) the expected number of trainings provided to industrials was almost reached. However, no scenario library was built during the project (A3) because it does not fit with pedagogical goals of trained organizations and appears to not be an optimized way to process. Instead, the exercise design process was improved to produce original scenario meeting industrials needs. This improvement did not only rely on Expert'Crise's exercises' feedbacks but also on a literature review, detailed in the Chapter 3 and Chapter 4, completing Chapter 1.

Chapter 3 **Pedagogy in crisis management trainings**

The conception of the Expert'Crise methodology strongly relies on continuous improvement from an exercise to another, but not only. Indeed, even if in its first part, the project constraints did not allow to deepen the literature review, this last one was then extended to improve Expert'Crise methodology and strengthen its conceptual basis. In the end, Expert'Crise relies on a cross-thematic literature research from various fields such as pedagogy, dramaturgy, game design, and crisis management. Therefore, the methodology may be seen as the cross point of a bottom-up process of feedback from exercises and a top-down process of literature review.

Nevertheless, as said in the previous chapter, this literature review occurs late in the project and main features were already implemented because of project time constraint. That is the reason why it is presented in this document after the Expert'Crise project description, although this theoretical basis allowed to build an in-depth discussion on what the Expert'Crise project was doing and how it was doing it.

Then, several themes were reviewed, some being more important in the training conception than other. Especially, because Expert'Crise project aimed to teach competences to trainees, pedagogy was one of the most important fields studied and lead to a specific approach for trainings related to trainees' characteristics and competences aimed.

3.1 Pedagogical approach

Trainings developed during the Expert'Crise project – as well as those of the IMT Mines Alès which inspired them – are based on the socio-constructivism theory and target a professional adult target. This training belongs to a historical process of improving how people – child as well as adult – learn. Then, the main steps of this process should be mentioned, at least briefly. Even if pedagogy is something old, Plato dealt with around 400BC, major developments are relatively recent with first behavioral theories developed at the beginning of the 20th century. From since, several main evolutions in how the learning process is understood lead to the actual situation.

Behaviorism is a pedagogical approach, first developed by Watson in 1913 (Watson, 1913) then developed by Watson, Skinner, Hull, Crowder and Tolman (Baum, 2005) among other, based on the stimulus-response concept. This concept explains that stimulus may lead to dedicated responses through behaviors build on previous experiences of the relation between stimulus - behavior – response (Skinner, 1938). Trial-error learning is a representative learning process based on behaviorism. This pedagogical approach is linear

in how learning is done and how fast and efficient it is. This characteristic lead Skinner to split complex activities in elemental behaviors that may be taught. Nevertheless, very complex activities may not be split. On the other hand, this approach is only focused on output of behavior and not on what the learner understood.

Cognitivism completes behaviorism by explaining intermediate steps between stimulus and its response. Cognitivism focus on mental picture built and processed during the learning process (Mandler, 2002). These individual mental pictures may then be modified during learning session to reach the pedagogical purpose (Fillol, 2004). This approach leads to developing new ways of learning such as problem-based learning, mainly done in group supposedly more efficient for mutual comprehension (Martel, Lejeune, Ferraris, & Vignollet, 2007). This approach consists in addressing a problem to learners that have to explain and solve it. Therefore, problem-based learning focus on how trainees learn and process new knowledge and skill in a (pseudo)-practical way to solve the addressed problem. However, this kind of training work on how trainees interact with each other, then they may build incorrect mental representations from their experiments (Stern, 1997) so the pedagogical approach requires to be fairly directly led by a teacher to keep learner on the good pedagogical path.

Building, processing and modifying mental picture are the foundations of constructivism. Developed in 1969 by Piaget, this pedagogical theory assumes people learn through interaction with one's environment (Piaget, 1971) and willingly modify previous own mental pictures according to new experiences that become knowledges. It is a two-step process starting with the assimilation of raw new data acquired through experiences followed by the accommodation, a reflexive process during which old mental pictures are modified or confirmed according to new experiences (Wadsworth, 2004). This accommodation reflexive process may be activated by social interaction that raise cognitive conflict and may lead to a common solution (Martel, Lejeune, Ferraris, & Vignollet, 2007). This pedagogical theory is related to experience learning consisting in setting learner in a situation allowing to experience something, then direct one's thinking to targeted knowledge and competencies (Dewey, 1938).

As discussed, social interaction may improve the constructivism learning process. Social-constructivism extends this link between building mental picture and human relation, especially in collective learning where interactions with the environment also include other trainees. Therefore, trainees may compare their personal mental pictures and influence each other in the building of a new mental representation according to a collective new experience, an exercise or a training for instance and optimizing learning process (Baudrit, 2005). Indeed, efficiency of learning is improved by teamwork and verbalizing concept and mental picture to collaborate in solving a problem (Johnson, Suriya, Won Yoon, Berrett, & La Fleur, 2002). Nevertheless, conflict-free collaborative work is not the best setup for learning because it does not involve competitive dynamism that should lead to dialectal process. Indeed, even if strong conflictual environments shut down communication and open-mindedness, moderate conflict may be more productive for pedagogical activities (Stern, 1997). Social-constructivism reveals the learning group as an important fourth stakeholder in pedagogical relation besides teachers, learners and knowledge (Faerber, 2003). The learning process appears then in social-constructivism as both an individual and

collective's activity and match with the crisis team organization, in group with individual dedicated competencies (Tena-Chollet, 2012)

(Socio)-constructivism became the main pedagogical approach, with some variations in it. Nevertheless, even these variations converge from the last decades to similar processes, named under the Data, Information, Knowledge and Wisdom (DIKW) theory name, explaining learning with about the same path and milestones as Figure 18 shows.

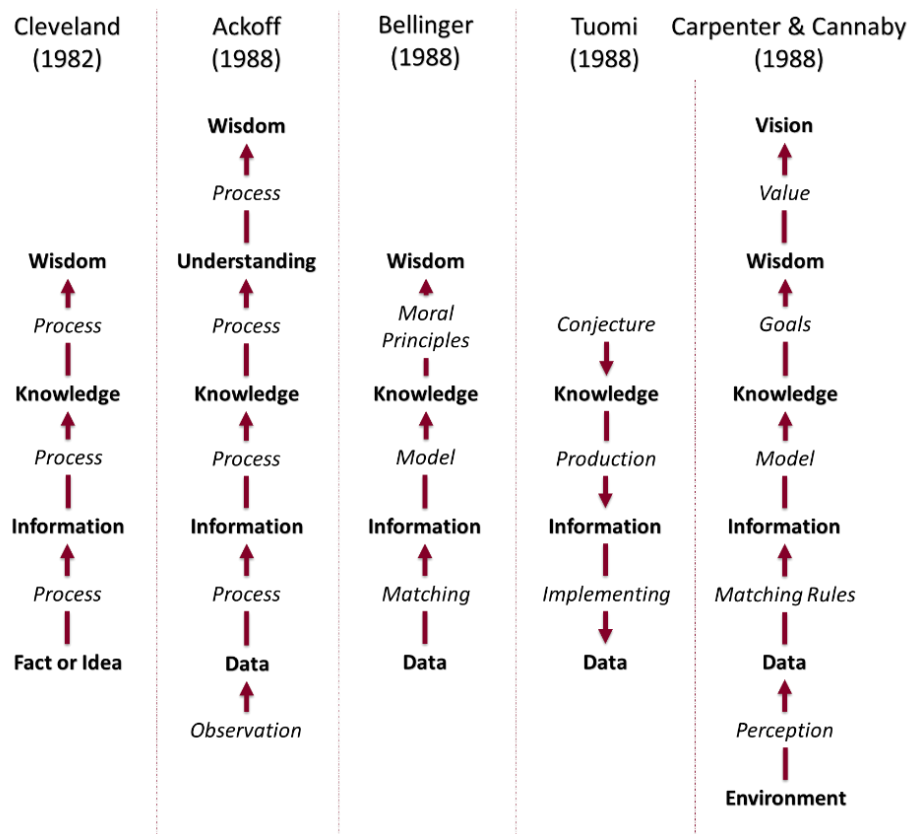


Figure 18: Models of human understanding process (Tena-Chollet, 2012)

The last model resumes correctly these converging processes. The first environment produces stimulus that the trainee receives and processes in raw data. Then these data combine with formal cognitive rules in consistent information possibly connected to other information. Once information is enough linked to each other to produce a cohesive mental picture able to drive the decision-making process, they grow into knowledge. Knowledge develops into wisdom when it is related to other knowledge that allow to anticipate, to decide and act according to the situation and trainee's memories of similar situations. In the end, wisdom turn into a vision when it integrates an ethical framework and when the decisions made are also done based on values without endangering the system involved.

Besides pedagogical framework used to explain learning process, there is a consensus on milestones in this process. Indeed, three levels are usually identified based on what trainees' cognitive processes involved: initiation, improvement and training (Guilbert,

1990). Initiation aims to gather raw data and converts it into relevant information based on a first brief presentation or course on the subject. Because trainees have no previous experience and knowledge on the topics, teamwork is not really relevant for this phase with no interesting team outputs. Then improving phase aims to make memorize information according to a problem addressed or a theme. Therefore, trainees gather information in categories through teamwork interaction that build common references to these knowledges that are shared through the working/learning group. In the end, the training phase consists in making trainees search back in their previous experiences to find a specific information or a decision previously made. Therefore, trainees remember and build reflex on how react in such situation (Baumard, 1995), (Girod, 1995). On the other hand, these three levels match with the Anderson classification (Anderson, et al., 2005) that reviewed Bloom's one (Bloom, Englehart, Furst, Hill, & Krathwohl, 1956). This classification considerate that six steps are required to learn skills: to remember, to understand, to apply, to evaluate and to create. This approach is different from the DIKW model that explain how fact and observation are processed into knowledge and aims to identify where the learner is on the learning path and what this one is able to do at this moment. These six steps may be matched two by two to build three levels as represented in Figure 19: novice, initiated and expert. Novice level relates to common sense and understanding of the situation, trainees must be able to build their thinking on the little they know – in our case, they do not have any prerequisites and then do not know documentations or have technical information on how a crisis center work– and what they understand do produce first actions. Initiated level matches with trainees that already have some information, know documentations and technical topics related to the target field, then this level focus on the analysis and implementation of actions through available means to apply their knowledge. In the end, the expert level refers to trainees that know well the taught field, in our case how crisis management processes and already have participated in several exercises, this level focus on deep evaluation of the situation to identify discrete elements and weak signals.

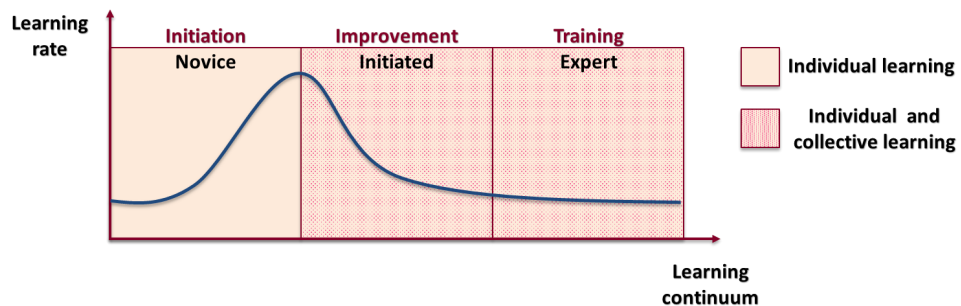


Figure 19: Learning Continuum (Tena-Chollet, 2012)

Note that these three steps do not follow linearly. Indeed, important improvement may be observed early in the learning process then learning rate progressively decrease at the same time learners become more and more expert (Liu, Nickens, & Wang, 2006). As presented in the Chapter 5, this observation match with another topic from game design: the difficulty curve and flow state.

Therefore, a professional or an expert requiring a training phase will have a little learning rate regarding novices. Then the teamwork must be considerate in choosing a pedagogical approach to reach target chosen for each learner's profile. Note that, even if it is not considered in this document, Sanghi proposed a fourth level, « Advance », between Initiated and Expert profiles where trainees still learn something, but slowly making Expert profiles a more static level where trainees learn almost nothing (Sanghi, 2007).

3.2 Knowledge and pedagogical relations

Learning is defined as a “knowledge acquisition process” (Fillol, 2004) and if the last paragraph explained how these knowledges may be learned, it seems relevant to define what is learned: knowledge, competencies, skill or other? Indeed, pedagogical taxonomy is complex and concepts used must be clarified. First, competencies are what is expected as final output of a training: it is the processed information that may be used in a concrete situation. Competencies are usually formalized with the KSA approach (Knowledge, Skill, Attitude) (Salas & Cannon-Bowers, 2001). Knowledge is what the team thinks and know, it fully relates to cognitive domain and exist independently to what happen. Skill is what a member can do, having theoretical and practical required background to operate the task the appropriate way to meet team goals. Attitude is how team members feel and react to other members feeling and reaction, it then relates to the ability to use knowledge and skill relevantly depending on the situation and other team members.

Nevertheless, this three-part definition of what is a competence is challenged, especially because the distinction between a knowledge, a skill and an attitude is blurred (Gérard, 2000). Then competencies must be re-defined taking into account that the sum of knowledge does not represent the full competency simply because these knowledges does not sum but combine: having cognitive resources is not enough, knowing how to apply them and when is as much important (Le Boterf, 2010). Then competency is then defined as a knowledge and skill interdependent combination (Legendre, 2004) and these knowledge and skills can be classified as follows:

- Theoretical knowledge, such as academic or disciplinary knowledge
- Procedural knowledge, such as codified or standardized procedures
- Environmental knowledge, such as available human and material resources, and working setting, including rules, working habits or business operation process.
- Operational skills related to how specific operations must be done
- Cognitive skill such as how a situation must be analysis or how a problem must be solved
- Social and relationship skill such as ability to get in contact with someone or having the correct attitude and etiquette.
- Experiential skill built through experience that make confirmed professionals comfortable in such situation.

Knowledge and skill are deeply related in this paradigm: without knowledge, skills cannot exist because they lack of “components” and, on the other hand, without skills, knowledge is useless, inoperant (Perrenoud, 1995).

Then for emergency and crisis management, dedicated knowledge and skill are required. Lapierre proposed 6 main knowledge fields based on expert meeting and exercises' feedbacks (Lapierre, 2016): **(1) land territory knowledge**, crisis unit must know and understand the sector where occurs the disaster, its issues, vulnerabilities, risk areas, its history including previous disasters and, naturally, its geography, **(2) organization knowledge**, crisis team must understand the organization where the crisis team set up and know involved stakeholders and procedures, **(3) emergency plan knowledge** – implying crisis unit belongs to the organization then relates to the previous point – including all documents, acronym and how to use documents of the emergency plan, **(4) risk culture and reflex knowledge** meaning the crisis unit must know different information and data providers and provide crisis decision-makers information on how to use social media during crisis, **(5) risk and phenomenon knowledge**, especially hazards and effects of such phenomenon to make adapted decisions, and **(6) organization's equipment knowledge** because crisis must know what can be used during the situation, especially in the crisis room. However, not every member of the crisis unit must have all these knowledges that may be shared through the crisis team.

Besides, a competence has other characteristics: it is complex, involving several resources to be mobilized, it is systemic being more than the sum of its sub-systems and including how they work together, it is dynamic, integrated in a set of different activities and it is adaptable to several situations (Legendre, 2004).

Once competency is defined as a concept, it matters to identify what competencies are involved in emergency and crisis management. Lapierre gathers 37 competences identified in literature as required for major risk management from different emergency organizations such as a medical team, military unit, aeronautics and aerospace organization, industries and project management team. Nevertheless, competencies mentioned were scattered in original papers, do not cover the same meaning from a paper to another and do not really match with our previous definition of what is a competence. Indeed, this approach is not widespread in crisis and emergency management training papers. Then he classifies these competencies in 3 main categories: competencies related to performing a specific action, competencies related to managing team and optimizing its work and competencies related to individual characteristics, specific to each member. In the end, he refines, combines and eliminates less relevant competencies to get only 15 competencies (Lapierre, 2016) : (1) assess the situation, (2) assume the leadership, (3) delegate, (4) communicate, (5) take decision, (6) monitor teamwork, (7) coordinate, (8) cooperate, (9) share a mental picture of the situation, (10) adapt, (11) mediate disputes, (12) ensure team cohesion, (13) support other team member, (14) control emotional state, and (15) show confidence. Following paragraphs describe briefly these competences, resuming Lapierre definitions.

Assessing the situation (1) competency is required by decision-making as a preliminary step of this process (O' Connor, et al., 2008). It relies on three main steps: characterize, expertise and anticipate crisis situation. Characterize a situation aims to understand phenomenon involved and considerate event's consequences in surrounding environment (Crichton & Flin, 2004) (Flin, Fletcher, McGeorge, Sutherland, & Patey, 2003) then plan task to do (Kosarzycki, Salas, Wilson, & DeRouin, 2002). The complete characterization of a situation may require a technical expertise proceeded by a member of

the crisis unit or a requested external expert (Crichton & Flin, 2004). This characterization of the crisis situation is especially needed to anticipate – at short and medium term – evolutions of the phenomenon, its propagation, and emergency response delay to proceed intervention (Crichton & Flin, 2004). Correct assessment of the situation is particularly difficult to do during a crisis because of the inherent uncertainty of such situation. Therefore, this competence is critical to build the least incorrect mental picture of what happen (Gurtner, Tschan, Semmer, & Nägele, 2007).

Assuming the leadership (2) competency is the ability, for the leader, to define target to reach in a global strategy to lead the team. It includes assigning taskwork, motivate the team and manage its resources. Leading the team is the main function of the leader who gives instructions and set target (Salas & Cannon-Bowers, 1997), (Burke, et al., 2006) (Dickinson & McIntyre, 1997), (Hull, Arora, Kassab, Kneebone, & Sevdalis, 2011), and encourages to share information through shared support (Dautun, 2007), (Lagadec, 2012) to keep a shared mental picture of the situation throughout every team member (Day, Gronn, & Salas, 2004). Leading the team requires to support its organization to optimize its performance then the leader must tell what is expected and remember everyone mission (Andersen, Jensen, Lippert, & Ostergaard, 2010), ensures work standards are respected (Burke, et al., 2006) and clearly and precisely communicates (Andersen, Jensen, Lippert, & Ostergaard, 2010). To lead the crisis unit, the leader must define a target to reach, a strategy which several planned goals (Burke, et al., 2006), (Crichton & Flin, 2004), (Dickinson & McIntyre, 1997), (Weil, Hussain, Diedrich, Ferguson, & Macmillan, 2004) and monitor team progress on these targets through status reports either with all the crisis unit and with sub-cell managers. Ensuring good coordination and keeping everyone with the same representation of the situation is also an important leader task that may be done through assigning taskwork (Salas & Cannon-Bowers, 1997), (Burke, et al., 2006), (Andersen, Jensen, Lippert, & Ostergaard, 2010), (Flin, Fletcher, McGeorge, Sutherland, & Patey, 2003) and asking for the resume of the situation and confirmation of on ongoing actions (Andersen, Jensen, Lippert, & Ostergaard, 2010), (Crichton & Flin, 2004). Leadership competency also includes the motivation and encouragement to team members to ensure a proper team-building then a good teamwork (Burke, et al., 2006), (Dickinson & McIntyre, 1997), (Flin & Patey, 2011). On the other hand, it may require to show authority in conflictual situations (Salas & Cannon-Bowers, Methods, tools and strategies for team training, 1997) (Flin, Fletcher, McGeorge, Sutherland, & Patey, 2003) and take crucial decisions when several paths are possible (Lagadec, 2012). Note that, even if we mention leader in singular, this function may be ensured by several members – with a second leader, highly involve in the organization, for instance – in a shared or distributed leadership (Yammarino, Mumford, Connelly, & Dionne, 2010), then this competency must be mastered by all leaders in the crisis unit.

Delegating (3) competency is different from “Show leadership” and applies to every crisis member. It consists in giving to another team member one’s authority or mission to do (Sanghi, 2007). It is composed of two sub-functions: “to assign”, meaning a team member design another one to do some of the one’s missions and “to reorganize” consisting in definitively redefining team members’ mission and responsibilities to adapt the crisis unit functioning mode to the situation.

Communication (4) competency relates to how information is shared between team members then it is different from “crisis communication” dedicated to communication to media, populations and authorities. How to communicate inside a crisis unit is a complex competency involving several components related to members’ abilities to tell something, listen someone, take position, share and respond. Moreover, this competence is critical for teamwork efficiency. Indeed, no teamwork neither collective decision-making is possible without a clear and appropriate communication. Therefore, as said, communication relies on several components. The first component of communication, speaking implies to clearly formulate one’s question, order or request (Flin, Yule, Paterson-Brown, Rowley, & Maran, 2006) and, possibly, repeat and/or reformulate to ensure the information is correctly transmitted (Andersen, Jensen, Lippert, & Ostergaard, 2010) (Dickinson & McIntyre, 1997). Then, if speaking is the first step of communication, listening is obviously the second one, listening consist in paying attention to what is said but, more important, to do it actively (Salas & Cannon-Bowers, 1997), (Dickinson & McIntyre, 1997) to ensure a good global comprehension including what is said through non-verbal communication (Stevens & Campion, 1994). These two previous components are the basis of communication but during emergency or crisis situation, team members must use a dedicated communication expertise which is the third component of the communication expertise. This communication expertise consists in using a procedural way to communicate with closed loop including feedbacks (King, et al., 2008), using a dedicated terminology (Andersen, Jensen, Lippert, & Ostergaard, 2010), (Salas & Cannon-Bowers, 1997), (Dickinson & McIntyre, 1997), communicating with the adapted interlocutor (Weil, Hussain, Diedrich, Ferguson, & Macmillan, 2004), being up to date on shared information (Andersen, Jensen, Lippert, & Ostergaard, 2010), (Lagadec, 1993), checking sources (Dickinson & McIntyre, 1997), arguing and resuming. Communication also consists in adapting how communication is done according to the environment, especially sound environment (Crichton & Flin, 2004). Moreover, crisis unit communication also requires a pooling of information in a shared medium such as a script paperboard, a monitoring board or a cartography must be strengthened by regular status reports ensuring everyone has the same information. In the end, internal communication also consists in answering to other team member (or other sub-cell member) to repeat, rectify or complete information.

Decision taking competency (5) consists in the team's ability to gather, integrate and assess information to formulate a decision by identifying alternatives and choosing the more adapted one. Decision-making is a process and its related competency relies on three steps. The first one is the ability to diagnose the problem to solve by identifying it (Flin, Fletcher, McGeorge, Sutherland, & Patey, 2003), gathering the required information (Salas & Cannon-Bowers, 1997), (Flin, Fletcher, McGeorge, Sutherland, & Patey, 2003) and checking their relevancy and sources (Salas & Cannon-Bowers, 1997). The second step consists in proposing several alternatives (Salas & Cannon-Bowers, 1997), (Flin, Fletcher, McGeorge, Sutherland, & Patey, 2003), (Flin & Patey, 2011) through a teamwork activity requiring to share point of view to integrate different options or opinion. Then, before taking the decision, team members must anticipate its consequences (Salas & Cannon-Bowers, 1997), (Flin & Patey, 2011) and risks (Flin, Fletcher, McGeorge, Sutherland, & Patey, 2003). Sharing is an important part of decision making. Note that, even if decision making

is a collective activity – so called distributed decision-making – especially for important choices, it may also be an individual task but having more risks (Crichton & Flin, 2004).

Monitoring teamwork performance (6) competency relates to the ability, for a team, to develop a common understanding of the team environment while monitoring other team members performance through appropriate strategies (Lapierre, 2016). This competency may be analyzed through five axes to distinguish what relate to member consulting, shared media and sharing incentive. The first axis is how members consult each other to get information about their activities (Day, Gronn, & Salas, 2004) (Dickinson & McIntyre, 1997) (Hull, Arora, Kassab, Kneebone, & Sevdalis, 2011) (Salas, Rosen, Held, & Weissmuller, 2009), monitor procedures how are applied (King, et al., 2008) and, possibly, help them in their task if required (Kosarzycki, Salas, Wilson, & DeRouin, 2002). The second axis is how the team organizes itself to monitor crisis unit performance, especially through note taking, internal resume, dedicated monitoring on a specific task or, eventually, refocus. The third axis is how involved stakeholders – including sub-cells – are contacted to get information or confirmation on the situation (Dickinson & McIntyre, 1997) (Weil, Hussain, Diedrich, Ferguson, & Macmillan, 2004). The fourth axis is how share medium are used and how frequently information consistency and completeness is checked. Then, the fifth and last axis is how team members are encouraged to use share medium and, globally, to share information and make status report. Monitoring team performance allows to identify errors, lacks or mismatching actions besides improving internal communication and shared representation of the situation.

Coordination (7) competency relates to the team's ability to pursue common targets, making converge all team's interactions. Coordination competency includes four abilities: “making feedback” of the situation, “organizing” crisis unit in a functioning mode, “communicating” and “sharing” crisis unit goals. As it appears in previous competencies, “making feedback” is a critical action for each team member may work together then feedback on actions done must be vertical but also horizontal (Dickinson & McIntyre, 1997), (Flin & Patey, 2011). “Making feedback” includes to close the feedback loop by getting confirmation (Dickinson & McIntyre, 1997), (Weil, Hussain, Diedrich, Ferguson, & Macmillan, 2004) and/or validation (Lagadec, 1991). Organization and coordination are closely related then coordination requires that role and missions of members are defined and reminded (Flin & Patey, 2011) as well as the functioning mode that must be clearly set and defined with dedicated members doing specific missions. As well as organization, communication is a major matter for coordination: communication functioning mode must be set, ideally in a close loop setting with feedback (Salas, Rosen, Held, & Weissmuller, 2009). In the end, “sharing” is central for coordination then missions planification and precise target identification must be a collective task (Andersen, Jensen, Lippert, & Ostergaard, 2010) (Stevens & Campion, 1994), as well as task planification and assignment, even if it is difficult during crisis situations (Salas & Cannon-Bowers, Methods, tools and strategies for team training, 1997) (Burke, et al., 2006) (Flin, Fletcher, McGeorge, Sutherland, & Patey, 2003).

Cooperation (8) competency relates to teamwork and the ability for each member to work together. It relies on several team's actions and behaviors: to organize teamwork to take into account each team members work (Crichton & Flin, 2004), to communicate in

close loop and answer other members' queries (Flin & Patey, 2011), and to encourage team member to cooperate all along the situation, to mediate conflict (Flin, Fletcher, McGeorge, Sutherland, & Patey, 2003) and to be active in team performance monitoring (Flin, Fletcher, McGeorge, Sutherland, & Patey, 2003).

Sharing a mental picture of the situation (9) competency consists, for team members, in receiving information about the situation, understanding how events locate in space and time and understanding what do they mean and how they will affect close future through the construction of a common representation of the situation, shared in the team. As mentioned in the Chapter 1, situation representation processes may be biased with several crisis and emergency feedback proving it, that is why the ability to share a mental picture of the situation through the crisis unit is particularly important for crisis management. This competency includes behaviors, improving shared representation of the situation grouped here under three verbs: "Communicate", "Share" and "Expertise". Again, communication competencies are involved and communication in close loop is recommended to ensure information sent is correctly received or to provide a status report. (Dickinson & McIntyre, 1997), (Flin & Patey, 2011). Then to share a mental picture, sharing information seems critical. Indeed, it is through pooling of information, status reports, monitoring board support as well as the use of all shared medium available, as cartography for instance, that a common picture of the situation is built (Salas & Cannon-Bowers, 1997) (Gaultier-Gaillard, Persin, & Vraie, 2012). Moreover, sharing information and discussing them may reveal dysfunction in the team. Expertise does not relate to information flows, but to how the crisis unit is lead. Indeed, collective introduction of goals, how they are prioritized, where they lead and instructions that must be followed to reach these goals help the team to collectively build a representation of the situation according to this information as long as these ones are correct (MacMillan, Entin, Morley, & Bennett, 2013).

Adaptation (10) competency is the team members' ability to change strategical orientation according to internal and/or external information incoming flows that reflect changes of situation, environment or behaviors. Strategical orientation changes imply to modify some crisis unit behaviors, functioning mode and require to reassign resources and taskwork. This competency includes five functions: to organize, to assist, to expertise, to reorganize, to anticipate and to be flexible. Organization is required to adapt to new situations. Indeed, to overcome evolution, the basis organization must be clear, and each team member must be assigned, operational and able to implement strategical decisions at one's level, in particular by gathering information. Then, to correctly adapt to a situation, members must be able to identify and assist their colleague who are in difficulties or under pressures. On the other hand, members overwhelmed must ask for help if it is required (King, et al., 2008), (Kosarzycki, Salas, Wilson, & DeRouin, 2002). Triggering the adaptation process requires to identify when adaptation is needed. That may be done through an expertise of members' behaviors reflecting possible changes of the situation by deviating from their original mission to answer new problems, and requiring to modify ongoing actions (Day, Gronn, & Salas, 2004), (Hussain, Feurzeig, & Cannon-Bowers, 2010). Then, confronted to the need of change, reorganization is required with new action plans or modification of crisis (sub-)cell's functioning mode to match new requirements of the situation, especially if this one is unexpected. The more unexpected a situation is, the

deeper reorganization is needed then anticipation is crucial to smoothly adapt to the new situation in the crisis cells – because a rotation is needed or logistic is insufficient to provide resources to team members – or outside, onsite of the disaster. In the end, adaptation builds changes in functioning mode of the crisis unit and team members must be able to be flexible enough to deal with their task under different – and possibly degraded – conditions, to identify and grasp opportunities and build witness in unexpected new context (Lagadec, 2012).

Mediating disputes (11) competency may be both a leader competency as well as team members' competency. Indeed, team members may regulate themselves to avoid conflict to spread in the crisis cell degrading team interactions and its efficiency. This competency requires to be able to recognize that a conflict appears and who are involved to find its source and solve it (Lo, 2011). On the other hand, it also requires abilities to solve it using a consensus strategy (Kosarzycki, Salas, Wilson, & DeRouin, 2002)

Ensuring team cohesion (12) competency relates to dynamic processes that allow team members to collectively reach common target. Team cohesion may be impacted by how the team considerate itself, its performance, leadership methods, communication between team members, team members' involvement and their personalities (Kosarzycki, Salas, Wilson, & DeRouin, 2002). Ensuring team cohesion relies on four actions: « to share », « to organize », « to motivate » and « to deal with conflict ». Indeed, communication and sharing of information in a listening environment are the basis of team building that is strengthened by organization which assign to everyone to a role with dedicated missions and targets to reach in a collective vision. Then team motivation through encouragement both from leader and from other member is important for cohesion and allow to prevent conflict and, if required, to deal with it more easily.

Supporting other team members (13) competency consists in anticipating and answering the needs of other team members. It requires to share with others team members through collaboration and providing them feedback to let them know one's situation and if there is need of help (Salas, Rosen, Held, & Weissmuller, 2009). Based on information shared, team members must be able to identify failures in how other team members process theirs mission (Day, Gronn, & Salas, 2004) or what they need (Andersen, Jensen, Lippert, & Ostergaard, 2010) (Hull, Arora, Kassab, Kneebone, & Sevdalis, 2011) (Hussain, Feurzeig, & Cannon-Bowers, 2010) (Salas, Rosen, Held, & Weissmuller, 2009). Then, once other team member's is assessed, other member must intervene by helping in one's task and assisting in case of task overload by doing some task (Day, Gronn, & Salas, 2004), (Hussain, Feurzeig, & Cannon-Bowers, 2010), (Johnson, Suriya, Won Yoon, Berrett, & La Fleur, 2002) (King, et al., 2008) (Salas, Rosen, Held, & Weissmuller, 2009).

Controlling emotional state (14) competency consists in several actions required to face strong emotion such as stress. First, it requires to apply at one's level general advices such as staying calm, isolating some time to refocus or communicating on one's state with other team member requesting some help. Then, if the emotional state of another team member is impacted, it requires to identify that this member need help then intervene by helping or assisting as said before. Note that dealing with stress or other emotion during a crisis or emergency situation requires additional resources to team member while they are

already assigned to their task and missions (Crichton & Flin, 2004) then it may be considered as an extra-work.

Showing confidence (15) competency is the last competence of this list and implies that team member appears to be confident in the situation management. Confidence is a key behavior that positively impact team efficiently (Salas & Cannon-Bowers, 1997), (Flin, Fletcher, McGeorge, Sutherland, & Patey, 2003), (Kosarzycki, Salas, Wilson, & DeRouin, 2002). Confidence appears, on one hand through argumentation of one's ideas, proactive force and the will of convincing other and, on the other hand, through the question process if there are doubts on proposals made and, in the end, through mutual help and solving emerging conflict.

Therefore, we defined what is learned during a training and how it is learned but we did not introduce the stakeholder who must link knowledge to trainee: the trainer/teacher. Indeed, teaching is the interaction between three stakeholders – teacher, knowledge and trainee – through three relations: teaching, training and learning. These three relations lead Jean Houssaye to model the pedagogical process in a triangle (Houssaye, 2000), represented in Figure 20. Ideally, this triangle must be well balanced, with each relation having the same importance.

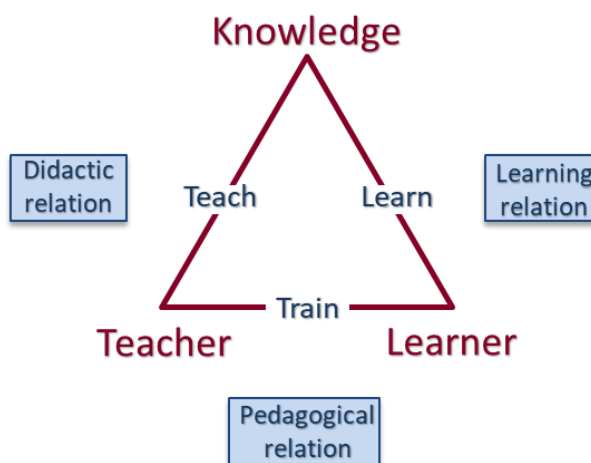


Figure 20: Pedagogical triangle

The didactic relation between teacher and knowledge aims to make this knowledge easy to process by students in their own relation – the learning relation – with it, through the student-teacher relation, the pedagogical relation. This last relation is reciprocal teacher must considerate student feedback to adapt the pedagogical relation and student, on the other hand, must verbalize those feedbacks on their learning relation including particular needs and difficulties they have on the topics. Trainer (or teacher) can adopt different way to facilitate the training: transmissive, incentive, permissive or associative (Therer & Willemart, 1984). Transmissive approach is the classical teacher-learner one-sided relation with a knowledge-keeper teacher providing this knowledge to ignorant learners. Incentive approach may be seen as the opposite of the transmissive because it consists in a facilitation

where trainer rely, in a double-side relation, on learner's knowledges and experience to develop the training. As saw previously, this approach is more relevant for adult training. Permissive and associative facilitation confronts directly trainees to pedagogical targets and let them, after a context explanation, learn by them-self. In permissive facilitation, the trainer may help trainees with tips, advices or detailed explanation but only at the explicit request of trainees. On the other hand, in associative facilitation, the trainer does not help trainee and only observes their reactions without interactions except if trainees leave the frame of the exercises or, at the end of the training, to debrief on observations and suggest improvements. This kind of facilitation is particularly adapted to collective training because the lack of active trainers promotes cooperation and then transversal competences.

Moreover, as said, social-constructivism implies taking into account the learning group. This fourth element added in the pedagogical triangle bring another dimensions with three new interactions in a social-constructivist pedagogical tetrahedron (Faerber, 2003), see Figure 21. The learning group assists the teacher by being a positive place for trainees to share their knowledge and what they understand, involving them in the training and strengthen the learning relation. Moreover, group's dynamics in a team up to twenty persons promotes competencies sharing and synergies to solve a problem (Johnson, Johnson, Johnson-Holubec, & Roy, 1984)

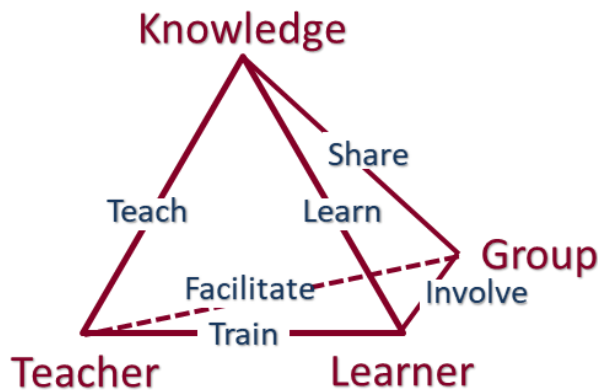


Figure 21: Pedagogical tetrahedron

Then it appears that several stakeholders of this tetrahedron have not been presented, especially the most important one: trainees target by the training.

These human interactions in the learning group, required by the social-constructivism approach, occur in a specific group of people with its own characteristics: a group of adult workers in industrial companies. Even if the word “pedagogy” wandered off its original meaning related to children, there are significant differences between pedagogy and andragogy, dedicated to adult training. One of the first differences is the reason why people learned and how they perceived the training. While school education is imposed to children, adults “choose” to follow a training. This choice may be driven by professional obligations and workers may not be totally free to not follow it, under penalty of losing their jobs for

example, which can be a serious limit for this choice. Nevertheless, the purpose of the training is clear for adults and pedagogical targets must be directly exposed with practical implementations that trainees will have to deal with in a close future in their professional life. In the context of cost-killing widespread in industrial companies, workers have a few times to learn. The training must be the shortest possible with operational exercise or ride-along to focus (Mucchielli, 1988) on the essential points and optimized training time. Therefore, adult trainees need training with clear, structured and easy to memorize goals (Noye & Piveteau, 1987) which are understood and accepted by trainees as well as directly link with their day-to-day work (Courau, 1993), indeed too many serious games need an important cognitive process to understand the connection with worker life (Tena-Chollet, 2012). Therefore, expected output must be explained to all trainees and milestones must be set for each major pedagogical goal to clarify the pedagogical structure. In that way, adult trainee gets personally involved in the training which is the more efficient (Mucchielli, 2008). Individual involvement is important and participates in the learning group dynamic which strongly influence adult learner who is more easily convinced by one's colleagues than by an organization's alien or a hierarchal superior (Noye & Piveteau, 1987), group learning must therefore gather workers with similar experience, knowledge and responsibilities. This configuration allows to build a trust environment improving participation and therefore group learning dynamics (Mucchielli, 2008). Trainer's facilitation must ensure a good environment with possibilities of success and failures but promoting success and explaining failure reasons.

Nevertheless, application of those guidelines is not easy in practice, especially for crisis management training, for several reasons (Snizek, 2001). First, training content may be difficult to establish, especially because trainees' competencies are not always well picture by the training contractor or the manager. Then interactions between trainees and trainers must be reciprocal, especially to take into account trainees' feedbacks, their errors and explaining its, highlighting their causes and consequences. On the other hand, these trainings are usually tightly-planned with workers also having to deal with their day-to-days jobs. Therefore, it may be difficult to bring all the target audience together. Planning difficulties usually come with the training cost that limits the number of times training is proposed to employees to improve their competencies, it may be a direct financial cost but also indirect human or production costs (Schaafstal, Johnston, & Oser, 2001).

Another main difference with children, adult workers experimented during their professional lives then have already built numerous mental pictures. The more they have experimented, the more pictures they have built. Therefore, adult workers with a landscape of coherent mental pictures may be reluctant to modify or challenge their representations and have a high change resistance (Lagadec, 1991). Also, as a side-effect of this experience, the trainer's authority may not be recognized, and may be considered as illegitimate as a

trainer. Adults trainees usually does not accept scholar penalty or evaluation and require training topic have direct working output. For this reason, professional trainings must rely on workers' experiences to overcome their resistance and turn an illegitimate perceived

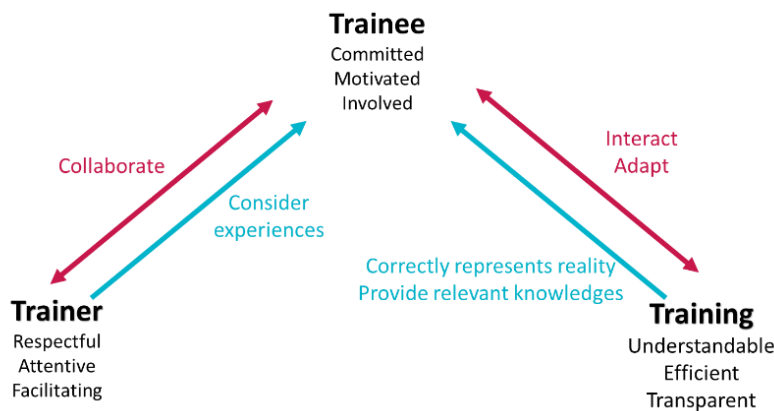


Figure 22: Didactic agreement

trainer to a helpful facilitator (Croix Rouge Francaise, 2008)

This teaching process is a bottom-up process, starting from workers' experiences to challenge mental pictures and share targeted knowledges by modifying or confirming these mental pictures.

Nevertheless, this process is only possible under two conditions: trainees must be motivated by the training and actively participated, and they must be free of the fear of being judged or compared, especially in competitive environments as workplaces are. This last condition, with the training target explanation, founded the didactic agreement between trainer and trainees as presented in Figure 22.

3.3 Pedagogical targets for crisis management training

Once members of this didactic agreement defined, constituting stakeholders of the pedagogical tetrahedron, targets of such emergency and crisis exercise must be defined more precisely. Indeed, training strongly relies on pedagogical goals then developing exercises required to clearly define what is aimed. Tena-Cholet and Lapierre developed successively two pedagogical repositories for crisis management but, because Lapierre proposed his repository after main Expert'Crise methodology developments, it was used only late in the project. Therefore, we will present Tena-Cholet repository then Lapierre one's which is more detailed and relevant considering previous definitions of what competencies are and how they may be implemented in exercise.

Tena-Cholet develops a three level pedagogical repository – summarized in Figure 23 – with six general targets, five intermediate targets involving dedicated knowledge, skills and attitude, and sixteen specific targets. General targets are the overall goals of exercises to improve emergency and crisis management competencies, even if these targets are not exclusively related to crisis management. They are all aimed during exercise but required

to be refined in more precise targets to be operationally implemented. Intermediate targets specify a general target in crisis-related pedagogical goals which may be either technical or non-technical knowledge, skill or attitude. Therefore, this repository is KSA based and do not focus on competencies as previously describe. These goals were described by Tena-Cholet from feedback analyses and meeting with crisis manager experts. In the end, these intermediate goals – which gather several knowledge, skill or attitude – are refined in specific targets aiming to develop pedagogical situations, in an EBAT approach, to train on specific topics.

This repository was the start point for first Expert'Crise trainings but during the project, Lapierre submitted his PhD thesis extending Tena-Cholet work on pedagogical targets for crisis and emergency exercises. Based on competencies required in organization commonly experiencing emergencies and literature review, he develops a four layers repository with three strategical axes carrying elementary crisis management missions which lead to goals or target, corresponding to what crisis unit must do, eventually refined into operational targets according to the trainees' profile, if they are already well-trained on crisis management or not.

The repository is organized around three strategical axes: the crisis strategical response axe, the crisis cell management axe and the strategical communication axe. Each axe includes missions gathered from literatures, sometimes with specificities related to the organization. Crisis strategical response relates to technical output expected from the crisis unit such as situation assessment or response management. Then, crisis cell management axe relates to crisis cell organization and processes during the situation including how team members interact and communicate, group dynamics in the teams and how teamwork is efficient. In the end, strategical communication relates to external interactions with media, authorities, population and others stakeholders, orally, written or through social media. Note that internal communication in crisis cells refers to the second axe, crisis cell management. Lapierre argues these three axes aim to propose adapted trainings according to organization needs: on technical topics, for crisis communication or focus on teamwork under tough situation.

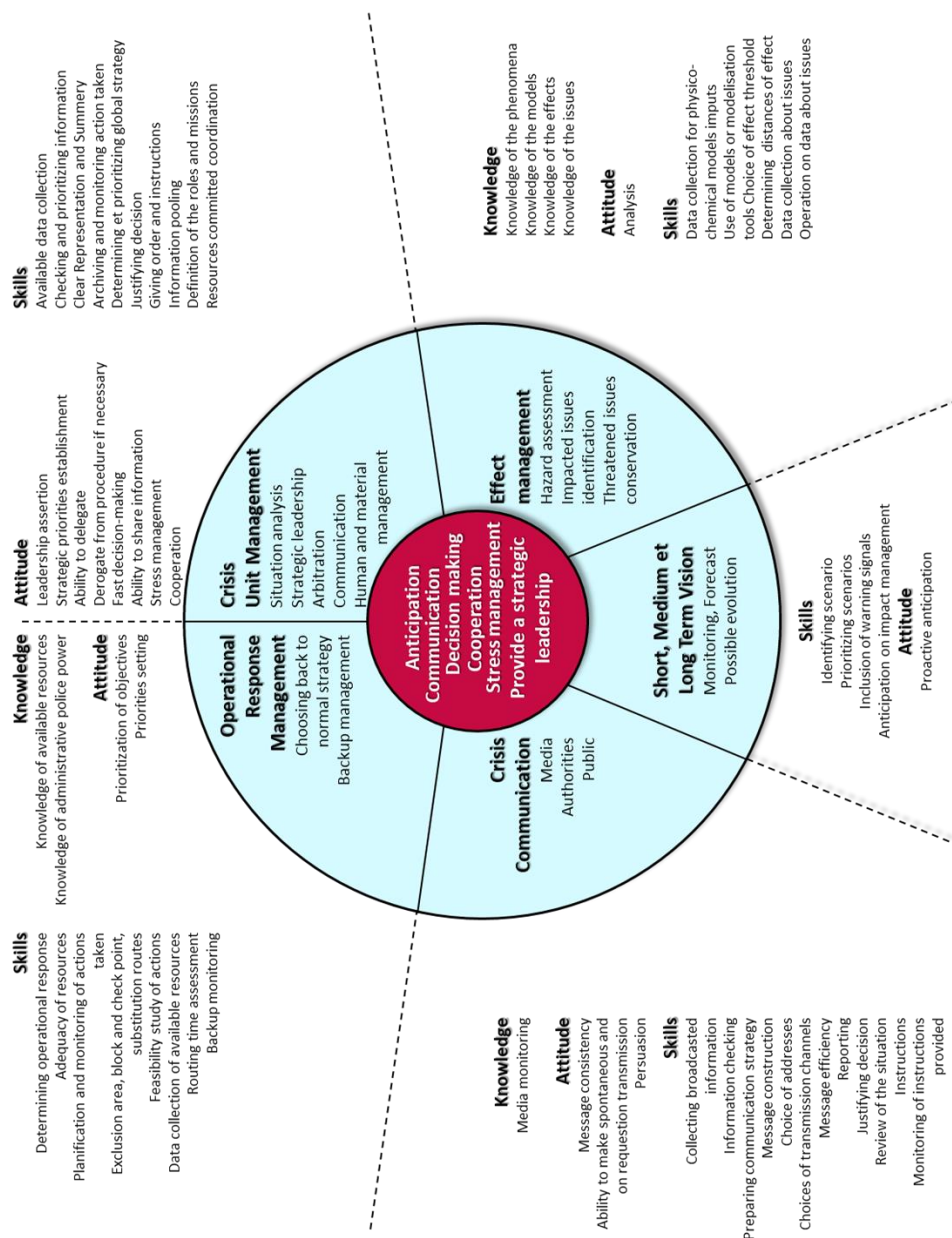


Figure 23: Pedagogical repository (Tena-Chollet, 2012)

General target sources: (Rasmussen, 1983), (Fredholm, 1999), (Weisæth, Knudsen, & Tonnessen, 2002) (Endsley, 2001) (Crichton & Flin, 2004)

The first axe, **the crisis strategic response axe**, is composed of five missions Lapierre extracts from Tena-Cholet work and completes by emergency plans review. These five missions are: the hazard assessment consisting in identifying and characterizing hazardous phenomenon and its effect (Tena-Chollet, 2012), the determination of impacted and threatened issues (population, environment, assess...) – counting for two different missions because functionally different – including characterizing these issues and determining threatening thresholds (Dautun, 2007) (Tena-Chollet, 2012), the management of response's resources and backup by anticipating actions to do, their feasibility and by committing resources to protect issues (Lagadec, 1995) (Lachtar & Garbolino, 2011), and the post-crisis management anticipation (Dautun, 2007) (Lachtar & Garbolino, 2011) (Tena-Chollet, 2012).

Second axe, **the crisis cell management axe**, is composed of seven missions written by Lapierre from several author's recommendations, advice and good practices because management mission was rarely clearly defined both in literature and in emergency planning. These ones are:

- The crisis cell activation that appears in several communal emergency plans and, we will confirm it in Chapter 6, also in industrial emergency plan.
- The identification of team's resources required by the crisis cell nature: unique and only set up for one dedicated situation then with various team members having particular competencies and able to mobilize specific resources (Ilgen, Major, Hollenbeck, & Sego, 1995).
- The information transmission management that is required under degraded condition because crisis cells are not prepared for such communication situation then have difficulties to manage internal information flows (Quarantelli, 1988).
- Leadership in crisis cell that is critical to bring the team to a wanted and deliberate operating mode (Lagadec, 1995)
- Keeping a shared mental picture of the situation to limit crisis cell "bunkerisation" (Lagadec, 1995)
- The teamwork coordination which is the most important part of teamwork (Mickan & Rodger, 2000) and therefore must have a dedicated mission.
- Dealing with one's emotion, especially to efficiently fight against identified and known cognitive bias.

The third and last axe, **the crisis cell management axe**, is composed of five missions, half inspired by Tena-Cholet work and emergency plan reviews, and half based on authors' recommendations agreeing on the importance of improving media communication and Social Media in Emergency Management (SMEM) (Coombs, Holladay, & Thompson, 2010), (Lagadec, 2012), (Martin, 2014). These five missions are: the media monitoring, the media information leadership, the communication with populations, the communication with authorities and the communication with the emergency response team. For this last mission, we may considerate it is redundant with the information transmission management from the second axe depending we considerate only the crisis unit or the crisis unit and its sub-cell including on-site teams.

Bring together, they are 17 missions distributed on the 3 axes:

Crisis strategic response	Crisis cell management	Strategical communication
<ol style="list-style-type: none"> 1. Hazard assessment 2. Determination of <u>impacted</u> issues 3. Anticipation of <u>threatened</u> issues 4. Response's resources and backup management 5. Post-crisis management anticipation 	<ol style="list-style-type: none"> 6. Crisis cell activation 7. Team's resources identification 8. Information transmission management 9. Leadership in crisis cell 10. Keeping a shared mental picture of the situation 11. Teamwork coordination 12. Dealing with one's emotion 	<ol style="list-style-type: none"> 13. Media monitoring 14. Media information leadership 15. Communication with population 16. Communication with authorities 17. Communication with emergency response team

Figure 24 : Crisis unit mission repository (Lapierre, 2016)

Nevertheless, because these missions are not precise enough to be evaluable, they require to be refined in goals or target, what crisis unit must do during the situation. These targets allow to address more efficiently trainees' specifics needs based on a global subject (the mission) and/or focused on a specific target. On the other hand, and it will be extended in this present project, these detailed goals help to design exercise through actual actions that must be done and could be observed. Missions were split by Lapierre in several targets according to three processes: by literatures reviews, expert meeting and by experiencing observation and evaluation in crisis cells during about forty crisis management exercises. However, the panel of goals Lapierre proposed for his repository is consequent with 64 identified targets and will not be fully developed in the core of this document. We only proposed a resume of these target in the Table 7.

Table 7: Crisis unit pedagogical goals repository (Lapierre, 2016)

Crisis strategic response							
1	Hazard assessment	Determine dangerous phenomenon	Knowing the consequences	Anticipate situation evolution	Use model tools	Choose effect's threshold	Determinate effect's distance
2	Determination of impacted issues	Characterize impacted issues	Manage protective actions on impacted issues				
3	Anticipation of threatened issues	Determine exclusion area and closure obstacles	Gather data on issues	Characterize threatened issues	Manage preventive action on threatened issues		
4	Response's resources and backup management	Identify available resources and backup	Study actions' feasibility	Monitor ongoing actions			
5	Post-Crisis management anticipation	Identify legal and administrative matters	Implement legal procedure				
Crisis cell management							
6	Crisis cell activation	Mobilize crisis unit team	Go to the crisis room	Equip the crisis room	Manage the crisis unit	Organize information transmission	
7	Team's resources identification	Identify lacking competencies	Request lacking competencies	Anticipate the take over	Identify resources and equipment		
8	Information transmission management	Manage information transmission	Gather information	Share information	Archive and monitor ongoing actions		
9	Leadership in crisis cell	Lead the crisis cell	Delegate and divide taskwork in the group	Show authority	Keep mutual confidence	Mediate disputes	
10	Keeping a shared mental picture of the situation	Make regular status report	User shared medium				
11	Teamwork coordination	Coordinate sub-cells	Make team decision	Monitor team performance	Support sub-cell		
12	Dealing with one's emotion	Manage stress in crisis unit	Manage tiredness in crisis unit				

Strategical communication							
13	Media monitoring	Gather information on the event	Check information	Answer to media questions			
14	Media information leadership	Define a communication strategy	Make a press statement	Follow strategic decision taken	Show persuasion	Deal with media	Contact media
15	Communication with population	Transmit instructions	Write a consistent message	Choose a relevant communication medium	Communication on social media	Deal with social media	
16	Communication with authorities	Choose the relevant recipient	Write a message	Make regular status report			
17	Communication with emergency response team	Choose the relevant recipient	Write a message	Coordinate with emergency response team	Identify available resources		

Then, each one of these 64 targets is declined in three difficulty levels depending on where trainees are in the learning continuum (see Figure 19). Therefore, these targets are adapted to novice, initiated or expert profile to propose a progressive active pedagogy and set, prior exercises, milestone of the learning continuum. Targets are then related to tasks for each level of difficulties adapted to trainees' experience in order to make them reach wanted pedagogical goals. These tasks, related to targets and situations in which they can be scripted as discussed in Chapter 8 are presented in Annex 5. These three variations for each goal are pedagogical targets that constitute, with the crisis competencies spectrum presented before, the fully developed Lapierre's pedagogical repository.

In addition of difficulty declinations for each pedagogical target, the number of targets set in exercise is also an important parameter that allows to adapt trainings to trainees. Based on the analysis of several exercises with different number of pedagogical targets, Limousin proposes a guideline – represented in Table 8 – to choose the correct number of these targets according to trainees' profile. He states this number is well adapted if the stretching area is reached (see Figure 9), the risk area is almost reached, trainees are involved in exercise, and if crisis and difficulty levels are considered high by trainees (Limousin, 2017).

Table 8: Number of pedagogical and crisis goals to implement in a scenario (Limousin, 2017)

Trainees' profile	Number of pedagogical goals to implement in the scenario (by hour h)	Number of crisis goals to implement in the scenario (by hour h)
Novice	[0; 5 [x h	0
Initiated	[5; 10 [x h	[1 ;3 [×h
Expert	[10; >10 [x h	[4 ;>4] ×h

On the other hand, crisis goals are – in Limousin methodology – dedicated situation aiming to put trainees in a realistic crisis environment including its uncertainties, stress and other degraded conditions. These goals do not have intrinsic pedagogical purposes but participate all together in building an adapted pedagogical environment for crisis trainings,

promoting trainees' involvement. Twelve goals were identified in the literature and from crisis feedback, each one matches with inputs categories such as (Limousin, 2017):

- **Surprising elements** aiming to disturb trainees by sending unexpected information that may be observed through trainees' reaction, how they use technical devices or how they manage the situation after such input.
- **Ambiguous elements** meaning both information that may be understood in several ways and, on the other hand, several contradictory information on a same topic.
- **Uncertainties** that may be increased by providing imprecise information or by hiding information.
- **Red-hearings which** are information or elements send as clues to induce actions from the crisis unit, but which are either fake or ambiguous and conduct to time loss or inadequate actions.
- **Stressing inputs** aiming to induce this emotional state in trainees with an "aggression" input. These inputs may considerably vary according situation and trainees.
- **Deadlock** requiring creative decision that consist in dedicated moments in the scenario where trainees have no more resources to fight against events and have to be creative to break the deadlock.
- **Disruptions** which are improbable or extreme no-win situations that deeply disturb the crisis unit organization and force it to adapt.
- **Disorders** including all employees' actions that do not follow regulations, law or working standard of the organization.
- **Time pressure** including actions that must be done in a limited time or under a certain delay.
- **Complexity** that includes at the same time a high number of stakeholders, a diversity of possible reactions, various connections between scattered events, a complex environment, expertise required to understand what happen and all other parameters that made a crisis a complex situation
- **Severity** related with how heavy are the possible consequences of the situation: how much dangerous goods is involved; how many people are impacted; how important are the damage on the environment etc...
- **Crisis dynamics** corresponding to the simulation of a realistic and disturbing crisis kinetic.

Such crisis goals do not directly relate to pedagogy as they do not refer to competencies but to phenomena trainees must experiment in order to be ready during a real crisis situation. However, crisis goals are, besides pedagogical targets, at the beginning of designing crisis exercises but, meanwhile pedagogical targets aim to improve trainees' competencies, crisis goals implement dedicated crisis-like situations in order to drill trainees to react to them, which is slightly different than teaching something but remaining close enough. Then, such goals intersect the pedagogical part of Expert'Crise literature review and its exercise design methodology review, discussed in the second part of this document.

3.4 Chapter 3 Resume

Expert'Crise project's trainings are based on a socio-constructivism approach refined in Data-Information-Knowledge-Wisdom model that assumes knowledge is built through a process transforming data gathers during experiences – through observation, sensation, thinking... – into information then into knowledge until they become wisdom, integrated to other wisdom in a moral value system. This model revealing learning is a process with three main trainees' states that may be identified: novices, initiated and experimented. Trainees in each state learn at different speeds and require different kinds of training to remain focus.

Even if the K in DIKW stands for Knowledge, knowledge alone is useless and requires skill and attitude to be properly implemented when it is needed. These three components together – knowledge, skill and attitude – form a competence according to the KSA definition. Competences relate to the specific teaching field then crisis management have dedicated competences that were identified and implemented in Expert'Crise trainings. Moreover, because Expert'Crise's purpose consists in improving trainees' competences, it requires to not only focus on competences but also discuss relations between the four poles of the pedagogical tetrahedron: the knowledge/competences, the teacher, the trainee and the learning group. Yet, because Expert'Crise's target audience is a group of adult workers in industrial companies, they already had experimented a lot during their professional lives and have already built various mental pictures. Therefore, both relation with teacher and knowledge/competences are modified when compared with child education that support pedagogical theories. Indeed, trainees may have difficulties to modify those already built knowledge in order to accept new elements bring by the teacher and, on the other hand, this one may be considered as illegitimate as a trainer. Then trainer must adopt an incentive, permissive or associative facilitation – but not a transmissive one – in order to rely on workers' experiences, especially in a group, where interactions between trainees may ease teacher work. Therefore, Expert'Crise's lectures rely on incentive facilitation while simulation exercises rely on associative facilitation.

These elements, gathered from the field of pedagogy, constitute the Expert'Crise theoretical basis as a training and characterize it. They allow to go further into crisis exercises description, starting from pedagogical targets. If Expert'Crise first exercises relied on Tena-Cholet repository composed of 6 general goals refined in 5 intermediate goals involving 62 knowledges, skills and attitudes, this repository was then substituted by Lapierre's one. This last one has the same global philosophy but is built around 3 axes: the crisis strategic response axe, the crisis cell management axe and the strategic communication axe. The first one involves 5 missions, the second one involves 8 missions and the last one involves 5 missions. Each one of these missions are refined in target – 64 targets in total – divided into 3 difficulty levels according trainees experience. These pedagogical targets are completed by crisis target that aimed to set trainees in specific situations in order to experiment phenomena related to crisis management such as stress, time-pressure or uncertainties. Lapierre repository defines 12 categories of crisis goals that aim to put trainees in stressful situations and must be set in parallel to pedagogical target. Those particular goals do not really relate to pedagogy and introduce – besides pedagogical targets – how exercises are designed according to the literature. Indeed, Expert'Crise

trainings was developed based on existing design methods for crisis and emergency exercises and implemented several improvements in the procedure of conceiving more efficiently such trainings. These two topics are discussed in the second part of this manuscript.

Part 1 Conclusion

Contributing to crisis management training design required first to explain what is “crisis management training design”. Yet the design of crisis management exercise is a cross-theme activity that required to scan several research fields to provide a correct description of what it consists. Main themes of this landscape of topics discussed in this PhD thesis are crisis management, pedagogy, crisis exercise design and game design.

Therefore, this part aimed to describe the first half of these themes, starting from explaining what a crisis is and how emergency management operate, especially for major accident in hazardous chemical industries in Belgium. This topic allows to introduce all bias that may occur in the dedicated management team of such situation – the crisis unit – and deals with the main solution to prevent such bias: trainings. Then, before continuing the review of literature on different fields that must be discussed, it seems important to consider the project at the genesis of this work, which is precisely a training project for hazardous chemical industries in Belgium. This project, called Expert’Crise, lets us gather an important amount of data and experience. These pieces of information related to the target audience and goals of this project that are described as well as how these trainings proceed, including the infrastructure used to set up immersive simulations. Therefore, it matters to describe these trainings done during Expert’Crise project. After that, a deep review of crisis and emergency training is required to contribute in an innovative way to the domain.

However, before considering such trainings – which are detailed in the second part of the document – it matters to deal with the proper way to teaching something and discuss the related literature. In other words, the pedagogical field must be examined: how the learning process works and what relations exist between trainer, trainees and knowledges. Knowledge, especially, is not enough to define alone what exercises should teach to trainees. Indeed, knowledge only refers to information known by trainees, independently to the ability to transcribe such information into an action or the ability to choose the proper way to perform it. These two abilities are respectively skill and attitude which form, with knowledge, a competence in the KSA approach. Nevertheless, this approach is challenged and other definitions of “competence” are discussed in this part. Based on these definitions and literature review, competences required for crisis management are detailed and allow to introduce trainings’ pedagogical targets, logically based on these competences and aiming to improve them. Two crisis management pedagogical targets repositories are introduced for this work: the first one developed in 2012 by Tena Cholet used in the first part of the project and the second one, more detailed, developed by Limousin some years later and used in the last part of the project.

This part sets the literature base for the following of the document on two main themes: crisis management and pedagogy. As these topics rely on an important amount of literature, they could had been considerably extended but, as they are the background where this work set, only an introduction is required to provide required information to answer incoming

questions. First, in order to properly define the scope of this work, “What is crisis management training design?” then, and more important, “How to improve it?”, which is the purpose of this contribution.

Part 2: Designing Crisis and emergency trainings for hazardous chemical industries and how to improve it

The first part lays the foundations for global themes of this document, explaining what a crisis is and how they are managed as well as introducing the pedagogical project underlying this PhD thesis, the Expert'Crise project, its main pedagogical features and on what pedagogical concept it was based. This second part, on the other hand, consists in precisely describing the core topic of this document: crisis and emergency training design. Indeed, as discussed, Expert'Crise relies, beside feedbacks from its own exercises, on existing design methodologies it matters to describe in order to define the start point of this contribution as well as its scope.

Then, once the state of the art is laid, the question of how to improve such design methodology comes and opens new literature fields to review. Crisis and emergency trainings include very often serious games and are usually, as introduced here, analyzed from a pedagogical point of view, their “serious” part. Occasionally, serious games’ authors state the game design process underlying their training design methodologies but it is uncommon they implement game features in their design framework. Then, the “game” part of such training is rarely analyzed and one reason that may explain it is the difficulty to state what is a game and study them scientifically. Therefore, a classification of serious games was built in order to specify what kind of serious games Expert'Crise trainings deal with. It appears that these trainings relate to Learning Role-Playing Games and role-playing literature was reviewed in order to bring new innovative elements to improve Expert'Crise training.

The **Chapter 4** focuses on crisis exercise design based on crisis unit missions and pedagogical targets developed in the Chapter 3 and completes it by a review on how to design a crisis exercise including all needed elements for such endeavor. Therefore, constitutive elements, structure and transcription means are defined and characterized then the design methodology is described. This chapter reveals some difficulties to overcome or lack to fill which are detailed in the following chapter.

The **Chapter 5** proposes two major improvement ways for exercises’ design that will be completed and refined in the second part. The first one consists in making the design process simpler to set up such exercises, requiring less information and man-work by focusing on central and essential elements. The second one consists in prospecting game design process to identify relevant points that may improve both interactivity and enjoyability of crisis and emergency trainings.

Chapter 4 **Scenario Design for Crisis Management Training**

In the first part of this document, the pedagogical purpose of trainings developed during Expert'Crise project as well as the context of these trainings were stated. Then, both crisis management and pedagogical concepts were introduced in order to provide bases to support the understanding of the main topic of this document: scenario design for crisis management training.

As said in Chapter 2, Expert'Crise trainings had to be ready to use from the very beginning of the project so was based on existing trainings. Then, they were improved, based on feedbacks from exercises and the deepening of literature taking place alongside the project development. Therefore, existing methodologies were reviewed in order to improve the Expert'Crise way to prepare exercise. Several methodologies exist and are usually strongly related to the nature of organizations targeted by trainings – often public authorities – and to the nature of exercises realized. Indeed, a full-size simulation for firemen is not organized nor scripted the same way a table-top for industrial plant managers is. Limousin and Tena-Cholet in particular propose interesting elements for designing exercises. Despite those trainings are mostly designed to be held in simulators and dedicated for public authorities' trainees, an important part of their design and script methodology may be transposed in the precise setting described in Chapter 2.

4.1 Scenario constraints

The first kind of feedback we have from existing crisis exercises design methodologies is constraints on this process and the people who are involved in it. At the forefront of these constraints, exercise scriptwriters (or designers) have to work with people from the targeted organization on scriptwriting, which is a challenging process for them. Indeed, scriptwriters must know how the involved organization work and what it does, then they must design an exercise that (1) simulate a crisis, (2) use pedagogical tools to improve crisis managers' competencies (and must be observable during exercise) and that (3) could be staged and facilitate by facilitation team. Therefore, strong constraints apply on scriptwriting teams that must know the principles of team management, pedagogy and organization process, at least in broad terms.

The exercise's script is a tool meant to reach training goals and then must meet the needs of several exercise's stakeholders (Rolland, 2003) from exercise facilitators to crisis manager trainees. However, the needs of these stakeholders are not the same. Indeed, for trainees, script must be plausible and credible as well as involving and improving their

competencies (Gaultier-Gaillard, Persin, & Vraie, 2012). On the other hand, for facilitator, the script must provide a crisis characteristic event sequence that allows to set and support the training, then define their facilitation action. For observers, the script must come with SMART (specific, measurable, achievable, relevant and time bounded) targets. Because of these various partners using the script, Villot-Leclercq defines four constraints that should be seen as guidelines a scriptwriter must considerate to take into account essential elements for each one of these stakeholders (Villiot-Leclercq, 2007). The first one is a **genesis constraint** related to limitations during the creation of a mental scenario process and its transposition into a feasible and executable form. The second constraint is called **direction constraint** and relates to intentions and pedagogical goals pursued under a determined context. Then comes the **explanation constraint** that is required to make a clear, precise and formulated under comprehensible words scenario for users. In the end, the scenario is provided to users under specific conditions that is represented by the **delivery constraints** covering all modalities to transmit the scenario under adapted conditions depending on the kind of users targeted, one's role in the scenario and one's individual characteristics.

A script organizes chronologically events and can be seen as the exercise and evaluation framework (Gaultier-Gaillard, Persin, & Vraie, 2012). The literature identifies several conditions required for a scenario and exercise (Tena-Chollet, 2012), (Heinzen, 1995) (Bernard, 2014), (Direction de la Sécurité Civile, 2009):

- **Consistency:** Script must have an internal consistency and logical, events must have a reason and *deus ex machina* – or unexplained interventions magically solving problems – should be avoided
- **Credibility:** If consistency means event must have a reason, credibility means these reasons are possible and logical links between cause and consequence are valid
- **Plausibility:** Trainees must believe the situation could happen
- **Likeliness:** Script must be as close as possible of what would happen if such simulated situation really occurred with, if possible, immersive devices
- **Relevancy:** Script must involve targets that required crisis management competencies aimed.
- **Motivating:** Trainees must find interest, and be involved in the proposed exercise through adapted targets both challenging and reachable. The scenario must frequently stimulate trainees to maintain their involvement all along the exercise (Asproth, Borglund, & Öberg, 2013)
- **Immersive:** Trainees must feel they are in a particular dedicated training environment and do not leave it
- **Flexible:** Exercises always require some adjustment when they are ongoing so script must be adaptable to always match with trainee actions.

These requirements influence how the script is written by promoting, for example, communication means used or events chosen for accidental sequence. Indeed, the more realistic – i.e. consistent, credible, plausible and alike – a scenario is, the more it involves and motivates trainees in the exercise then make it more efficient.

Moreover, a scenario must simulate crisis features such as uncertainties, ambiguities, contingencies and so on. Therefore, trainings must rely on original scripts, possibly based

on real crisis, to set trainees in realistic situations (Limousin, Bony-Dandrieux, Tixier, & Dusserre, 2015). Script originality aims to focus on trainees' abilities to adapt and be agile under new and unexpected situations, crisis' features that induce a destabilizing incredibility state when occurring. The principal risk of staging unexpected events in training is the possibility that trainees refuse it, especially with adult learners, saying they are not possible. There is not, in crisis exercise, "willing suspension of disbelief" (Coleridge, 1817) as in a work of fiction, especially because adult worker trainees may be in a defensive attitude in front of what they may feel as an evaluation of their aptitude or their organization. Therefore, scriptwriter faces the challenge of all combining previous constraints and designing exercise with an experienced scriptwriter, used to develop such crisis training (and knowing these constraints) is a major stake (Limousin, 2017).

4.2 Scenario constitutive elements

As said above, a scenario must simulate crisis features. These features are transposed, in pedagogical process, into constitutive elements which help scenario designer to write the crisis script. The first crisis feature that may be transposed is the relation to time during exercise. If time does not really belong to the scenario – it does not compose it properly speaking, time belongs to the context, the setting, where the scenario takes place – it strongly influences how a script is written and its rhythm. Moreover, as said in the Chapter 1, time perception is strongly impacted by individual stress state and varying exercise time may be relevant to "force" this crisis feature. It is either possible to simulate in Real Time Simulation, accentuate time flow in a Fast Time Simulation, or, on the other hand, give more time than in a real situation to deal with the crisis in a Slow Time Simulation according to pedagogical targets pursued. Simulation speed, if it may be set as slower or faster than in real life but remains constant all along exercise, may also vary during exercise to make punctual focuses on specific points. Even if, independently of the exercise setup and how it is managed, speed of the simulation does not impact simulation accuracy or correctness (Centre de simulation et d'expertise maritime, 2019), it may affect how trainees perceive simulated environment and their immersion in the training. Immersion may be more or less impacted according to consequences of these changes on simulation realism and strongly depends on how trainees interact with the simulation and perceive it through its interface. There are several difficulties to properly interface trainees with simulation in a realistic setting and that's why computer assisted trainings are promoted (Tena-Chollet, 2012). These ones allow trainees to receive directly live-feedbacks on their actions and allow trainers to analyze these actions and evaluate trainees' performances later: portability and flexibility of such system are relevant pedagogical advantages of such system (Mouloua & Koonce, 1997).

Based on these recommendations, Tena-Chollet developed a methodology adapted for semi-virtual pedagogical environment (Tena-Chollet, 2012). Even if this topic is not directly related to how Expert'Crise managed its trainings, several outcomes of Tena-Chollet work are still relevant, especially classification he made for scenario constitutive elements. To develop his classification – which was extended by Limousin, generalizing it – he compares crisis management exercise scriptwriting with classic scriptwriting and

narratology to determine what is required to write a scenario. According to Polti theory, all possible scenarios rely on a limited number of dramatic situations that make protagonists and story in movement (Polti, 1895), (Souriau, 1950). These dramatic situations are conflicts between goals – what protagonists want – and difficulties, stumbling-block on the road of heroes, protagonists encounter (Lavandier, 1994) (Cotte, 2014). These conflictual situations are stimulus that push the story forward. Without them, there is nothing to tell and storyteller must include enough stimulus to keep the audience entertained. In pedagogy a similar approach relating stumbling-block to progress is called problem-based learning (Rieunier & Raynal, 1997). In narratology, problems make the story move forward while in pedagogy they make trainee learn by solving them. Tena-Chollet proposed an EBAT-compatible approach for scriptwriting, transposing dramatic situations into pedagogical elements he classified in three categories: **situation-task**, **phenomena's** and **perturbations**. Situation-tasks are meant to set an environment encouraging targeted competencies learning. This environment takes place in uncertain conditions where dangerous events come with hazardous phenomena that may have anthropic as natural origins. Moreover, uncertainty is strengthened by perturbations that simulate crisis degraded situations and may be related to the root cause of the situation or to deeper and diffuse problems. All crisis aggravating factors (Dautun, 2007) inside or outside organization may be a perturbation as defined here. These elements support crisis and emergency training exercises' pedagogical design then relate to taskwork and competencies that must be clarified during scriptwriting (Joab, Auzende, & Moinard, 1999) to assign these elements to pedagogical targets.

Stimulus aiming to set previously defined pedagogical elements have several characteristics (Limousin P. , 2017), (Gaultier-Gaillard, Persin, & Vraie, 2012), (McCreight, 2011), (Bernard, 2014) : a time stamp, one or several senders, one or several receivers, a stimulus category (detailed below), one or several pedagogical goals, and a transmission mean as realistic as possible such as phone, radio, walkie-talkies, map, pictures, social network or, simply, orally. Stimulus may be either planned to be injected into the scenario independently of trainees' reactions, in that case they support the scenario and form its structure, or be spontaneously injected during the exercise to adapt scenario to trainees' actions, especially their difficulties, to encourage trainees to react (Alberta Emergency Management Agency, 2012) or to bother them in the purpose to reach a pedagogical target. Adapt scenario during the exercise requires to prepare extra stimulus to inject them when (and if) it is required (Bernard, 2014) accorder observers' feedback.

As said, stimulus may be classified in categories, Limousin identified five of them: situational, support, challenge, event and reminder stimulus (Limousin, 2017). **Situational stimuli** (see **Erreur ! Source du renvoi introuvable.**) set circumstances of the situation such as phenomenon, involved stakes and, more globally, what happen during the scene. Information is transmitted through onsite stakeholders, sensors, sound or visual effect, or any other means and aims to set trainee in a crisis scene. First situational stimuli are called initial stimuli and establish the context of the exercise, usually before it, during briefing, are just at the beginning of the simulation. **Support stimuli** (see **Erreur ! Source du renvoi introuvable.**) relate to unselected pedagogical goals that still appears in the exercise because it would not be realistic to override them. Then support stimulus aims to bring help

to crisis unit – with a message describing the situation, extra confirmations, feedback and so on – to deal with these unselected pedagogical goals and then reduce scenario difficulty if required. On the other hand, **challenge stimuli** (see 4.2.2) relate to selected pedagogical goals to achieve difficulties trainees must overcome to achieve their goals. Challenge stimulus may be a perturbation, someone, an object, a situation, a behavior, a natural event or anything that may interfere with trainees' activities (Mélou, 2002). Challenges aim to trigger selected pedagogical goals by destabilizing the crisis unit and requiring, from crisis manager, to change their strategy through a process that should involve targeted competencies. Then these stimuli are closely related to pedagogical goals of the exercise as a tool to implement them in the exercise. **Event stimuli** (see 4.2.3) are close to challenge stimulus but aim to set crisis particular characteristics such as surprise, red herrings or uncertainty that set degraded conditions in a crisis situation. Limousin calls these characteristics “crisis goals” because, if they do not relate to pedagogical target, they have a pedagogical purpose by putting trainees in a difficult realistic environment. In the same way as pedagogical target, crisis goals cannot be all reached during the same training because the situation would be too difficult to be educational. **Reminder stimuli** (see 4.2.2) are sent by facilitator who have a list of these stimulus ready at the start of the exercise to trainee reached remind them target that have not been reach yet. Reminder stimulus aims to “force” trainees to achieve task – that may have been forgotten or left out – to reach pedagogical goals.

Stimuli, independently of their categories, deal with several topic such as phenomena, stakes, situation inside or outside the crisis room, technical equipment for crisis management or safety/security, materials and/or energies, process and/or methods, human resources, internal organization, decisions and decision-making, pressure (from media, authorities, corporate level and so on) on the crisis unit and expectation of these pressures, or, in the end, message sent or received by the crisis team. Note that all these topics may be subject of a support as well as a challenge stimulus or any other categories of stimulus. They will have different effects on crisis cells and are supposed to help reaching pedagogical targets (Limousin, 2017). Situational stimuli, because they support the exercise background, usually refer to involved stakes and phenomena.

4.2.1 Situational Stimulus: Stakes and phenomena

Stakes are usually categorized under three families: environmental stakes, material goods and human stakes (Dautun, 2007) (Tena-Chollet, 2012) (Tixier, 2003) (Blockley & Dester, 1999). Limousin adds a fourth category of stakes related to internal crisis cells resources and equipment required to perform crisis management he called crisis organization stakes (Limousin, 2017).

Environmental stakes stand for protected natural areas including animal and vegetable species, urban green spaces, grounds, atmospheric air and water environment as well as visual and auditive environment (Tixier, et al., 2006). **Material goods** include critical infrastructure such as energy (electricity, gas and fuel), drinkable water, telecommunication and transport (road, rail, air, river and sea) network, services infrastructures such as transport, public security, emergency, teaching or health but also private property such as housing and industrial plant. Structures protecting others stakes such as dams or walls may

also be considered as stakes. **Human stakes** stand for sedentary local population, people in public building access, passing people or users and workers of the impacted organization. Limousin completes human stakes by including human relations – especially social and legal relations – between these last ones. In the end, Limousin categorized crisis organization stakes in two sub-categories. The first one relates to finance, brand image, product or services provided by the crisis unit as well as its relations with civil society, shareholders, customers, suppliers, outsourcing companies and local groups. The second sub-category relates to crisis managers and infrastructures where crisis management processes including its environment (vent, heater, air conditioning, light...), technical devices and networks involved. Technical devices refer to emergency plans, communication means, computers, servers, coordination and monitoring means (Limousin, 2017).

Limousin designs a 0 to 5 scale – based on literature (Dautun, 2007), (Bureau d'Analyse des Risques et Pollutions Industriels, 2004) – to evaluate how much each stake are involved in exercises to write script adapted to organization by adjusting difficulties. Four levels are described for each stake: **impacted** if it is directly impacted by the considered phenomena in the initial situation, **conditionally impacted** if it may be impacted depending on crisis managers' decisions to protect them, **threatened** if it is not impacted but may be impacted if the situation evolve, and **involved** if it is neither impact or threatened then does not require care but require specific actions such as information, supply and so on. Impacted stakes are then graded with a score related to how much impacted they are. For human stakes, it corresponds to a medical status – dead, absolute emergency, relative emergency and medico-psychologic emergency – whereas for material goods it corresponds to a deterioration level (destroyed, unfunctional, dysfunctional...).

On the other hand, **phenomena**, even if they were firstly conceived by Tena-Cholet as a constitutive element of his virtual environment for crisis training as an object (in an object-oriented programming meaning) refined in different specialized class depending their nature (fire, dispersion...) and inheriting general characteristics, are described in a more generalist point of view by Limousin. This one defines phenomena both according their nature (fire, dispersion...) as well and their “function” – what they do – in exercises. First, seven phenomenon natures are described in a non-exhaustive typology then declined in 167 specific kinds of phenomena not presented here, these seven main categories are: accident, natural phenomenon, terrorism or malicious acts, scarcity, socio-cultural or political events, war and invasion, and health events. On the other hand, phenomenon's “function” belongs to five categories: **Main phenomena** which are at the center of exercise as *the major* accident and defined other phenomena categories, **precursor phenomena** which causally lead to the main phenomenon, **reinforcing phenomena** that aims to modify one or several main phenomenon's characteristics (its range for instance), **domino phenomenon** induced by the main phenomenon and having consequences on crisis management or on stakes, and **independent (or secondary) phenomenon** which are, as main phenomenon, major event but without any connection with other ongoing phenomena. Precursors, reinforcing and domino phenomena are brought together under a dedicated category called “**Linked phenomena**”. Moreover, phenomena may be planned or unplanned causing crisis or emergency as said in Chapter 1.

Phenomena have several parameters characterizing them: their cause, their timestamp, their localization and area of effect, their effects (toxicity, heat flow...), their source terms or involved quantity (especially in an industrial disaster approach), the impacted installation or equipment characteristics and potential evolutions or particular hazard, especially related to the environment (domino effect for instance).

On the other hand, once phenomena characterized, Limousin proposed, the same way he did for involved stakes, a 0 to 1 scale to evaluate how many phenomena set in exercise based on existing rating (Dautun, 2007), (Bureau d'Analyse des Risques et Pollutions Industriels, 2004). The total score is the sum of the five parameters. First, (1) particular criteria's depending of the nature of the phenomenon, for instance: kinetic and gravity for industrial accident, alertness level, gravity and kinetics for natural phenomena, and number of terrorist acts, delay between these acts, localization, kinetics and domino effect for terrorism. Then other criteria that take into account : (2) the size of the impacted area and reflect, (3) how much crisis managers know about the phenomenon and how much information they get from the scenario, (4) how well identified the phenomenon is in emergency planning so how much familiar trainees are with this event, and, in the end, (5) how localization of the phenomenon impacts the crisis management.

This score – either for stake and phenomenon – is a help to design crisis management training and Limousin discussed on how many phenomena must be implemented in exercises to design adapted training that set trainees in the stretching area for learning as shown in Chapter 1 while implicating them in the exercise. Even if it is difficult to assess the influence of each constitutive element of a crisis management scenario to build an adapted pedagogical scenario reaching the stretching area, multiple test lead Limousin to propose a range of how many of these elements implement in a scenario for each of these ones, depending on the level of the trainees (novices, initiated or expert) and represented in Table 9.

Table 9: Number of phenomena to implement in scenario according trainees' level (Limousin, 2017)

Trainees' profile	Number of phenomena to implement in the scenario (by hour, h)
Novice	If exercise last less than 2 hours: $Nb_{phenomena} = ([1; 1,5[) \times h + 0,5$ If exercise last longer than 2 hours: $Nb_{phenomena} = ([1; 1,5[) \times h + 1$
Initiated	If exercise last less than 2 hours: $Nb_{phenomena} = ([1,5; 2[) \times h + 0,5$ If exercise last longer than 2 hours: $Nb_{phenomena} = ([1,5; 2[) \times h + 1$
Expert	At least, If exercise last less than 2 hours: $Nb_{phenomena} = (2 \text{ Linked phenomena}) \times h + 0,5$ If exercise last longer than 2 hours: $Nb_{phenomena} = (2 \text{ Linked phenomena}) \times h + 1$

4.2.2 Challenge and reminder stimulus: Situation-task and perturbation

The definition of pedagogical targets allows to choose events that lead trainees to dedicated situations, adapted for learning aimed competences. These events – designed from pedagogical targets and the analysis of what event leads to what situation according working and emergency plans and habits – constitute script milestones that structure exercise. Trainees are expected to deal with these situations and the facilitator must ensure they follow a correct learning path while proposing a response. If dealing with these events is not spontaneous, facilitators must send stimulus to focus trainees on that situation or to

lead them on the same problem but through another path. Nevertheless, facilitator help must stay as implicit as possible (Tena-Chollet, 2012).

These events are the entry point of situation-tasks by setting the situation. Situation-tasks are the direct transcription of EBAT and aim to “force” trainees to do an action (the task) under special circumstances (the situation). The task is a mean to involve trainees in a reasoning process harnessing knowledge targeted in a socio-constructivist approach. In this approach, learning is done mainly actively, by doing something. Then, it is advised that task’s consequences impact the scenario to make trainees feel they have an influence on exercise and therefore involving them and make them proactive.

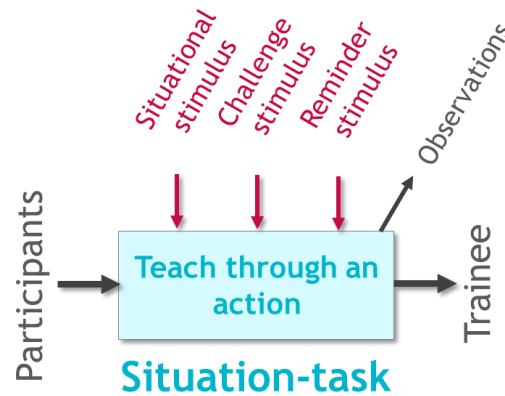


Figure 25: Situation-task's input and output

Situational, challenge and reminder stimulus are inputs leading trainees to do the wanted task: Situational stimulus are static elements of the scenario representing the sequence of events while challenge and reminder stimulus are dynamic inputs that can be injected into the simulation to adapt the scenario to trainees, especially to reach “crisis goals” in a CTT-like approach with event stimuli. According to this purpose, these stimuli are similar to Tena-Chollet perturbation, contributing in the trainee’s implication by reflecting consequences of their actions or simulating unexpected events that make crisis unpredictable and difficult to manage (Dautun, 2007). These dynamic inputs, if facilitator wants to lead trainees to an unrealized task and stay as implicit as possible, must first be general then, progressively, focus on the aiming task to not make it too obvious.

These stimuli that set obstacle, difficulties, on trainees’ road are inspired by artistic scriptwriting, adapted to pedagogical field. Instead of making the story move, overcoming these growing difficulty obstacles teach the trainees new competences (or improve existing ones). Classic scriptwriting categories obstacles depending on whether they are external with outside sources, internal with sources inside, or external obstacles but with internal sources, for example the consequence of crisis cell’s decision (Lavandier, 1994). The first category of stimulus appears to be the most relevant for crisis and emergency exercise even if others may be simulated with an undercover facilitator in the crisis unit that perturbate it with planned stimulus. Nevertheless, it is not easy to implement in actual exercise. Obstacles may also be characterized by, first, their duration – how long do they impact the crisis unit – and, second, their intensity. Intensity was ranked in three levels by Limousin

for the same reason as phenomena. First, low impact obstacles may be easily overcome with a dedicated action to do, then average impact obstacles require from trainees to solve a complex problem with limited resources and which may last some time, and, in the end, strong impact obstacles that may not be overcome in the duration of the exercise or only through a long and complex process involving innovative solutions. Moreover, if duration is an important characteristic, timing is almost as important and delay in providing information may, for instance, be the opportunity to make trainees search themselves for lacking information (Tardy, 2010). However, even if obstacles are important for scriptwriting, too many of them may be counterproductive bringing trainees beyond stressing area. Therefore, a guideline for setting a proper number of stimuli with an adapted intensity was proposed (Limousin, 2017). Note that intensity level with quantified “impact score” was also developed and implemented in original table, but is not represented in Table 10. Indeed, quantitative exercise difficulty assessment will not be developed in this work.

Table 10: Number of obstacle stimulus to implement in a scenario (Limousin, 2017)

Trainees' profile	Number of obstacle stimulus to implement in the scenario (by hour, h)
Novice	$([0; 1[\text{ obstacle stimulus per pedagogical target}) \times h + ([0; 15] \text{ obstacle stimulus}) \times h$
Initiated	$([1; 3[\text{ obstacle stimulus per pedagogical target}) \times h + ([10; 25] \text{ obstacle stimulus}) \times h$
Expert	$(3 \text{ obstacle stimuli per pedagogical target}) \times h + ([10; 25] \text{ obstacle stimulus}) \times h$

Besides classifying these stimuli, Limousin proposed a vast repository of stimulus related to pedagogical goals (see 3.3). This repository was built both by considering actions that must be done by crisis management during a situation and what obstacles may impede them and how, and, on the other hand, by reviewing previous crisis literature and exercise to identify obstacles that may appear. These obstacles may have a primary cause (a leaking pipe, an operator accident...) or deep causes such as organization or safety culture (Bureau d'Analyse des Risques et Pollutions Industriels, 2004) which may be relevant to implement in exercise – to raise a reflexive process on habits – even if they are difficult to implement.

Therefore a 11-class obstacles repository refined in 52 categories was proposed. Each category is itself refined leading to 794 stimuli items including 380 stimuli dedicated to reach crisis **strategical response** pedagogical targets (as defined in 3.3), 256 stimuli dedicated to reach **crisis cell management** pedagogical targets and 158 dedicated to reach **strategical communication** pedagogical targets (Limousin, 2017). We only present here the categories of obstacles in Table 11. Note that one pedagogical goal may be targeted by several stimulus about different topic.

If an obstacle is not reached the first time trainees met it, facilitators may send reminder stimulus to confront trainees again with the problem. Then sending a reminder stimulus is a reactive process and trainers must have some stimulus ready to be injected in the scenario if trainees do not reach their goals. Reminder stimulus must be implicit enough to not make trainees feel they are forced to deal with the topic, adapted to the obstacle and it must not modify the global scenario. Limousin proposes a repository of 114 items for these stimuli: 77 to call crisis strategical response axe's goals, 25 for the crisis cell management axe and 22 for the strategical communication axe.

Table 11: Obstacle classification (Limousin, 2017)

Organizations or relation		Event	
<ul style="list-style-type: none"> • Coordination/Teamwork • Tension/Conflict between stakeholders • Heavy documentation • Backup • Out of contact • Absence • Claim 		<ul style="list-style-type: none"> • Surprise • Ambiguity • Uncertainty • Red herring • Stress • Dead-end 	
Information		Activities / Operations	
<ul style="list-style-type: none"> • Directly sent to crisis unit (wrong, scattered...) • That crisis unit must look for • Broadcast on social network • Broadcast through medias • Interview • Real (but altered) documentation (emergency plan for instance) 		<ul style="list-style-type: none"> • None • Non-cooperative behavior • Reduced efficiency • Mistake • Behaviors ignoring recommendation • Illegal behaviors • Behavior request 	
Situation		Decision-making	
<ul style="list-style-type: none"> • Phenomena • Stakes • Protagonists • Material resources 		<ul style="list-style-type: none"> • Dilemma • Hierarchization • Management pressure • Dead-end 	
Time		Legal	
<ul style="list-style-type: none"> • Delay for providing required means • Delay for feedback • Time pressure 		<ul style="list-style-type: none"> • Complaints • Request of evidences • Liability / Fields of action limits 	
Environment		Finance	
<ul style="list-style-type: none"> • Inside crisis unit • Outside crisis unit 		<ul style="list-style-type: none"> • Donations • Claim • Budget 	
Social / Cultural			
<ul style="list-style-type: none"> • Exceptional events • Spontaneous event 			

4.2.3 Event stimulus

As said, event stimulus aims to implement crisis particular characteristics such as surprise, red herrings or uncertainty that set degraded conditions in a crisis to reach “crisis goals”. Based on dramatic art literature (Lavandier, 1994) (Cotte, 2014), Limousin developed a repository of event stimulus triggering crisis goals defined in 3.3 (Limousin, 2017). Actually, the nature of each stimulus is already defined by the category of goals they aim and what they are expected to do (surprise, stress, uncertainty...). As for obstacles inputs, event stimulus generates frustration and dissatisfaction (Lavandier, 1994) and may lead to anxiety but such inputs bring trainees closer to realities of a crisis situation. Quantity and impact of such stimulus must stay limited to not overload trainees and keep them in an optimal learning environment. Event repository – not presented here – gathers 184 stimulus items with 38 for surprising elements, 14 for ambiguous elements, 21 for uncertainties, 9 for red-herrings, 43 for stressing inputs, 9 for deadlock requiring creative decision, 17 for disruption, 7 for disorders, 8 for time pressure, 10 for complexity inputs and 8 for severity (Limousin, 2017). This repository presents stimulus, how to implement them in a scenario and, in the end, how to observe them.

4.2.4 Support stimulus

In the end, and as said, support stimulus aims to make trainees focus on pedagogical target by helping them on out of scope topic, problems that appear during a situation but are irrelevant for designing the training. These stimuli must ease the crisis situation or avoid supplementary difficulties, provide information – with the adapted timing to anticipate problems – helping trainees so they do not have to look after them or avoiding them to find a solution to one problem, implement methods or techniques avoiding trainees to do specific actions, implements means that guide trainee in crisis management and limit stress, and set most credible communication means (Limousin, 2017). Limousin defines seven categories of supports stimulus: Crisis situation modification, stakeholders' actions, particular actions communicated, cooperative behaviors, notifications of particular stakeholders, time, and untouched element. Note that stimulus does not have to be sent to trainees and may consist to give them supplementary time to deal with ongoing actions ("Time" Category) or reduce the gravity of planned event ("Crisis situation modification" category). "Stakeholders' actions" category relates to actions done by external stakeholders without crisis unit ask it such as policemen establishing a safety perimeter. Similarly, "notifications of particular stakeholders" consist in feedbacks or information from stakeholders on what happen onsite or on other topics. "Particular actions communicated" category relates to explicit information sent to the crisis unit to disambiguate the situation or to clarify it. "Untouched elements" category relates to rules set by facilitator excluding some stakes of being harmed or impacted to reduce stress on crisis unit. The same way he did for obstacles stimulus, Limousin establishes a database of support stimulus gathering 74 stimuli related to untargeted pedagogical goals (Limousin, 2017).

4.3 Scenario structure

Once all elements of a pedagogical scenario are defined, the way they will be arranged must be explained. Because storytelling is an old practice with important feedback, artistic scriptwriting is the main inspiration for designing interesting pedagogical scenario.

In cinematography, structure is what bring together disjoint elements to make them move, occupy space in a certain way, to build a rhythm for the story (Léon-Garcia, 2004). Then structure arranges event chronologically to unfold the plot and modify dramatic intensity. Storytelling is usually divided into three main phases (Campbel, 1949): exhibition of the initial situation, development of dramatic problems or "build-off", and conclusion of them or "payback". This three-act model matches with how a crisis process as shown in Figure 26. Indeed, crisis situation has a pre-crisis situation phase, crisis and its development phase, then the conclusion of the situation or post-crisis situation.

Artistic scriptwriting recommends to reveal all main characters in the first part of the scenario (Léon-Garcia, 2004) then, by analogy, Limousin recommend to start a crisis unit scenario by a call coming from firemen or the intervention team onsite (Limousin, 2017). This way, trainees easily understand the exercise context, especially who are their local contact, simulate by facilitator (Limousin, Bony-Dandrieux, Tixier, & Dusserre, 2015). First phase must finish on a dramatic plot which escort spectator to the second act. This first

dramatic plot must be an important change in the situation, a disruptive event, and spectators must understand that the paradigm of the story change, it is a brand-new world where protagonists are strangers (Campbel, 1949). Second act must then alternate quiet moment and time of tension (Léon-Garcia, 2004) which build-up dramatic intensity. Then, to build-up intensity until the payoff, obstacles may be more and more difficult to increase global tension (Cotte, 2014) even if this one is less important during quiet moments. With obstacles and obstacles hitting protagonists, new dramatic situation – plots – will occurs and must lead to a final situation – the climax – that seem to cannot be overcome, which finished the second act and introduce the third one. The third act is where the initial disruptive event that came at the end of the first act finds its solution. It doesn't have to be neither a happy or expected ending, but must be the result of previous dramatic situations alongside the second act (Cotte, 2014). End of a scenario is an important moment because it is when all build-up events payback in climax. Nevertheless, tension must not decrease too fast because it may disappoint spectator expecting more (Cotte, 2014). Then exercise – as film or theatre performance – must have a starting point, a middle and an end. Exercise scriptwriter must keep this classic three act structure (Field, 1984) with the following repartition key: $\frac{1}{4}$ for warning chain, $\frac{1}{2}$ for setting, crisis management and implementation of solutions and $\frac{1}{4}$ for ending phase.

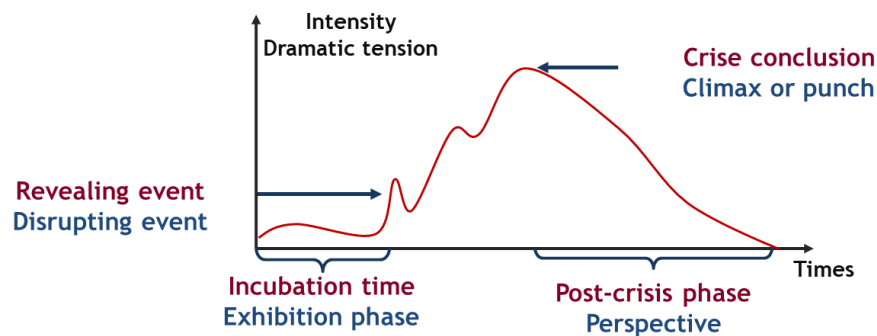


Figure 26: Crisis and Scriptwriting

Describing a scenario as a succession of dramatic plots is relevant for structure crisis exercises, especially to relate these plots each to another in order to make the scenario consistent, build an adapted dynamic and involve every trainee. A scenario must have at least two dramatic plots: one that starts the story, putting protagonists in move, and a climax at the end of the second act. How dramatic situations organized inside a story is not random and literature identifies common structure. Propp defines 30 generic sequences composing folktales that follow in a specific order (Propp, 1928) for instance and Campbell propose a global structure of myth with several steps that the protagonist of the story follows to become a hero (Campbell, 1949). Works of this last one was extended and generalize by Vogler in the *Writer's journey* (Volger, 1998) which is a major inspiration for movies (and other medium) scriptwriting in Hollywood cinema. Then what came from observations on classic stories' structures become a guideline for design story, reversing cause-effect

relation. Some elements of this scriptwriting may be adapted for crisis and emergency exercise design and will be extended in the second part.

Nevertheless, trainees in exercises are not as spectator in front of a movie, they interact with the scenario and play an active role in it. Then exercise scriptwriting is closer from video-game scriptwriting. However, this last one shares the same inspiration (Schell, 2008) from classic dramatic scriptwriting. Interactive scriptwriting allows to script several story-line according trainees' actions (Adam, 1992), (Caïra, 2014) as shown in Figure 27.

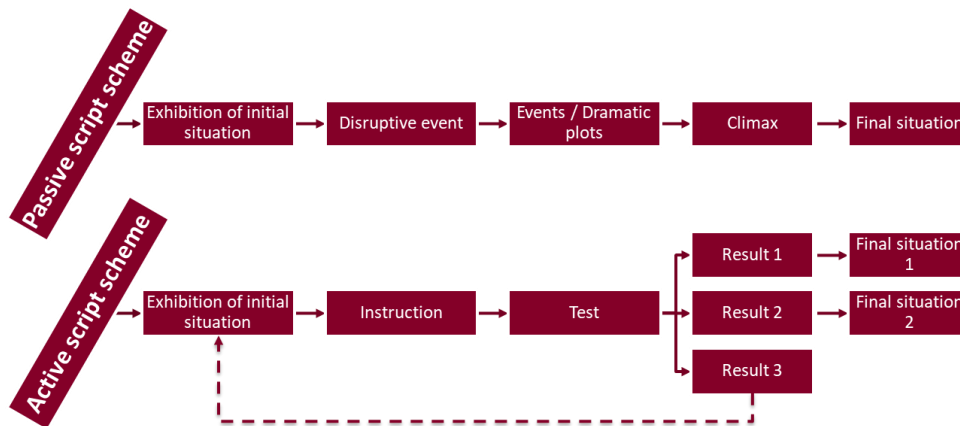


Figure 27: Comparison between active and passive scriptwriting (Caïra, 2014)

Even if crisis exercises are not organized around dramatic plots arrangement but around pedagogy and realism, especially without a climax build all along the script to be an ultimate challenge for trainees, there are several parallels that may be drawn in particular with the situation-tasks that are the milestones of pedagogical scenario, the same way dramatic plots are for artistic plot. Then the main framework of exercise may be designed the same way a dramatic script is written.

Alongside with situations-tasks, phenomena are the start point of exercise and it is important to know when to script them. Main phenomenon is – as its name says it – the central problem of the training. It may be an instant phenomenon, unpredictable and without any precursor phenomena and, in that case, it must be scripted at the very beginning of the scenario and will trigger alert phase including the setting of the crisis unit. On the other hand, it may also be a continuous phenomenon (as a flood for instance) with several precursors or domino effects and, in that case, the phenomenon's climax must match with the scenario's climax. That way, tension progressively rises alongside exercise and the scenario ends with the biggest obstacle as for dramatic scriptwriting, with a dedicated focus on the main phenomenon that may be teased with precursors and make trainees work in anticipation. For instant phenomenon, tension rise may be scripted with external pressure from stakeholders wanting to know what happen and what to do, protection or rescue of stakes especially population, perturbation or domino effect. Climax in that case must match with the last event (domino effect, impact on stakes...) with the most important consequences but without letting trainees know what will happen next to keep them focus until the climax.

Linked phenomena, on the other hand, are scripted depending on the main phenomenon (Limousin, 2017):

- Precursor phenomena must be scripted before the main phenomenon, in the first phase of the scenario. If they trigger the alert phase and the crisis unit setting, they must set at the very beginning of the scenario to start it. If a precursor phenomenon does not trigger any consequence phenomena, the main phenomenon must appear soon after, slightly before the middle of the exercise.
- Domino phenomena must be scripted after its source phenomenon, they must mainly appear in the second quarter of the scenario even if some may also appear at the beginning of the scenario.
- Reinforcing phenomena must be scripted after phenomenon they should reinforce, in another phase, ideally during the central phase of the scenario or around the third quarter of the scenario.
- Independent phenomena must mainly appear in the last phases of the scenario according pedagogical needs.

To clarify more precisely when phenomena – and then other elements – must be scripted, scenario and crisis duration is divided in 5 uneven parts represented in percent of the total duration of the crisis: from 0% to 25 % of the total duration, from 25% to 42%, from 42 to 58; from 58 to 75 %, and from 75% to 100%. Linked phenomena are distributed in different part of the scenario according the total number of them (see Table 12).

Table 12: Linked phenomena in scenario (Limousin, 2017)

	Percent of the total number of linked phenomena to implement in this part of the scenario					
	<i>The scenario is decomposed in 5 phases, represented by percent of the total length of it</i>					
	0%	25%	42%	58%	75%	100%
Linked phenomena	22 %	36 %	35 %	2 %	5 %	

On the other hand, events and obstacles which lie along both trainees and heroes' paths still have not a method to be implemented in training script. Based on analysis of 6 crisis, Limousin identifies when each kind of perturbation appears in the crisis chronology. The same way as for linked phenomena, crisis duration was divided in 5 uneven parts represented in percent of the total duration of the crisis. Then each stimulus group was analysis to see when it is preponderant in crisis' chronology and how much. This preponderance was at the end represented in percent of the total number of stimuli in the box representing the analyzed crisis' chronology period and transpose in a table, see Table 13. Note that some box has a red "1" meaning there is at least one of the matching perturbations occurring at this time sequence.

Table 13: Stimulus distribution on crisis chronology according existing crisis feedback (Limousin, 2017)

Stimulus group		Percent of the total number of perturbations occurring in this part of the crisis <i>Crisis is decomposed in 5 phases, represented in percent of the total length of it</i>					
		0%	25%	42%	58%	75%	100%
Casualties	Dead	100 %	0 %	0 %	0 %	0 %	
	Absolute emergency	78 %	11 %	11 %	0 %	0 %	
	Relative emergency	80 %	20 %	0 %	0 %	0 %	
	Involved	18 %	61 %	1 %	18 %	2 %	
Population perturbation		3 %	1 + 49 %	17 %	6 %	24 %	
Media perturbation		0 %	28 %	33 %	23 %	16 %	
Hierarchy-related perturbation		0 %	55 %	25 %	0 %	20 %	
Resources-related perturbation ton operationally fight against phenomena		14 %	34 %	16 %	0 %	16 %	
Perturbation on feedbacks feeding crisis unit		60%	40 %	0 %	0 %	0 %	
Economical perturbation		0 %	0 %	25 %	25 %	50 %	
Legal perturbation		0 %	16 %	0 %	0 %	1 + 83 %	
Crisis unit's organization related perturbation		40 %	31 %	3 %	0 %	26 %	

This analysis provides a canvas to realistically implement stimulus in a crisis scenario training and dedicated distribution for event stimulus was then proposed. Such distribution makes sense only for event stimulus because they aim to simulate a crisis by reaching “crisis goals”. Possibly, support stimulus may follow the same canvas to make simulation realistic by sending several perturbations but, simultaneously, helping trainees to focus on pedagogical target. On the other hand, challenge and reminder stimulus must have their own rhythm adapted to trainees’ profile to provide an adapted pedagogical environment as represented in Table 14 .

Table 14: Event stimulus recommended distribution (Limousin, 2017)

Stimulus group	Percent of the total number of event stimulus to implement in this part of scenario <i>Scenario is decomposed in 5 phases, represented in percent of the total length of it</i>					
	0%	25%	42%	58%	75%	100%
Red hearing	26 %	15 %	22 %	19 %	18 %	
Deadlock requiring creative decision	0 %	34 %	16 %	0 %	50 %	
Information flooding	100%	0 %	0 %	0 %	0 %	
Dysregulation	0 %	68 %	16 %	0 %	16 %	
Surprising element	46 %	22 %	0 %	4 %	28 %	
Ambiguous element	15 %	85 %	0 %	0 %	0 %	
Uncertainty	22 %	58 %	0 %	20 %	0 %	
Temporal perturbation	72 %	0 %	0 %	0 %	28 %	
Rupture	100 %	0 %	0 %	0 %	0 %	

4.4 Scenario transcription

Once scenario constitutive elements and structure are defined, the script may be written. Nevertheless, transcribing the information in an explicit way is not a trivial problem, especially for nonlinear interactive script with conditional storyline or randomness. A scenario may be expressed according to different formats (Pernin & Lejeune, 2004), (Rolland, 2003) in an informal way meaning it is told but not represented, in a semi-formal way meaning it is represented with a structured language with dedicated signs and allowing to automatize it, and in a formal way with a formal programming language.

In teaching domain, pedagogical scenarios are represented according to different types of models (El-Kechai, 2008), (Pernin & Lejeune, 2004), (Rolland, 2003), (Choquet, 2007). They may be represented with Unified Modeling Language or with State Diagram (Harel, 1987), (Riedl & Young, 2010). In the artistic domain, several software packages are available – such as *Final Draft*, *Movie Magic Screenwriter* or *Scrivener* – to write script timelines with dedicated event sheets organizing actions of the story (Cotte, 2014). This software allows to easily develop and modify the scenario structure while monitoring timeline, context, input data, transmission means and resources used, and actions done. *Persona* software in particular allows to build technical sheets for characters, helping the character design. Such sheets may be relevant for crisis exercise to design stakeholders simulate by facilitator and, more precisely, responses they can give according to trainee's actions while keeping a consistent and pedagogical context (Fagel, 2014). Nevertheless, an exercise scenario cannot be written the same way a film or a book is scripted (Fagel, 2014). Indeed, exercise scenario is nonlinear and, on the other hand, they are not written in stone with the possibility to considerably change during exercise according to trainees' actions, then an exercise scenario stays inherently dynamic.

Moreover, a crisis exercise scenario is discontinuous, composed of several successive stimuli that must be described. First characteristics to be set are those defined as constraints by Villiot-Leclercq – genesis, direction, explanation and delivery constraints (see 4.1) – then come other parameters such as a timestamp, one of several senders, the kind of stimulus (see 4.2), one or several receivers, one or several training goals and a transmission means. Transmission means may be (Fréalles & Tena-Chollet, 2017) warning horn, phone, radio, walkie-talkies, fax, board (white board, paper board, interactive whiteboard...), report and others files, visual files (picture, drawing, map, video...) or by oral transmission. Limousin proposes in his scriptwriting method to add or precise several characteristics : an identification numbers for each stimulus, the phases of the exercises concerned by the stimulus, sending condition of the stimulus to adapt the scenario to trainees' reactions and send stimulus according to pre-set conditions, possible links (of causality, proximity or other) between stimulus, information that must be transmitted by facilitator if there is a communication, and reference document for the stimulus that must be prepared during the exercise design phase.

Currently, main format to transcribe crisis exercise scenario is a table called Main Scenario Event List (MSEL) that registers each event, at which phase of exercise it belongs, its timestamp (in real time and exercise time), its characteristics, how it is evaluated and possible comments (Fagel, 2014), (Tissington & Flin, 2005). Such Event List provides an

overview of the scenario and interactions between stimulus and pedagogical goals. However, if the script includes numerous events, the list becomes too dense and is not efficiently understandable anymore. Then, in that case, a better representation is required, possibly a summary or several tables split between facilitators or stakeholders simulated. For example, French Civil Security Direction uses a synopsis summarizing scenario before it is developed to balance each role played by facilitators before stimuli were designed (Direction de la Sécurité Civile, 2011). This approach is relevant and allows to keep all information on stimulus on one hand, in dedicated sheets, and have a global overview of what happen during exercise on the other hand (Limousin, 2017)

4.5 Scenario design

As said above, Limousin proposed a full methodology for designing crisis exercises trainings (Limousin, 2017) but several other methodologies exist. However, they are mainly designed especially for public organization (Alberta Emergency Management Agency, 2012), (Direction de la Sécurité Civile, 2011). As the Limousin's exercise design method is both a global and detailed one, it matters to describe it, at least in its main features. It is a four phase method – five actually, but the fifth is the facilitation of the exercises which is not described – represented in Figure 28, based on literature reviews and exercises' feedbacks and composed of (1) defining the global context of the exercise, (2) designing the crisis scene and the space-time framework of the scenario, (3) refining and making the scenario pedagogical and, (4) checking and validating pedagogical scenario and develop script for facilitators and observers.

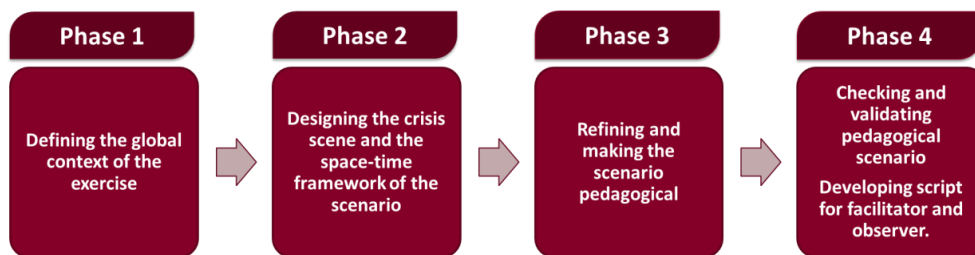


Figure 28: Limousin methodology phases (Limousin P. , 2017)

4.5.1 Defining the global context of the exercise

The first phase consists in defining the global context of the exercise: its main protagonists, boundaries, pedagogical purposes and interactions with other organizations. This step aims to set pedagogical goals after a need assessment and the characterization of trainees, their environment and interactions, especially in crisis unit. Pedagogical goals belong to one of three categories: operational goals, crisis goals and setting goals. The first phase's expected outputs are: (1) a profiling of trainees, (2) a generic description of the crisis unit with its interaction and (3) pedagogical goals for each of the above categories.

This first phase is itself divided into four steps: identifying trainees' profile, identifying crisis cell interaction with other stakeholders, setting an exercise length, and choosing pedagogical goals depending on trainees' profile and exercise length.

First, identification of the trainee's profile consists in assessing if trainees are novices, initiated or expert on the chosen topic. However, a trainees' group may be heterogeneous with a few experts, several initiated and some novices for instance. In that case, Limousin recommends to consider the main population and adjust number of chosen goals (or other stimulus) on the upper or lower limits of the proposed range.

The **second step** of the first phase consists in defining the limits of the simulation, especially by identifying crisis cell interaction with other stakeholders. This step aims to define organizations that must be simulated by facilitator and organizations that will be involved (at different levels) in the exercise. At the same moment, communication means between organizations and between facilitators and trainees are defined. Note that, as mentioned in 1.3.6, number of involved organizations must match with both preparedness level of the target organization and pedagogical goals. Moreover, each organization must have its own targets and common goals must be clearly set and be adapted to each stakeholder needs and abilities. If no other organization is involved, every interaction with the external environment is simulated by facilitators.

The **third step** of the first phase consists in choosing the length of the exercise. Usually this parameter is set by consensus between exercisers designers, trainees and, possibly, authorities. Literature (Direction de la Défense et de la Sécurité Civiles, 2005) recommends exercises from one to two hours for awareness-raising exercise and, on the other hand, longer exercises from 4 to 6 hours for other trainings. Nevertheless, on simulator, others constraints add-up (Limousin, 2017). Such exercise shorter than two hours are not enough to ensure a satisfying ending of the situation, letting trainees frustrated. Moreover, time management may be difficult to adjust and, if accidental sequence may be accelerated at a rate of up to 1.5 with good outcome on trainees' cognitive process (Lorains, Ball, & MacMahon, 2013) and memories (Milazzo, Bernier, Rosnet, Farrow, & Fournier, 2016) while keeping a realistic environment as said in 4.2, fast-time training simulating several days events in several hours exercise induce a major difficulties for trainees who do not represent properly the situation then, for instance, a slow kinetics event may be feel as a fast kinetics event. Limousin recommends to deal with such situations by only testing wanted crisis phases (alert, mediatic crisis peak...) with a clear briefing to trainees explaining what happen in previous crisis phases and decisions taken. Nevertheless, how fast time flies in the simulation is not the only parameter to consider. Indeed, exercise length also depend on training goals and may be chosen according to trainees' profile. Then exercise may be designed to be especially long to make feel tiredness and long-term management in a crisis for instance.

The **fourth step** of the first phase consists in choosing pedagogical goals according to exercise length and trainees' profile following recommendations discussed in 4.2. Then because choosing and prioritizing training goals are difficult, it is recommended to focus on main categories of goals scriptwriter want to implement and not use the refined repository at this step so crisis and pedagogical goals may be selected among a limited number of

items. Note that, as said above, the more stakeholders are involved in the exercises, the more dedicated targets will be set by them

4.5.2 Designing the crisis scene and the space-time framework of the exercise

The second phase consists in designing the crisis scene and the space-time framework of the scenario. After several meetings with exercises' scriptwriters, Limousin states they mostly define these elements first when designing an exercise. As well, in dramatic field, scriptwriter used to set first their main plots – corresponding here to phenomena including main phenomenon, precursor, domino effect or reinforcing phenomena – on their script to build-up tension until the major obstacle – the climax – come and tension pay-off. Besides, while setting these different plots, scriptwriters, set space-time framework of the scene (Cotte, 2014) by dividing in several phases or acts, with at least three acts as seen in 4.3. Therefore, this phase allows to produce a resume of the scenario by phasing the exercise and defining its global framework, by defining involved stakeholders and their relation with trainees, and by choosing and scripting involved phenomena and their impact on affected stakes as well as their location and how (and when) they manifest. Then scriptwriting will expand this resume into a complete script but still based on elements defined, characterized and localized during this phase.

The second phase – as the first one – is itself divided into three steps: choosing and characterizing the main phenomenon, choosing and characterizing linked phenomena, and choosing and characterizing involved stakes.

The **first step** of the second phase consists in choosing and characterizing the main phenomenon by asking trainees what topic, phenomena, particular stakes or stakeholders' interactions they want to work on. This inquiry allows to identify phenomena and stakes trainees expect and those imposed by regulation. Note that main phenomenon – as said above – is usually the main thing identified in exercise design, way before pedagogical target, for several reasons such as the will to test dedicated plan for a particular phenomenon or the priority given to a local and frequent phenomenon. Then if crisis unit must or want work on a particular phenomenon, scriptwriter may directly go to the next step and choose linked phenomena. If it is not the case, main phenomena may be chosen according to three parameters: trainees' profile, phenomena described in emergency planning, and pedagogical goals of the exercises. Choosing a main phenomenon according trainees' profile means that, for novice and initiated teams, the chosen phenomenon must appear in emergency planning, be described in it, and be known by team members. On the other hand, for expert group, it may be combined events with simultaneous phenomena, possibly planned but not together. Independently of that, for initiated and expert team, phenomenon chosen must have low probability and high impact on crisis cell to ensure team members destabilization and relevancy of the exercise. However, trainees must have the possibility to rely on emergency planning even if they need to adapt it to the situation and fill plan's gaps. Still, a main phenomenon may be selected even if it does not appear emergency plan, it is the second parameter. Choosing a phenomenon described in emergency plans allow to test the plan and check if it is well known by the crisis unit while choosing a phenomenon that does not appear in these plans allow to evaluate how resilient crisis unit is to deal with unexpected events. Nevertheless, finding an unexpected phenomenon that stay credible and

possible is not easy, especially for scriptwriter who need to rely on several resources or information's such as:

- Members of the trainees' organization – or from a similar one – who know what are main hazards they usually face and what it is possible,
- Hazardous activities, substances and utilities used, transiting or stored onsite, as well as phenomena involved in the organization's activities (disease, high pressure or temperature, toxic chemicals...),
- The territory of implantation including its geology, hydrology, topology and possible natural hazards that may occur,
- Social and meeting point where high population concentration may be presented temporarily (local fest, market...) or on a permanent basis,
- Feedbacks (including previous exercises' feedbacks) on previous phenomenon – especially from experienced workers or older persons who experienced previous events – and archives,
- Emergency planning of other similar organizations,
- Existing repository of phenomena (see 4.2),
- National and international news.

Then scriptwriter has several inspiring sources to design unexpected phenomena. Moreover, scriptwriter may promote phenomena instead of others according to training needs, obligations and wish – such as doing particular operations or operate technical simulation – but also depending on their open-mindedness for working on “exotic” phenomenon, for being surprise and their ability to find new solutions. Organizational reasons may encourage the choice for a particular main phenomenon according to exercise's date, its hour, its kinetic and other organizations involved. However, scriptwriter may be careful with phenomenon that may overcome crisis unit responsibilities and must identify phenomena that may be either too geographically spread or too severe to be handled by the target crisis unit, requiring other team members' profile.

In the end, main phenomena must be chosen according to pedagogical goals previously set. For instance, if a succession between two crisis team want to be tested, scriptwriter must choose a long phenomenon with, for example, slow kinetics requiring several successive teams in command of the situation. Limousin made recommendations to link the phenomenon to pedagogical target, summarized in Table 15:

Table 15: Recommendation to relate pedagogical goals to phenomena (Limousin, 2017)

Pedagogical or crisis goals	Recommendations
Assess the phenomenon or create the surprise	<ul style="list-style-type: none"> • Script an unlikely event, never or few exercised before by crisis unit or an emerging phenomenon, brand new and unrelated to trainees' job, • Script a planned event but while keeping the opportunity to enhance its intensity, severity or complexity, • Script an unplanned event, • Script an event evolving according to several parameters that may be modify during the exercise, • Script an event evolving more or less fast depending on organization's emergency plan or trainees cognitive process, • Script an event targeting a strong point of the organization and aiming to bend it to raise awareness on over-confidence, • Script domino effect opportunities
Identify involved stakes and test alert process, evacuation and casualties' management	<ul style="list-style-type: none"> • Script many different direct involved stakes • Script impact on population by the phenomenon or its domino effect triggers by not reaching alert and evacuation goals. • Script impact on building open to the public
Test emergency response resources management	<ul style="list-style-type: none"> • Script a phenomenon requiring specialized response (such as chemical response) • Script a phenomenon impacting simultaneously several organizations • Script difficulties in accessing response location or difficulties in setting equipment • Script hard to control phenomenon (such as forest fire or flooding) • Script an event requiring highly technical operation or many different operations • Script unbalance between operational needs and resources to make the crisis unit ask for reinforcements.
Test media pressure management (Heiderich, 2010)	<ul style="list-style-type: none"> • Script an event involving the three medias characteristics "V": villains, victims and visual • Script an event impacting symbols – with a heavy emotional weight – as children, elderly, historic building or art etc... • Script an event impacting everyday life of the society • Script an event revealing hidden truth • Script an event during low activities period for medias (holidays for instance) or in parallel of other event building a synergy with it
Test legal and financial impact management	<ul style="list-style-type: none"> • Script event impacting either products, branding, productive base or people under the responsibilities (worker, customers...) of the targeted organization. • Add-up side effect of a, event that does not specifically impact previous element (media pressure for branding, wounded worker...)

These elements should allow exercise scriptwriters to design an adapted main phenomenon to put at the center of the exercise. Now causes and consequences of this main event must be design and implement in the scenario which is the purpose of the next step.

The **second step** of the second phase consists in choosing and characterizing linked phenomena (precursor, reinforcing and domino). Two main approaches – that does not exclude each other – are possible to select such phenomena. The first one is to proceed to the complete risk analysis of the targeted organization which will reveal linked phenomenon in fault and cause trees. Alternatively, a reduced risk analysis may be done to research what phenomenon may cause the main phenomenon, it then consists in detailing the fault trees of the main phenomenon to find precursor phenomenon and, possibly, weak signal (Ansoff, 1975). This research may be partly done through accidental feedback database or literature

analysis, previous accidental event or exercises of the targeted organization and other sources such as accident covers by the media. This review may help to proceed the risk analysis and identify independent phenomena that may reinforce either intensity, severity, kinetics or another parameter of the main phenomenon. The second main approach consists in holding technical meetings with technicians and operators to identify causes of possible events and possible consequences. Meetings may, for example, aim to fill an Ishikawa diagram (Ishikawa, 1991) or identify faults in each layer of protection following Reason Model (Reason, 1990). Whatever the approach adopted, it matters to identify if a precursor event causes domino effect – that may also be reinforcing events – besides main phenomena and add them to the script according to Table 9 (on number of phenomena to implement) and Table 12 (on when to script them) recommendation. Once identified, phenomena must be characterized with their geographical localization, kinetics and intensity set. Note that position on the timeline was already discussed in 4.3, Table 12. Limousin proposed, to properly characterize phenomena, that scriptwriter questions several points (Limousin, 2017):

- Do several positions and intensities are possible for phenomena?
- What are geographical, functional or logical dependencies between phenomena (and involved stakes) (Rey, 2015) (Rinaldi, Peerenboom, & Kelly, 2001)
- What are the phenomena's required position and intensity to impact chosen stake (without hypothesis on trainees' reaction) and what are those required to generate major damages, if it is a pedagogical goal?
- Will the phenomena impact other organizations the crisis unit may interact with?
- What are the geographical positions that allow the phenomena to properly follow each other?
- What is the phenomena intensity required to trigger emergency plans and allow to reach the desired warning level?
- What are the positions and intensities required to mobilize every trainee?
- What are the positions and intensities allowing to have the proper number of domino effect (according those previously chosen)?

Note that the simulation may be required to answer some of these questions and Tena-Cholet recommends to properly model the system to later implement the interactions between phenomena, stakes and trainees' actions and simulated them with a multi-agent software (Tena-Chollet, 2012).

Position may be an important parameter, especially if operational response is selected as a pedagogical goal and implies that access point and intervention choice are milestones of the exercise. Depending on the decision on intervention, exercise may be more or less difficult according to trainees' profile. Once – or meanwhile – phenomena identified and characterized, scriptwriter must do the same thing with stakes impacted by these phenomena.

The **third and last step** of the second phase consists in choosing and characterizing involved stakes. Selecting relevant stakes may start with the analysis of the organization's responsibilities on people (permanently or temporarily), properties, infrastructure or territory to have a first picture of what is important for this organization. Responsibilities over properties includes business responsivities (even if it is also a responsibility over

people: workers, customers, shareholders...) and induce questions on marketing stakes and production stakes. Marketing stakes include branding, customer relations, and product quality. On the other hand, production stakes include means involved to make sold goods: utilities, infrastructures and technical devices or equipment but also relation with authorities that may prohibit activities under certain circumstances such as pollution (which also have an impact on branding). Such prospection must also aim organizations near the trainees' organization. Closeness does not only refer to geographic proximity but also to functional dependencies such as mentioned in the previous step, such as customers requiring produced goods or services. Scriptwriter may rely on cartography done in the previous step linking phenomenon and impacted stakes or emergency plans of the crisis unit and other organization that may have planned scripted events and assess their impact. Additional analysis may be required such as the study of consequences that scripted phenomena may have on other organizations which may be impacted or mobilized. An onsite visit coupled with meeting with operators or technicians – especially safety manager – or impacted stakeholders is also an interesting way to picture more precisely what could happen in an emergency situation by identifying habits that does not appear in plans. Then, once stakes are chosen, scriptwriter must characterize them by deciding how much they are involved – impacted, conditionally impacted, threatened, involved – as discussed in 4.2. Once phenomena and stakes are identified and characterized, crisis scene may be described by associating phenomena and related stakes then by identifying trainees that should work on this couple. It requires to identify what must (or could) be done during the scene and the effect of each action on the crisis situation.

4.5.3 Refining and making the scenario pedagogical

The third phase consists in refining and making the scenario pedagogical, calling all defined training goals. Indeed, starting crisis scene is usually not enough to reach all of them (and moreover call unwanted target). Then scriptwriter must use a CTT-like approach (Cohen, Freeman, & Thompson, 1998) to define proper stimulus, calling wanted targets and completing scenario phases with consistent and precise situations. Several constraints apply on stimulus that must be implemented in an adapted number, at the proper moment of the scenario, in consistency with starting crisis scene and according to a both realistic and pedagogical adapted rhythm. The third phase – as previous ones – is divided into three steps: implementing situational stimulus and checking script consistency, implementing support stimulus related to unselected goals, and implementing challenge stimulus calling chosen goals.

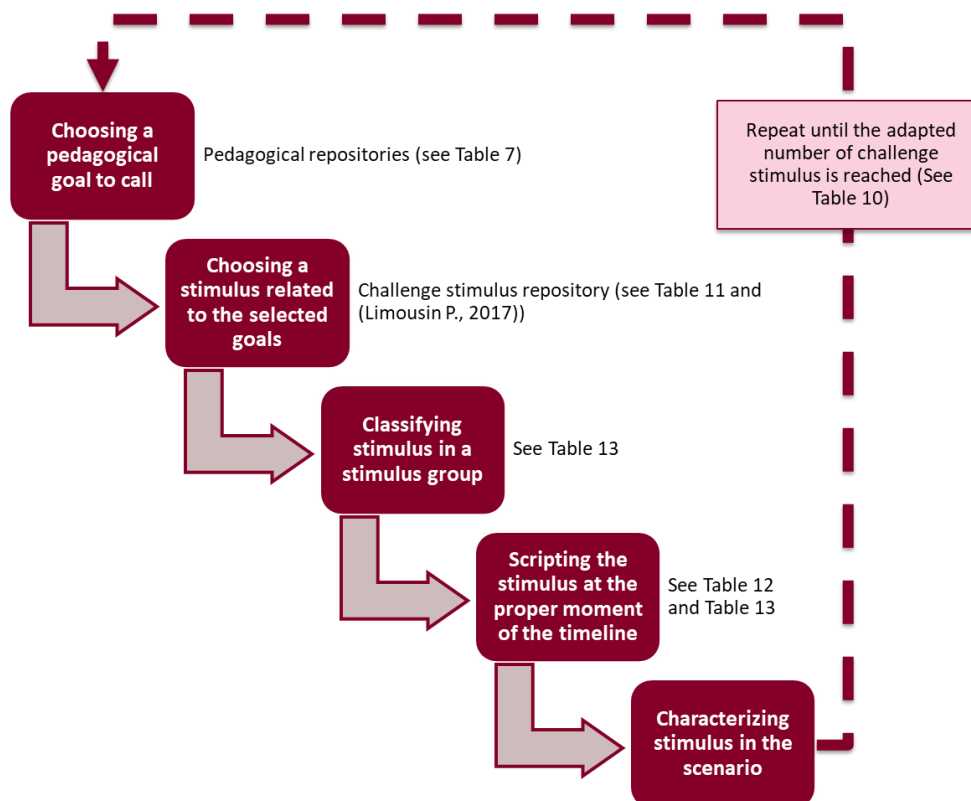
The **first step** of the third phase consists in implementing situational stimulus and checking script consistency. As said in 4.2, situational stimulus describes information transmitted to trainees related to the crisis scene. Script timeline describes successive phenomena that have been selected and arranged in the previous phase but not refined, they still have not consistency in the story and lack details that will be provided by situational stimulus. However, only phenomena – distributed all over the scenario – must be fully described in this phase. Indeed, information on stakes will be scripted at the support and challenge stimulus implementation step because the crisis scene may be altered to reach pedagogical target and adapt to trainees' reactions. Therefore, to describe a phenomenon,

scriptwriter must identify pieces of information that would reach the crisis unit if such phenomenon really occurred and may start by determining information providers – human or devices – and how information would arrive into crisis cell, through what means. Information providers may be aggregated in warning, reconnaissance or preventive systems that automatically triggers when an emergency occurs. Then, scriptwriter must write a clear, precise – with expert words to boost realism – and unambiguous message describing the phenomenon and its characteristics with possibly historic of the situation if this one lasted long before the crisis unit mobilized. These situational stimulus descriptions must comply with the stimulus framework described in 4.4. Quality and quantity of information transmitted will be adapted in the challenge stimulus step according to chosen training goals. Scriptwriter must also detail evolution of phenomena at regular interval in the script to integrate update in the scenario. Eventually, phenomena must disappear at the end of the scenario to progressively reduce tension on the crisis unit and start post-crisis phases. Once situational stimuli are implemented in the script, these ones must be checked to enhance consistency. This step may be required for phenomena which do not have a direct causal connection or that should be excluded by protective systems so need perturbations to follow each after the other “naturally”, without inconsistency. Scriptwriter may, for instance, add challenge stimulus related to Activities or Operations (see Table 11) to justify next incoming phenomena. At the end of this step, scriptwriter must check that the number of implemented phenomenon matches with trainees’ profile requirements, discussed in 4.2 and, if not, adjust it. Once phenomena are properly scripted, in a logic, consistent and adapted way, scriptwriter must implement support stimulus to help trainee on chosen goals only.

The **second step** of the third phase consists in implementing support stimulus related to unselected goals. For each unselected goal, scriptwriter must implement a support stimulus that was aggregated by Limousin in the database discussed in 4.2. Support stimulus may be scripted near related phenomenon or a few times after it and must be described following the canvas described in 4.4. Once unselected goals are supported by dedicated stimulus, scriptwriter may focus on selected goals and challenge stimulus.

The **third and last step** of the third phase consists in implementing challenge stimulus calling chosen goals. This is a 5-step process, iterated for each target goal, as represented in Figure 29. The process starts by selecting the pedagogical goals that will be called by challenge stimulus, then scriptwriter select – possibly in a randomized process to generate a new script each time – a stimulus in the repository proposed by Limousin according the pedagogical goals (Limousin, 2017) and dedicated to call it. Note that some stimulus may call several pedagogical targets and must be preferred to optimize challenge stimulus used and make the script more consistent. Indeed, scriptwriter must comply with challenge stimulus limits in the scenario (see Table 10) then may require to compile several pieces of information in one stimulus to stay in these limits. Once the stimulus chosen, scriptwriter classifies it in one of the categories represented in Table 11 and then, according Tables 12 and 13, decide when to script it in the timeline to make exercise both realistic and dynamic. Intensity of challenge stimulus must – as for theater and according previous discussion – progressively increases all along exercise to build-up tension until a final climatic situation (Lavandier, 1994). Such progression aims to increase difficulty and encourage trainees in

the first phases of exercises to motivate them. In the end – before restarting the process until the proper number of stimuli is set – challenge stimulus must be characterized according



the same template than before (see 4.4). The full process is represented in Figure 29:

Figure 29 : Challenge stimulus implementation steps (Limousin P. , 2017)

4.5.4 Checking and validating pedagogical scenario – Developing script for facilitators and observers

The **fourth and last phase** consists in checking and validating pedagogical scenario and develop scripts for facilitators and observers. The main goal of these phases is to ensure scenario is dynamic enough – with the ability to adapt to trainees’ reactions – and meets the trainees’ needs by browsing the database formed by the aggregation of all stimuli. It also ensures script is understandable for all stakeholders, especially observers and facilitators, with action expected by trainees (how they should react to stimulus) and monitoring criteria to assess during observations. Script verification relies on seven check-points that screenwriter must assess first alone then with an exterior point of view. **The structure** of the scenario is the first thing to check and consist in verifying that the scenario is consistent, without oversight or mistake in script elements orders. All the script must proceed logically, with causal link between elements and without contradiction (Bernard, 2014). Each stimulus must be checked – possibly several time – to be sure each one has a cause clearly explained for other exercise stakeholders, it is scripted at the correct place (not after its consequences for instance), it will be solved in time by trainees even considering all previous stimuli, its consequences are planned if trainees do or do not succeed to deal with the problem, its relations with other stimulus are consistent without contradictions or oversight (all stimulus it may generate for instance) and if it is scripted at a time trainees (and facilitators) will have time, will be able, to work on it with the adapted or wanted resources. **Realism** is the second parameter to check. It consists in ensuring that the scenario properly simulate crisis conditions, especially its dynamics. Intensity of stimulus must then be assessed to check if tension progresses at an adapted rhythm, increasing in the first half of the exercise and progressively reducing in the second half. If intensity evolution is not adapted, scriptwriter may modify either stimulus strength or their frequency to reach the wanted dynamics with a tension climax around the third quarter of the exercise. **Credibility** is the third aspect that must be checked in this fourth phase. It consists in assessing the stimulus frequency to evaluate the global scenario probability and, then, its credibility (Barot, 2014). It is the lower probable stimulus that drive the global scenario probability which may be qualified, for a crisis exercise, as “incredible” meaning the stimulus will not appear in real life, “unlikely” meaning the stimulus may exceptionally appear or, in the better case, “rare” meaning it is reasonable to expect that such stimulus occurs (Barot, 2014). Note that if several stimuli are incredible, warning hints must be scripted before these events to prepare trainees to accept those stimuli as credible enough. The fourth element to evaluate is how much **motivating** the scenario is. Scriptwriter must ensure that every trainee has enough thing to do all along the scenario and may proceed by assessing the numbers of stimulus calling an action that every sub-cell receive every 5 (or 10 minutes) as represented in Table 16:

Table 16: Checking table for sub-cells activities

	Number of stimulus calling an activity						
	0-10 min.	10-20 min.	20-30 min.	30-40 min.	40-50 min.	...	XX-XX min.
Sub-cell 1							
Sub-cell 2							
...							
Sub-cell 2							

Such table may reveal a sub-cell does not receive input for a long period of time – estimated to about 30 minutes (Limousin, 2017) – then that scenario required some modifications to correct that. Nevertheless, scriptwriter must check, before adding supplementary obstacles or event inputs, that the sub-cell does not receive inputs from other sub-cells. However, media or communication sub-cell is a particular case. Indeed, this sub-cell must receive significantly more inputs than other sub-cell and one input every 30 minutes is not enough to simulate realistically a crisis. Therefore, media sub-cell must be little requested at the beginning of the scenario then progressively more and more called until being heavily requested at the climax with slightly less and less calls after it until the end of the exercise. Scenario's **difficulty** is the fifth element to be checked by assessing that its complexity, severity and intensity is adapted to trainees' profile. First, scriptwriter must check if the scenario complies with goals set and needs expressed. Then every stimulus must be controlled to ensure they properly call – and recall if they are not reached – all chosen pedagogical goals. Stimuli interaction must also be checked to ensure they allow to reach pedagogical targets even blended together. On the other hand, obstacles on trainees' road must also be assessed to be surmountable as well as resources provided must be in sufficient quantities to achieve exercises goals. If chosen pedagogical goals must be checked to ensure they are properly called, scriptwriter must also check if unwanted goals are called and, in that case, add support stimulus soon enough to avoid trainees to deal with these problems. In the end, scriptwriter must check if stimulus number, where they are scripted and their intensity comply with previously discussed recommendations, depending on trainees' profile. The sixth parameter to check is **how the scenario is staged and how immersive it is**. Scriptwriter must verify if scripted elements can be operationally implemented during exercise and if there are supplementary elements that may be added to improve trainees' immersion. Global immersion must be checked throughout the scenario by assessing if the environment is properly simulated with adapted messages (with the adapted vocabulary and language level for instance) and realistic (and feasible) staging element, such as horn, heat sources, casualties, smoke etc.... Such elements may considerably improve trainee's immersion but some of them required significant logistic before exercise. The seventh and last step of the checking process consist for the scriptwriter in **presenting the scenario to others facilitators** to discuss, improve it and validate it (Borglund & Öberg, 2014). Other facilitator, because they have an exterior eye may be more critical and have a different point of view of how the scenario will be played then bring new solutions and improvement ways. Scriptwriter must involve as much stakeholder as possible in scenario design. Nevertheless, it may be relevant to only partially involves some stakeholders which may have biased point of view such contractors or trainees' representants. Indeed, scriptwriter may be careful that stimuli do not raise pre-existing tension between trainees or remind traumatic experience for some of them.

Once the checking step is done, the scenario is transcribed under an operational form to be used by observers and facilitators. The first step of transcription consists in identifying all actions expected from trainees. Scriptwriter must then consider each pedagogical target, stimulus related to them and, finally, “operational goals” which are the operational adaptation of pedagogical goals that Limousin gathers in a 145 item database (Limousin, 2017), each item related to a pedagogical target. These operational goals must appear in the scenario and constitute what observers will be able to concretely observe. Scriptwriter may also include others expected actions in the script to clarify what it is expected from trainees and make the exercise clearer for the observer. Therefore, at this step, scriptwriter writes in the MSEL table operational goals. Because obstacles restrain trainees in doing these goals, these ones are more visible for observers who can note if a goal is reached or not. Moreover, because the scenario is presented before exercise, observers may add their own performance indicators to monitor how efficient trainees are during the simulation which may be used during the hot debriefing as Lapierre proposed (Lapierre, 2016). On the other hand, observers may also consider event stimuli to observe if a red-hearing or a surprise event had the expected effect and provide, during the simulation, a feedback to facilitators to make them adapt the scenario according trainees’ reactions and operational target reached. Then facilitators may inject reminder stimulus to recall pedagogical goals a second time if the first stimulus does not trigger the proper reaction in trainees or if they forget it during the simulation. Scriptwriter must prepare reminder stimulus for each pedagogical target then facilitator may inject them if it is required. Limousin proposed a 114 item database with several reminder stimuli related to each pedagogical target (Limousin, 2017): 77 for the crisis strategical response axe, 25 for the crisis cell management axe and 22 for the strategical communication axe. These stimuli aim to help trainee without alteration of the original script and are mainly injected to rise an unresolved problem. They also allow to adapt the scenario during the exercise to make it more dynamics, able to meet trainees’ particular needs, even if its main framework remains static. Implementation of such stimulus required, as said, cooperation between observers and facilitators to make fit observations in the crisis unit with the support bring by stimuli in an adapted delay. Then injecting support stimulus may strengthen the scenario pedagogy while keeping exercise consistent. However, if a trainee makes a major mistake, injecting a support stimulus may be insufficient and a facilitator may have to directly interact with the trainee to show the error and make the trainee correct it. Nevertheless, facilitators must keep as much as possible the realism of the intervention and force the least possible trainees to do an action or take a decision (Gaultier-Gaillard, Persin, & Vraie, 2012).

This step concludes the fourth phase of the Limousin exercise design methodology for crisis management training. These exercises may be checked with a test panel to ensure it is fully operational to be played with professionals.

4.6 Chapter 4 Resume

Designing a crisis exercise needs to face several constraints that result in using specific constitutive elements, different inputs working as lines in a theater piece. Moreover, in order to arrange these inputs in a relevant and consistent way, a structure must be followed (Limousin, 2017) and, because resulting script is not linear, has multiple lines and stakeholders, a particular way to transcribe way must be used, for the same reason theatre pieces are transcribed in a specific way including didascalies (Pernin & Lejeune, 2004), (Rolland, 2003). Then, once constraints, elements and transcription methods – which are similar in crisis exercises design methodology – are explained, the design method may be presented.

Main constraints in this process consist in scriptwriting a consistent, credible, plausible, relevant, motivating, immersive and flexible scenario (Tena-Chollet, 2012). As a guideline to fulfill these constraints, several constitutive elements have been identified as stimulus to be injected in the exercise to lead trainees to wanted pedagogical goals (Limousin, 2017). First of them, **situational stimulus** related to involved stakes that may be either environmental, material or human stakes as well as resources required by the crisis unit and these 4 main categories are refined into 22 stakes items. These stakes may be more or less impacted, with a four-level scale: impacted, conditionally impacted, threatened or involved. On the other hand, situational stimulus may also refer to dangerous phenomena involved. Nature of crisis phenomena may considerably vary and a 7-categories repository including 167 types of phenomena exists in the literature to help scriptwriting. Those phenomena are classified in 5 categories: the main phenomena at the center of the exercise, precursor phenomena that come before the main phenomena, reinforcement phenomena that worsen an existing situation, domino phenomena following main phenomena and independent phenomena. Each phenomenon may be rated to guide scriptwriter to choose how many of them must be selected and where to position them. Then, another constitutive element is **challenge and reminder stimulus** relate to situation-task – which are the main pedagogical mechanics of such training, inspired from EBAT – and perturbations that allow to adapt the situation to trainees' reactions in live. Challenge stimulus aims to reach pedagogical target by making trainees work on dedicated problems related to the competencies they have to acquire. According to trainees' experience, more or less challenge stimulus must be set to keep the training challenging for trainees. That is the reason why these stimuli may be injected in live, during the simulation, to match with the trainee's actual situation and adjust difficulty. Obstacles are set on a trainees' path to lead them on the wanted topic, 794 challenge stimuli staging obstacles have been identified, categorized into 11 main categories and 52 sub-categories, aiming to reach goals on the three pedagogical axes. On the other hand, reminder stimulus aims to recall tasks forgotten or abandoned by trainees after a while to make them achieve the wanted task then reach the related pedagogical goals. The same way challenge stimuli aim to reach pedagogical target, events stimulus aim to reach crisis goals and are the elements that simulates crisis characteristics such as surprise, stress or uncertainty. Event stimuli are classed in 11 class gathering 184 event items. The last kind of stimulus described is **support stimulus** that aims to prevent trainees to work on missions that was not identified as pedagogically relevant to reach goals set. They consist in a plot

help to make trainees focus and are classified in 7 categories with, in total, 74 support stimuli. Therefore, there is a vast panel of stimuli that may be used in an exercise's scriptwriting 167 type of phenomena impacting 22 kinds of stakes, reinforced by 794 challenge stimuli and 184 event stimuli, supported by 114 reminder stimuli and 74 support stimuli. In all, they are 1355 stimuli that may be used in scriptwriting to reach some of the 64 pedagogical goals, declined in three levels, and 11 crisis goals.

After being chosen, these elements are arranged according to a methodology similar from theatre or cinema scriptwriting field. Indeed, it appears that fictional work – even if they do not picture the reality – have an interesting structure for crisis exercise. This structure is composed of three acts with the two first building tension through intermediate plots to bring intensity at its maximum at the end of the second act where the climax occurred and protagonists deal with the story's main problematics (Cotte, 2014). This description of the story as plots following each other until a main problem is relevant for exercises where plots are substituted by situation-tasks introduced by situational or challenge stimuli. Recommended length for each act in a crisis management exercise is about 1/4 of simulation time dedicated to the first act (corresponding to the warning chain), 1/2 of simulation time dedicated to the second act (corresponding to crisis management) and 1/4 of simulation time dedicated to the third act corresponding to the post-crisis phase. This first canvas is complete by guidelines precisising what kind of stimulus must be implemented in each act and how many of them depending on trainees' experience.

Once the crisis scenario is scripted, a way to transcribe it on a shared support is required. Nevertheless, because a crisis scenario is not a straight storyline that may be written from its beginning to its end in a simple text, it requires to have a support that represents the discontinuity of the scenario, places where trainees work and need to have freedom to learn. Therefore, crisis training script is close to some game design methodology where a situation may have several consequences depending of players's actions. The most used transcription system used in crisis exercises design is MSEL consisting in one or several tables – first global then particular ones, dedicated to facilitators roles – gathering all inputs that must or may be injected, when they must be, how, by whom and other messages characteristics (Fagel, 2014). The scenario is then a succession of coordinated inputs sent to trainees through different media and gathered in a stimulus table.

Nevertheless, defining exercise constitutive elements and how to arrange them in a consistent and pedagogical scenario transcribed under a comprehensive support is still not enough to properly design an exercise. Indeed, such undertaking required a full process scanning from need analysis to facilitator briefing and operational implementation. Yet, several crisis exercise design methodologies exist, being more or less relevant, and we relied, for this work on Limousin's one which is a 4-phase procedure (Limousin, 2017). The **first phase** consists in defining the global context of the exercise through the profiling of trainees – their profiles, experiences and missions they do in a crisis situation – to choose, with someone representing the trainee's organization, pedagogical goals for the simulation and its limits. Therefore, physical, functional and time limits of the exercises are set from the beginning of the design process and constitute a first framework where the exercise will be developed. The **second phase** consists in designing the crisis scene by choosing and characterizing the main phenomenon, linked phenomena and involved stakes that will

constitute the heart of the scenario. The **third phase** consists in refining the scenario and making it the more pedagogical possible. At this step, situational, support and challenge stimuli are scripted while event and reminder stimulus are prepared to be injected during the exercise. In the end, the **fourth and last phase** consists in checking and validating the whole scenario, alone first then with other people help to have external eyes on the script. Moreover, to allow other people to give their point of view on the scenario, it must be transcribed into a sharable form. Such transcription is also required for facilitators and observers may use the script during the exercise then need to be developed to fit each stakeholders' needs.

This design methodology is complete and allow to build a relevant scenario but has few considerations for trainees' interactions with each other and with their environment while it is a critical point of socio-constructivism. On the other hand, it is a heavy procedure involving a lot of plot items – more than a thousand – that may be implemented according pedagogical and crisis target. Therefore, it opens two main improvement paths. The first one consists in improving interaction by analyzing game design methodologies which consider interaction and experience as central in games to make the serious game we made more playful. The second one consists in analyzing targeted organization needs to build a design methodology more adapted to their needs and that may be more easily implemented.

Chapter 5 **Perspectives for crisis and emergency management improvement**

As mentioned in Chapter 2, Expert'Crise's first exercises were developed based on other organization feedback and in literature, described in Chapter 4. However, meanwhile exercises were processed, the design process was improved aiming two main goals: how to make the exercise design simpler and, on the other hand, how to make them more efficient through a better interactivity. As our predecessors made several links between crisis exercises and cinema or theater domain, we prospect, in the continuity of artistic and leisure activities, games and game design field to bring new ideas and methods to make Expert'Crise's serious game more playful and interactive in order to improve trainee's involvement. On the other hand, because we closely work with Seveso companies, we identified their point of view on the design of such exercises and tried to match with these needs and will considering their actual situation and their constraints.

5.1 Serious game and crisis management training

The Expert'Crise project started, at the end of 2015, based on IMT Mines Alès trainings and simulation platform. Its first training session was developed on-site at different crisis management level. Meanwhile, Hainaut Provincial Institute of Training (IPFH), partner of the UMONS Expert'Crise project, developed its own training session based on reduced-scaled model for the training of the emergency services and, after observing several training sessions, questions appeared about the differences between these two kinds of crisis management simulation. Beyond target audience and physical support, the focus of these questions was related to mechanics of the training i.e. pedagogical levers available during the simulation. It appears these levers were respectively similar to those used – in a playful way – in Live-Action Role Play (LARP) for UMONS training and in wargame for IPFH training.

Simulations implemented in the training program were, from the very beginning of Expert'Crise, presented as “serious game”: exercises aiming to combine serious aspect of a training with playful levers belonging to game design field (Alvarez, Djaouti, Jessel, metal, & Molinier, 2007). Nevertheless, the kind of game on which they rely was not specified and needed to be clarified here. Moreover, it appears serious games are rarely properly defined or classified according mechanics or entertaining approach they use, but more often depending on the target they aim. Then, serious games may belong to the following categories: advergaming, edutainment, politically committed games, edumarket games, engaged game, training games or simulation. Advergaming are games – usually basic ones

– with an advertising purpose, with for instance ubiquitous branding. Edutainment is trainings relying on entertainment mechanisms to stimulate the learning process. Committed games are games aiming to reveal, denounce or condemn (geo)-political matters. Edumarket games are edutainment targeting a dedicated topic – a market – to focus or raise awareness about it, they may also be committed games. Last, training games and simulation aim either to allow players to train on a task or a set of tasks in a safe environment and are, in that case, close to edutainment or, on the other hand, they may aim to virtually simulate an existing environment to build models and anticipate. Nevertheless, this classification is not really relevant to characterize serious games actually done. For instance, in Expert’Crise’s case, serious game used is an edumarket game but it gives no information but purpose. Then, there is a need to describe and classify what Expert’Crise’s training performed for two reasons: the first one is to find other similar serious games as inspirational sources and the second one is the will to generalize implemented solutions according to the serious game we used. However, before categorizing serious games, we need to introduce what a game is.

5.2 Introduction to games classification

Defining the kind of game on what relies Expert’Crise training requires to define what is a game. Caillois firstly defines game as a free, split, uncertain, unproductive, ruled and fictitious activity (Caillois, 1958). Nevertheless, because of the wide range of games, the word “game” may be polysemic and lead to several heterogeneous definitions (Mariais, 2012). However, let explain Caillois definition, a game is a free activity, so players are not forced to play it. Nevertheless, if they accept to play it, they must follow the game’s rules, different from usual social rules or norms. Despite this ruled environment, a game is never lost or win ahead because of its uncertain nature. Moreover, a game is a split activity that does not relate to others activities, standing alone and not impacting other tasks, especially work – then it is unproductive – and outside environment, i.e. reality, that is the reason why it is described as a fictitious activity.

As said, “game” may be polysemic and share its semantic field with the word “play”. Mullich clarifies this difference in meaning saying that “play” refers to “freedom of movement” while a game is “a system in which players engage in an artificial conflict, defined by rules, that results in a quantifiable outcome” (Mullich, 2016). Therefore “game” relates to the rules of the game and how to win while “play” relates to how players can interact with these rules to win, what they can do, their freedom inside the framework of the game and its rules. Then the “Gameplay” – that is the combination of these two words – means how to play in the game and its rules. Even if these two words are today widely spread, Caillois first distinguish these two different concepts with Greek words: “paidia” for playful activities and “ludus” for ruled games. Based on this definition, he proposes one of the first game classifications dividing games according to four axes (Caillois, 1958):

- **Agon**, the competition between players
- **Alea**, the part of randomness
- **Mimicry**, the part of role-play
- **Illinx**, the part of thrill induces by movement or loose of control

Even if this classification was proposed before video-game development and board game boom, it is still relevant today, mainly because it relies on pleasures which may be sought in a game or a playful activity. However, it is a very generic classification and it does not allow to understand on what kind of game relies Expert' Crise training. Therefore, an analysis of other classification systems was made to build a proper classification adapted to this need. ESAR system (Filion, 2015), Diberder brothers' video-game classification (Diberder, 1998), GPS classification (Alvarez, Djaouti, Jessel, Methel, & Molinier, 2007) and Klabbers' game architecture (Klabbers, 2003) was reviewed and lead eventually to a multicriteria description.

ESAR system, proposed in 2002 based on the analysis of games played according to players' age with a special focus on toddlers and children, categorizes games according to six parameters from A to F. The first parameter – A – is the game “category” among four families identified in the methodology: (1) Exercise games where actions and perceptions are at the center of the game, they are mainly playful “paidia” activities in illinx Caillois' category, (2) Symbolic game based imitation and roleplay, mimicry Caillois' category, (3) Assembly game where player must build something by combining element and (4) Ruled games which limit players action to reach the goal set. This last category is the closest to “ludus” and “games” activities. The B, C and E parameters deal with skills developed by the game : B relates to cognitive skills developed by the games meaning how information is processed and mental skill required to take decisions in the game, C relates to functional skills, meaning all competencies – agility, strength, speed or accuracy for instance – required by the game, and E relates to language skill including all communication means and mode – oral, written, incoming or outcoming – used by players in the game. D parameter relates to social activities involved and their characteristics so it depends on how competitive or cooperative the game is, the numbers of players, etc. The last parameter considerate in ESAR methodology is associated with affective processes involved: trust, gratitude, autonomy, betrayal... Because this categorization method was initially developed to characterize toddler and children's developmental games, it appears relevant for serious games, especially with B, C and E parameters focusing on developed skills. Nevertheless, this method is not precise enough to distinguish games and identify mechanisms funding them. Moreover, ESAR description may be subjective and cause characterization problems.

Diberder brothers' video-game classification – proposed in 1998 – is dedicated to leisure activities on computing device making players interact with a virtual environment. Then this classification is actually a sub-classification of games with a support-driven first layers of classification. This method categorizes games in 8 families: action games, adventure games, action-adventure games, role-playing games, puzzle games, simulation games, strategy games and serious games. Action games are real-time games mainly based on functional skills such as speed and dexterity. Adventure games are usually story-driven with important place given to storytelling and dialogue, the same way film or literature have. Exploration and puzzles are also a significant part of adventure games. Action-

adventure games compile characteristics of the two previous categories: they are real-time story-driven games where functional skills are important as well as cognitive skills for puzzles. Role-playing games are digital transposition of paper role-playing game with the same mechanics of these ones: players assume the role of characters involved in stories staging various difficulties and problems-solving situation which leads these characters to become more experienced to deal with more and more difficult problems. Puzzle games rely on cognitive abilities – logic, memories, thinking – and where players progress through puzzles, riddles or enigmas. Simulation games allow players to simulate more or less realistically situation and experience them without taking any risk and for a very little time investment, as for flight simulator that does not require hours of preliminary trainings. Strategy games are cognitive skills-based games, putting at the center of their mechanisms the abilities, for players, to make the best choice to reach goals, usually in competition with other players or an artificial intelligence. Last, serious games or useful games have other purposes that only leisure and may aim to train the player in a playful context. Diberder classification characterizes games more precisely than EASR method, especially taking better into account pieces of mechanism used in games. However, criteria and categories are heterogeneous and not exclusive then games may easily be classified into several categories.

GPS classification was proposed by Alvarez in 2007 (Alvarez, 2007) after analyzing numerous games and extracting common and frequent parameters that may form homogeneous classification criteria. This analysis focuses on games' gameplay and some of their features such as support used or topic addressed. Alvarez identifies gameplay bricks combining each with another – as “fundamental elements” of the game – to form rules and goals underlying games. These gameplay bricks are divided in “play” brick related to the player-game interface and “game” brick associated to game's goals. Play bricks are *Have luck, Write, Select, Move, Manage, Shoot and Create*. On the other hand, game bricks are *Destroy, Match, Avoid, Block*. For instance, in Pacman or Space Invader, the play brick *Move* is involved as well as the game brick *Avoid* to compose the rules “If the player's element collides with enemy elements then negative output”. Based on this gameplay brick proposal, Alvarez develops the GPS classification categorizing games according to their Gameplay, Purpose and Scope. A game purpose is what it is meant for, its goals beyond leisure, such as a message it must carry or function it must fulfil (training, education...). Scope describes the target audience of the games, and provide information on age, profession, experience in games or others characteristics.

Klabbers' game architecture (Klabbers, 2003) focus on games' elements and structures to classify them. Three main components are identified: players, rules and resources (Klabbers, 1996). These three items are described according to three approaches: their **syntax**, their **semantic** and their **pragmatic** (Marshv & Popov, 1983). The syntax of a game consists in how elements arrange in the game and rules coordinating them. The semantics of a game is the meaning of each represented elements, for example Meeple is a token representing a worker in most of board games. In other hand, the pragmatic of a game includes the design and the use of a game. Therefore, a chess pawn has a dedicated form, a starting position and limited (ruled) movement which constitute the syntax. On the other hand, during the game, it represents a unit of the player's army commanded by the king,

that is the semantic. Finally, players must use this pawn and others to build a strategy – involving to sacrifice a pawn for instance – to protect the king and put mat the adversary’s king, it is the pragmatic.

Table 17: Klabbers' architecture framework (Klabbers, 2003)

Design specifications	1. Client 2. Purpose 3. Subject matter	4. Intended audience 5. Content of use	
Social System	Syntax	Semantics	Pragmatics
Actors	Players who may play several roles. Number of game's places: to m to n players, n team involved...	Roles: function(s) players assume during the game according rules	Allopoietic vs. Autopoietic steering according the game have an external goals (allopoietic) or is self-centered (autopoietic),
Rules	Game manipulation set , how to move game elements: <ul style="list-style-type: none">• Preparatory rules;• Normative rules;• Behavioral rules Set of game positions: intermediates position of the game described and fixed by rules Final game positions Evaluation functions: how points are scored	Relationships between roles: how roles interact with each other (communication and coordination) Cultural, socio-economic situations: meaning of the present games position in the game system (e.g first players become the “king”)	Facilitators , referees or coaches authorized actions Format: rigid-rule vs. free-form according how important rules are Assessment function: moment when points are scored
Resources	Set of pieces Game space: where game elements are positioned	Resources: meaning of each resource (e.g a brown token represent “wood”) Set of places: meaning of places (e.g brown tokens are taken from a “forest”)	Paraphernalia, Equipment, Facilities that are required to play the game

At the top of the Table 17, resuming the Klabbers’s architecture, “Design specifications” are mentioned. They relate to the Client who order the game, the (allopoietic) Purpose that must be reach by the game as in GPS classification, the Subject Matters representing the game theme, the Intended Audience aimed by the game, and the Context of Use where the game will be played. With this analysis, Klabbers states there is pre-set games categories according dedicated configurations of presented parameters. For instances, if the “Player” box is empty, the “game” described is not a game but a pure “simulation”. The main contributions of this method are the focus on resources – i.e. the material approach of what a game is – and on the three-approach done for each game’s component that deepen description of them.

Based on the four previous methodologies, we developed a methodology to describe game characteristics of serious game completing pedagogical description that can be made according existing literature (see Chapter 3).

5.2.1 Proposition of a serious game classification

The first criteria considered for this serious game classification is **players** and their characteristics. Age seems to be the most important characteristic to take into account because “game” does not mean the same things for children and adults. Indeed, children have an affinity for “paidia” games (Caillois, 1958), i.e. games without rules, focused on the “play” while adults need rules and, especially, goals. These rules may be complex to understand and required cognitive abilities developed during childhood. On the other hand, a game without complexity may appear as boring for adult players that explain why « Intended audience » as defined by Klabbers (Klabbers, 2003) includes a lower and, eventually, an upper border. Then, the number of players is also important to consider. A game can be mono-players, for two players or for more. Mono-player games may set virtual adversaries, “ghost” players or times, resources or rule limits. If they can involve a virtual player through artificial intelligence or a set of rules simulating another player, this feature is not a specific characteristic of mono-players games. On the other hand, multi-players games may include social interactions with or without specific rules which allow to share information, feeling or views and influencing each other.

Then a characterization by **game mechanisms**, as proposed by GPS (Alvarez, Djaouti, JP, Methel, & P., 2007) and ESAR (Filion, 2015) classifications, seem to be relevant and requires that we focus on these mechanics to define the second criteria. The review of classifications brings out 10 mechanism families:

- **Physical or mental abilities:** Games may require only physical skill or, on the other hand, only cognitive skills, they form a head-hand continuum from skill games to smart games.
- **Chance/Randomness:** Games may mainly rely on randomness or exclude it totally, letting full control to players that are only responsible of their strategy. The same way as for the previous mechanics, it forms a Random/Determinate continuum, most games being positioned between the two extremes.
- **Goals and end of the game:** GPS classification identifies four different goals for a game. It may be to destroy something, to make something match to another, to avoid something or to block something. Then a game ends according to a limit defined by one of these goals and leading to an end by elimination, by score or by a time limit.
- **Competition and cooperation:** Agon is one of the four axes of the Caillois (Caillois, 1958) classification and competition may be set in one against one, everyone for himself or by team, balanced or not. On the other hand, some games have all the players – who can be one, in a solo-game – cooperating to defeat the game (or the game-master, the referee).
- **Information level:** Players may have access to complete, incomplete, perfect or imperfect information during a game. Game with complete information means all players know, when they play, other players’ goals, what everybody can do and the consequences of every potential action. If they do not have access to all this information, the game is said Bayesian or with incomplete information. Further, if players know, when they play, every previous action and that players

intervene one by one, the game is a perfect information game. On the other hand, if players play together, information is imperfect because they must play without knowing what other players will play on the same time.

- **Interaction:** Incomplete or imperfect information may be a lever for interaction between player. They can share (or not) heterogeneous distributed information and, possibly, lying to trick other players. Lies and trust may be the main levers of a game depending on the competitive or cooperative aspect of the game or the role distribution. On the other hand, interactions may be forbidden to only focus the game on thinking and deduction.
- **Game dynamics:** Game may have various lengths which made them adapted to different players or situations: some are short adapted for a 5-minute break while others required an evening or a several full days. Short games usually require few rules and are simpler than long games which may have longer and more complex rules. Game dynamics are important in long games because each phase – drawing, interaction, trade, decision-making, token movement and so on – should be properly game-designed or became boring for players. Also, rules can regulate these times to force decision-making and induce stress or risk-taking.
- **Immersion:** Game are fictitious activity and develop their own diegesis. Diegesis is “everything that belong, in “the comprehensible field” (Cohen-Séat, 1958), to the story, to the supposed or proposed fictional world of the film “(Souriau, 1990). Therefore, inside game diegesis, some things may be true that are not in reality. This shift between game and reality requires players to get immersed in the diegesis, to be involved in the game. Immersion may be developed through players’ interactions – with roleplay for instance – or with physical support as visual, sounds or haptic inputs. All these elements aim to help player to believe in the fictional world proposed and may be intra-diegetic or extra-diegetic depending if they exist in the diegesis or not. Further, they may be homo-diegetic if they exist in the real world and the diegesis or hetero-diegetic if they only represent something in the diegesis (a stick representing a sword for instance) without existing in the real world (Gade, 2003).
- **Avatar:** As a part of the immersive process, games may use an identification process to link players with characters they play. It may be an effective way to reinforce the involvement of the player who incarnate someone in a mimicry game and mitigate the frontier between reality and diegesis.
- **Storytelling:** Immersive games often require an extra or intra-diegetic facilitation through a game-master who provide a coherent diegesis, ensure a fair use of game rules and keeps the story moving by telling players what happen in the diegesis. This storytelling may be simultaneous with events, before them or after them, when the situation is “resolved”. Depending on when the storytelling happened – before, meanwhile or after events – game-master has a different role: announcer in the first one, facilitator in the second one and reporter in the last one. Note that story-telling is not mandatory for games that does not rely on a story to run properly. On the other hand, as said, some other games are story-driven and absolutely require a strong and original story.

Games' characterization by mechanics is relevant because it explains the deep differences of game-design between games. Nevertheless, **support or medium classification** stays interesting because support influences players experience almost independently of the game-design and that is why it is the third criteria of this classification. First, supports are not mandatory, especially for mimicry game focused on interaction or some competitive game such as running or swimming. Then support may be very limited: a ball is enough for a wide spectrum of game and amateur sport or the couple "paper and pen" for some role-playing or "newspaper game". Then come more specific devices such as dices, cards or tokens which allow to introduce randomness or incomplete information, to record and represent scores (or progress) or start building a diegesis through heterodiegetic elements. In the end, complex supports whether physical with table-top or digital with video-game may also be used, developing either immersion or game mechanisms.

The two last criteria of this classification do not relate to the mechanics of the game, how it is played or how it works, but to why it is played. It concerns the content and context of the game: the story tells – **the theme** – and **its purpose**. The theme is both optional – a lot of games do not have a specific theme – and easy to understand. It refers to the story told by the game or the diegesis, the fictional universe, proposed. Often the theme is a pretext to develop specific mechanics and functions as an esthetic layer, especially for the game-art. Nevertheless, the theme plays an important role, especially in players' immersion and their involvement in the game. Last, the purpose of the game relates to targets other than entertainment, especially for serious game (Klabbers, 2003). It may be advertising, education, training, scientific or politic awareness raising as discussed before.

These parameters are resumed in Figure 30 which work as an ID card for serious games, dedicated to their game's characteristics. On the other hand, serious games must also be characterized through their pedagogical parameters. Mostly serious games rely on constructivism or socio-constructivism approach and aimed to build or modify mental pictures through interactions with the virtual – but not necessarily digital – environment. Serious games are controlled environment setting an inductive learning that makes trainees notice relevant punctual elements to then generalize them in a new mental picture. Inductive learning opposes to deductive learning where a general rule is *transmitted* by a teacher or a document (see 1.3.2) and then apply to precise situation, such as exercises (Prince & Felder, 2006). Nevertheless, such training where trainees are mainly free during the serious game requires to be included in a larger scope teaching process including an introduction to the serious game, the serious game and a debriefing, and possibly, deepening of concepts used during the game (Mariais, 2012), (Lagadec, 1991), (Lapierre, 2016). Therefore, pedagogical characterization is neither very relevant neither easy to do because it includes in a wider scope and rarely stand alone.

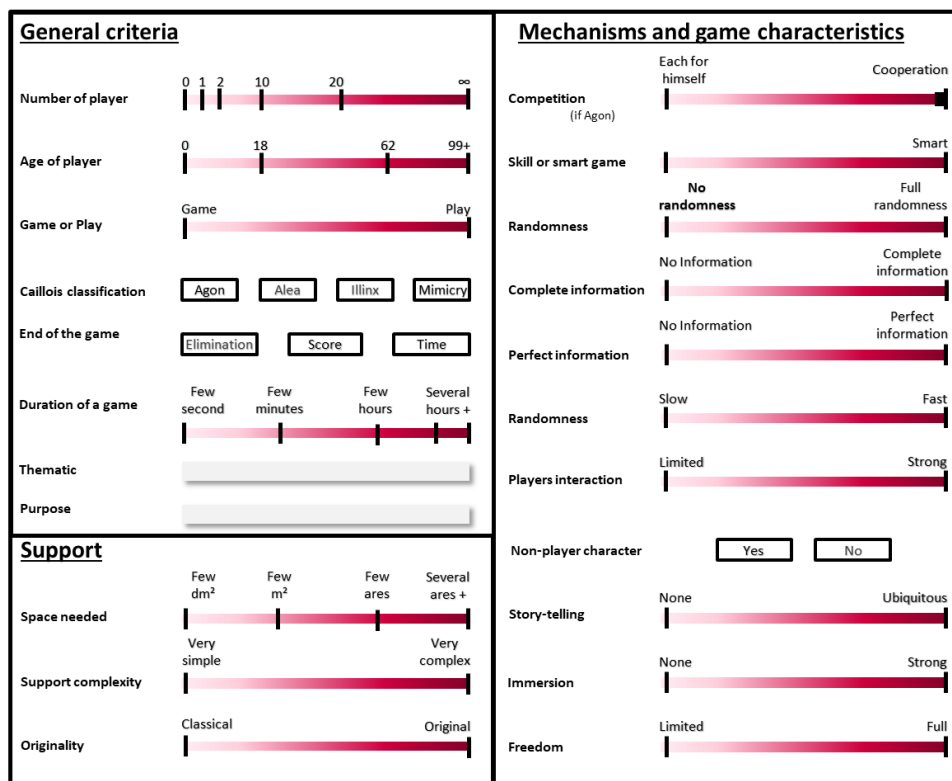


Figure 30: Serious game characterization: game parameters

5.2.2 Expert'Crise classification

Once this template comparing serious games presented, trainings developed during the Expert'Crise project must be characterized through it. First, pedagogically, these trainings – as well as those of the IMT Mines Alès which inspired them – are based on socio-constructivism theory and target a professional adult target. Moreover, they appear to be immersive collective trainings based on an associative facilitation.



Figure 31: LARP and Expert'Crise training comparison

Besides, a description of Expert'Crise training according to the previous template was done. As we anticipated, Expert'Crise project trainings appears to be close to Live-Action Role-Playing game (or LARP) and may be seen as a sub-category of LARP. Note that LARP is a big game family and have several sub-families such as fictious style with a strong diegesis requiring imagination and the capacity to project inside the diegesis, theatrical style focused on social interaction and investigation such as in murder parties, battle style that focus on physical interaction or Nordic style explaining diegetic states of each element to enforce immersion. All these sub-families explain that the following description is generic. On this generic “ID card” shown in Figure 31, previous Expert'Crise description is displayed in transparency. It appears, Expert'Crise is, as said, a sub-category of LARP, a Learning Role-Playing game.

This comparison helped in the improvement of Expert'Crise trainings by justifying the relevancy of the theoretical elements of game-design in training and explaining some difficulties of training such as the difficulty to make understandable the diegesis and diegetic states of elements or the importance of defining interfaced between players and facilitators.

5.3 Game design analogy

Several books deal with game design but our comparison will mainly rely on Jess Schell's work, *The Art of Game Design* (Schell, 2008), where successive game design steps are described and defined, accompanied by question a game designer must answer to have all information required to properly conceive (and sell) a game. As these steps are described, a global picture of the design process is drawn through a scheme, reproduced in Figure 32. Several parallels may be drawn between game design and Expert'Crise training design, those analogies axes are grouped under four different colors : orange for pedagogy related elements, blue for elements related to game mechanics, rose for diegesis elements related to the player interaction's environment and yellow for element that are pre-set by the nature of the serious game and are beyond the control of the serious game designer. Besides, some elements of Schell's diagram are not relevant for the comparison, especially those related to team management or game marketing: those elements are highlighted in gray.

Diegesis elements are both immersive devices, story-telling, and instruction that allow either through suspension of disbelief or realistic immersion to project players into a fictional world which may be different – historically, physically, with different rules, society, and so on – from real one. Then diegesis includes all elements that constitute this virtual world: space and times, characters living in, its (hi)story and its aesthetics, i.e. components that make it different of our world and artistically interesting. Diegesis is notably established through the manner how players interact with their environment and how facilitation intervene in this process. It may be direct but, in a training as well as in a game, players or trainees do not like following all traced paths and indirect control may be more relevant, especially by giving the impression of free-will through fake choices. Facilitation is only a part of how the interfaces between players and game works and this one may be strongly influenced by technology involved and how much it is used in a functional way and not in a cosmetic way, using Virtual Reality for instance when onsite interaction is possible and more relevant.

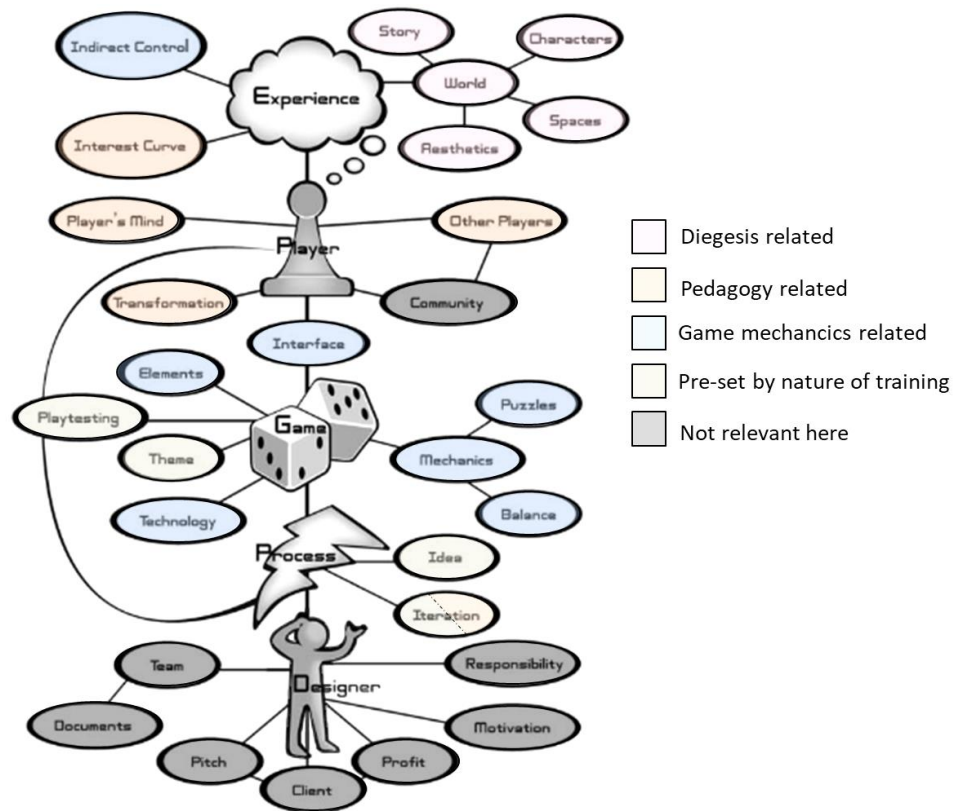


Figure 32: Game design process resume and analogy axes, from (Schell, 2008)

Pedagogy-related elements of the previous figure were discussed above: the serious game aims to teach – so transform – the trainees through interactions with the game and other trainees in a socio-constructivism approach building or modifying mental pictures inside players' mind. Moreover, to optimize the training, it must be difficult enough and put trainee in the learning stretching zone, the same way a player must stay focus on the game, following the interest curve.

Three elements introduced here – the diegesis, interface and interest curve – will be discussed in following paragraphs. Moreover, because Expert'Crise trainings are Live Action Learning Role Playing Games (LA-LRPG), a sub-category of Learning Role Playing Games (LRPG), these discussions will be focused on how LARP deals with these elements.

5.3.1 The Diegesis: A LARP point of view

Diegesis, as said, is all elements that constitute the fictional world of the story told. In other words, it is all the components that made this world run – such as space, time, people, environment etc ... – and continue to exist even if the story does not detail or explicit them. Therefore, the diegesis of a story is a consistent whole that make sense by itself, according to its own rules on condition it respects them. Indeed, consistency is an existence condition

for the diegesis that must respect its own defined rules. Because Role-playing games are a co-creative activity (Hannula, 2016) – as discuss in the next paragraph – the story consistency relies on a *Shared Imagined Space* (Young, 2005). During a role-playing game, each player attempts to figure how events told occurred. The same events draw different individual pictures of the situation in players' mind but with limited differences. Therefore, players are still able to discuss about a situation they roughly imagine in the same way. Nevertheless, to build this (partially) common picture, players require rules to interact with each other in real life and in the game. The (rules) "system" is what allows a player to form a consensus on what happen in the shared imagined space. The system may state that all players do not have the same influence on this space with a particular player – the referee or dungeon master – in charge of describing and deciding how the environment evolves during the game, whereas other players are only in charge to describe their character's (or avatar) actions and reactions. Then the system is a social norm that sets what each player can say and impose other player to "believe" it, to implement it in one's mental picture.

Moreover, the system is not the only parameter that impact shared imagined space. Indeed, because of the referee particular function, this one may use different approaches (or style) to lead other players to modify the common space in order to follow the wanted story. Young identified four main leading styles (Young, 2005): Illusionism, participationism, trailblazing and bass playing. **Illusionism** – considered as non-functional – consists in the referee taking full control of the shared space to develop the story, no matter what other players do to influence it, the referee adapts the environment to fulfil the story requirement while keeping the illusion that other players have a real influence. **Participationism** is similar to illusionism because referee keeps the total control over the major elements of the game and its diegesis but, and it is the difference with illusionism, other players know it and can bring minor elements into the diegesis, elements that do not strongly impact the story but make it more developed and that involve players into the co-creative activity. **Trailblazing** is relatively different from the two previous styles because, here, players have a real influence on the story: the referee only sets milestones and hints that should lead other players to the end of the story but there is no obligation for participants to follow these hints. Nevertheless, in practice, players implicitly accept to follow these hints until the end of the story but may interpret them in the wrong way or do not see them so there are still consequences of their actions. In the end, the **bass playing style** is very different from three other and consist in, the same way the bass player in a music band set the rhythm (with the drummer), the atmosphere and the tone but without playing the melodic part, the referee draws a picture of the diegesis, sets its global ambiance and presents first situations but then let other players improvise and choose their own story, possibly injecting change in the shared imagined space if things become too easy for players. Therefore, bass playing style may be seen as a sandbox for players in a particular diegesis, that remain under referee's control.

Meanwhile, with their limited impact on the diegesis, other players may also have different stances in interacting with their environment, in playing their character. They may approach their character in a *"pawn" stance*, using the character only as a projection of one's will in the diegesis and acting as one will do in this world, as a meeple or a token in a boardgame. On the other hand, they may interact using an *actor stance*, playing

character's reactions as it would do if it were real, according to its personalities and desires. Similar to this approach, *author stance* consists in playing character's personalities but injecting some player choices in actions done, to push the character in a particular situation or to follow a hint let by the referee. Last, *director stance* requires that player have enough freedom to make their own propositions in the existing diegesis, beyond their basic prerogative, that still must be accepted by the referee to be implemented in the common space.

As discussed through the concept of *Shared Imagined Space*, players' picture of the situation, their individual diegesis, interact with other players' diegesis in what Markus Montola called an interactive construction of subjective diegeses (Montola, 2003). These diegeses are inherently different for several reasons. First, because diegetic elements are different from a player-character couple to another. Indeed, the perception of the fictional universe occurred through the eyes of different characters that have different background, storylines, personalities etc... Then their thoughts or emotions, even if they never appear in the common diegesis – as well as their background that may only be communicated to the referee – exist and are subjective, only related to a player-character couple. On the other hand, these subjective diegesis are shared through communication that is imperfect independently of how it is done (orally, written, with video or other support...). Therefore, any piece of information given either by the referee or other players is incomplete, so is interpretable (Montola, 2003). If referee usually arbitrates inconsistent diegesis, there is another diegetic element strongly involved in LARP: the real environment. Indeed, in LARP, the physical environment is an element that directly completes communication in diegesis building. Nevertheless, real and virtual environment do not totally match and some elements of the real environment – for instance a trashcan – do not exist in the fictional environment and players will ignore it, they admit this element does not exist. Inversely, an element of the diegesis – a high cliff for instance – may not exist in the real environment. Therefore, between these two spaces – the real playground and the diegesis – some elements may appear in one but not in the other and vice versa. When elements appear simultaneously in the two spaces, there are said in a double diegetic state (Andreasen, 2003) and may have the same value, such as a real tree representing a tree, or different values with for instance a latex LARP weapon representing a real weapon. Carsten Andreasen defines two diegetic states for these two kinds of element: those in a homogenous diegetic state having the same value in the diegesis and the real world, and those in a heterogeneous state having different value in the diegesis and the playground. These two states are represented in Figure 33.

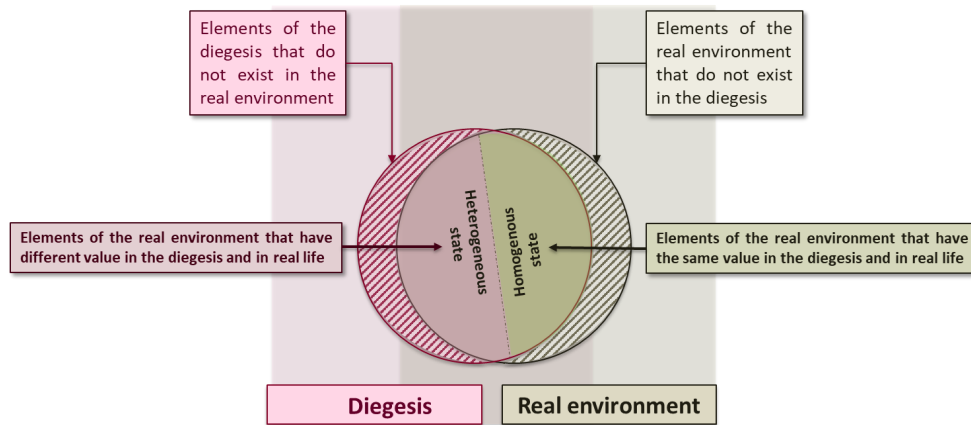


Figure 33: Diegetic space and state

Every person and object involved in the LARP are present in real environment but not necessarily in the diegesis. Physical artefacts may have a symbolic value and be present in the diegesis under a different form than in real life. Knowledge related to the fictional universe – such as characters background – only belong to the diegesis while rules exist in the two spaces: in the real world they are game’s rules and in the diegesis they are physical rule of the fictional universe. This approach explains why LARP is so immersive, it is because of this “Orwellian double think” (Orwell, 1949) that allow players to see at the same time the two present spaces and only focus on the diegesis, possibly adapting one’s attention according the situation (Spencer-Brown, 1979). Therefore, because of this ability to change one’s focus according the situation, there is few ambiguities between what is in the diegesis and what is not. Ambiguity is limited, especially because players know that this kind of activities requires such mental calisthenics and accept this constraint that was presented and explained, which is not always the case during an exercise.

A particular case is the player one-self that also have a double diegetic state: the character played (or role) and the character. According to the situation, these two entities interact with different space, either real or fictional.

5.3.2 Interaction

To describe in detail possible interactions in LARP, we need to define more precisely what elements are in the diegesis. Gade distinguishes the universe and the surrounding (Gade, 2003). The world represents the global setting where the surrounding takes place so include this last one with all other physical (such as other place far away from the surrounding) or non-physical (as historical background or physics rules) elements. On the other hand, the surrounding (or the environment) represents the physical reality of the LARP (a city, a room), the social structure between characters (player and non-player), other characters and the situation, the background, or the plot of the story. Moreover, the environment is both composed of a real physical part (what also belong to the real environment) and the description of the diegetic environment made by storyteller or a written description.

With this disambiguation, Gade identifies 6 kinds of interactions:

- **World interaction** meaning the world interact with itself, for instance political tensions evolving alongside a LARP storyline.
- **Macro interaction** meaning the world interact with the surrounding, for instance previously mentioned political tensions imply barricades that are set up in the environment.
- **Meso interaction** meaning the surrounding interact with itself and depend on the point of view considered. Indeed, as all roles (or characters) belong to the environment, interactions between roles may be seen as meso interactions from an outside point of view or practical interactions from an internal point of view. It may be, in the previous example, the discussion between a policeman and another character or a non-player character (NPC) operating a barrier.
- **Philosophical interaction** consists in the world interacting with role, for instance previously mentioned political tensions implies political questioning for character that may face dilemma between their background and such evolution. These interactions are important in LARP because it strongly influences characters' evolution
- **Practical interaction** consisting in role interacting with the surrounding, in particular other roles with the singularity mentioned in meso-interaction. This kind of interaction is the most important in LARP and common to every session, it may be refined in three sub-categories:
 - Personal practical interaction where the role interacts with another role by discussing or in a more physical way (a fight for instance),
 - Social practical interaction where the role interacts with social structure for instance by kneeling in front of a king because it is what is socially expected in the diegesis or ordering the local rotgut in a scum's tavern.
 - Physical practical interaction where the role interacts with physical environment such a door or a tree
- **Non-diegetic interaction** meaning *participants* (and not *roles*) interact with non-diegetic objects and which is controversial in LARP communities between those considering all non-diegetic interactions undermine immersion (Pohjola, 2003) and those considering rules and others games mechanics – such as dices or rules – are part of the activity (Gade, 2001).

Physical practical interaction may deal with a LARP particular rule call “Kan-man-så-kan-man”, abbreviate KMSKM and meaning “If You Can, you Can”. This concept presented by Lippert consists in a global approach of LARP assuming that if a player can do something then the character played can do the same (Lippert, 2003). This approach limits the use of formal rules to only focus on the “play” part of LARP, eventually using devices or accessories to restraining players' actions below their normal abilities. A main advantage of this way to do LARP is that it forces players to role-play and not rely only on rules: if they succeed to do something it is mainly because they were clever, smooth or deceitful talker and then fully lived the situation. On the other hand, it does not allow to play situation where players should be able to do impossible things (magical trick or other

special abilities for instance). Therefore, this approach requires for players to accept their physical limits and physics of the real world. In return, because every player has to play an adapted role (for example a charismatic leader, a strong warrior, etc...), the game is more realistic and immersive. On the other hand, KMSKM LARP insists on safety and responsibilities during the game: even if players can burn to the ground the surrounding, they must stay reasonable and limits their actions to what is acceptable to other players (including the referee) and the organization, it especially includes violence, intimacy or other unacceptable behaviors. This last characteristic, as Lippert said, is the main difficulties of KMSKM LARP and requires to clearly define what is allowed or not during the game (especially for safety or financial reasons) then let player evolves in this framework, which mainly relies on common sense and respect.

KMSKM LARP aims to improve the agency, “the feeling of empowerment that comes from being able to take actions in the world whose effects relate to the player’s intention” (Mateas, 2001). Players can do all they can do with KMSKM approach and then have easily an impact on the diegesis. Besides, that impact does not necessarily matters, having no or few effects, especially if the referee uses an illusionist style. Yet, if the illusion is good, the agency may remain high because it is a feeling, not a factual reality. The main way to modify players’ agency in a role-playing game with no limits, no boundaries and only restrained by players (and referee) imagination is to modify access to information: the less information players have, the less (significant) action they can make. On the other hand, letting them the possibility to gather information – and then have the possibility to make meaningful action – is a powerful mean to improve players’ involvement (Church, 1999). Player agency may vary from a role-play to another: in classic *Dungeon and Dragon* (Gygax & Arneson, 1974), the Dungeon Master (the referee) has alone the charge to describe the environment while in *Apocalypse World* (Baker, 2010), referee’s action are much more limited and diegesis may be modified by all players in a co-creation activity. This co-creativity environment is an adapted place to learn and build knowledge as Hannula states (Hannula, 2016). Fréalle identifies, in crisis management training, this co-creation process but under another name (Fréalle, 2018). Indeed, she categorized crisis management scenario under two different families: controlled and self-powered.

5.3.3 Controlled or self-powered scenario

Self-powered scenario is a scenario where situational stimulus setting the ambiance and the initial crisis situation as context – with weather or previous events information for instance – are sufficient enough to initiate the simulation. Trainees are distributed in several groups representing different stakeholders of the crisis management (Gregori, Brassac, & Sirvau, 2009), (Turoff, Chumer, Yao, & Van de Walle, 2005) and generates themselves stimulus to others crisis unit through their interactions with each other. Facilitators have little function and only introduce first situational stimulus and ensure the simulation of onsite team feedback, ensuring a control over trainees to keep them in the exercise limits as shown in Figure 34.

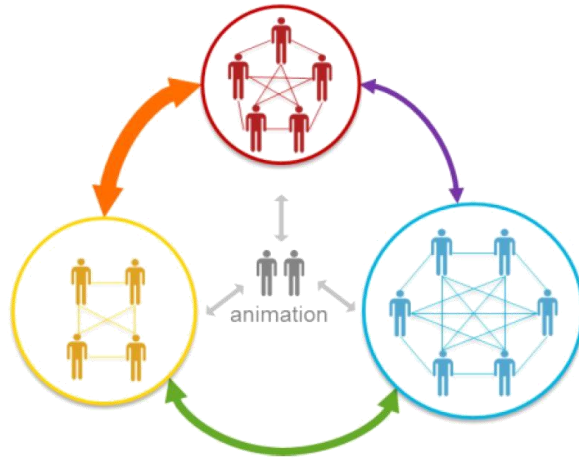


Figure 34: Self-powered scenario scheme (Fréalles, 2018)

Such scenario requires numerous trainees to properly simulate a global crisis system (November & Créton-Cazanave, 2017) then scriptwriter must design a situation justifying such mobilization. Meanwhile design process does not require to script all the environment reactions (all meso-interactions) because they are mainly played by trainees. However, several facilitators – up to a dozen (Verdel, Tardy, Lopez, Hansen, & Deschanel, 2010) – are required to control and properly facilitate all the trainees. One of the main interest of such exercise is – beside being realistic with every entity independently simulated – that it made trainees understand how complicated may be interaction during a crisis situation (November & Créton-Cazanave, 2017) and, in the case where each role is assumed by real worker of the organization, to become familiar with different structures work procedures and methods.

On the other hand, **controlled scenario** consists in structured script submitted to trainees constituting a single team, the crisis unit (Tena-Chollet, Tixier, Dandrieux, & Slangen, 2016). Other stakeholders and environment are simulated by the facilitation team (Dautun, Pardini, & Roux-Dufort, 2011) that explain why the script is more structured than for self-powered scenario and requires a stronger facilitation. Such scenario may be schemed as bi-lateral relationship trainees-facilitators as represented in Figure 35.

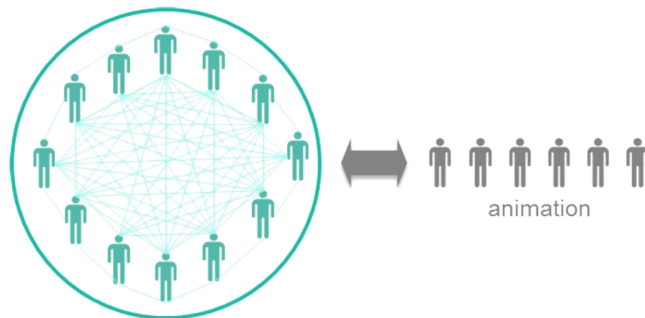


Figure 35: Controlled scenario scheme (Fréalles, 2018)

7Such structure requires that screenwriter design a complete script aiming every trainee all along the exercise and anticipating all elements – mainly information – needed by facilitators during the simulation to properly fake all the environment and lead trainees to pedagogical targets. Fréalles compares these two kinds of scenario according to four parameters: how prepared the script must be, how heavy the logistic is, how trainees are organized, and how important the facilitation must be. The three first parameters are resumed in Table 18 and the last parameter is discussed after it.

Table 18: Controlled and self-powered scenario comparison (Fréalles, 2018)

	Self-powered scenario	Controlled scenario
Script preparation	<ul style="list-style-type: none"> • Only requires an initial crisis situation and some control inputs • Facilitators have little role to play and need less information • Trainees' sheet must be prepared to provide them information on roles they play and what they can do. 	<ul style="list-style-type: none"> • Requires a complete and structure timetable • Rhythm depends of the script and must be adapted to trainees (Renger, Wakelee, Bradshaw, & Hites, 2009) • Facilitator sheets explaining each role played by facilitator must be prepared • Data sheets that <i>may</i> be used by facilitator during the simulation must be anticipated and designed (context, environment, or available action, Ressource and data...)
Logistic preparation	<ul style="list-style-type: none"> • A room for each crisis unit simulated plus one for facilitation • Enough communication devices to ensure proper simultaneous communication between crisis units' members • Planification adapted to implement pedagogical needs of each involved stakeholder (November & Créton-Cazanave, 2017) 	<ul style="list-style-type: none"> • A room required for trainees and one required for facilitation • Some communication devices to ensure simultaneous interactions between facilitation and trainees
Trainees organization	<ul style="list-style-type: none"> • Trainees must organize in as much team there is crisis unit simulated. • Trainees have different point of view of the situation according to the crisis cell they belong to, responsibilities, resources and stakes they have involved. 	<ul style="list-style-type: none"> • Trainees constitute one crisis unit facing the crisis situation. • Before the simulation trainees must study mission, they will have to ensure in the crisis unit and resources they will have available (Verdel, Tardy, Lopez, Hansen, & Deschanel, 2010)

Besides, how facilitators manage and control the simulation depend, as said, of the nature of the scenario. This function remains important in these two situations and aim to ensure pedagogical targets are reached through monitoring and script live modification (Lapierre, 2016). Moreover, facilitation ensures the consistent evolution of the scenario as discussed in Chapter 4. In controlled scenario, this exercise management directly relates to interaction between facilitators and trainees. According to the hierarchical position of the role simulated by the facilitator, this one may either give dedicated orders to refocus crisis unit on pedagogical target or, on the other hand, gather information on decision-making by asking what solution will be implemented at operational level and provide control feedback from onsite intervention. For self-powered scenario, in opposition, facilitation team starts the initial crisis situation by providing information on trigger elements then trainees activate emergency procedures of the different crisis units and take adapted action, especially by communicating to one unit to another (November & Créton-Cazanave, 2017). Then an

important part of the exercise relies on trainees themselves and facilitators do not have a lot of “grip” on the evolution of the situation neither feedbacks on discussion between units. Different solutions have been proposed in literature to overcome this problem in self-powered scenario (but also in controlled ones): facilitators may use a central email exchange platform to consult this communication medium (Dautun, Pardini, & Roux-Dufort, 2011), (Verdel, Tardy, Lopez, Hansen, & Deschanel, 2010), they may rely on observers in the different rooms to have regular feedbacks (Dautun, Pardini, & Roux-Dufort, 2011), (November & Créton-Cazanave, 2017), (Lapierre, 2016), a “spy” facilitator acting like a trainee in the crisis room may communicate with facilitator (and introduce stimulus as said in Chapter 4) (Gaultier-Gaillard, Persin, & Vraie, 2012), or a journalist coming in one crisis unit to gather information may be simulated (Dautun, Pardini, & Roux-Dufort, 2011), (Tena-Chollet, 2012). However, these methods, even if they provide crucial information to facilitators, are not easy to set nor fully efficient. Indeed, these means may be intrusive, breaking or harming trainees’ immersion, they may be difficult to install or to make it efficient for trainees and/or facilitator (as the mail platform). In that last case, it matters to note that crisis training facilitation may be challenging for facilitator and it matter to make things simple – which is not the case with a common mail platform – for the facilitation. If too many things are demanded from facilitators, they cannot focus on their basic tasks (managing the scenario, interact with trainees...) which impact global quality of the exercise

5.3.4 Flow state and game’s difficulty

Some logistic elements as we said may compromise immersion and reduce how focus trainee are on their tasks. Several fields aim to reproduce the high focus level that games may induce, strong enough to distract children during pre-surgery operation, avoiding them to stress without their parents (Patel, et al., 2006) and pedagogy is no exception. This special situation of very high focus – which is not exclusive to game but also all other immersive activities such as reading – is called the “focus state” and was conceptualized by Csikszentmihalyi, who defines it as a “feeling of complete and energized focus in an activity, with a high level of enjoyment and fulfillment” (Csikszentmihalyi & Csikszentmihalyi, 1988). Note that, firstly the “focus state” was not related to games and was linked to physical or mental activities, communicating, writing, working, coping with stress and loneliness, or philosophizing (Csikszentmihalyi, 1990). Nevertheless, it appears that games are good to induce this state, mainly because they are designed to. Schell lists, in his game design book, some key components to put a player into a flow state (Schell, 2008) : have clear goals set to concentrate player’s attention on a task, let no distraction likely to steal players’ attention, provide direct feedbacks to make players feel that what is done matters and influences the environment (see agency in 5.3.2), and be continually challenged then players continuously have something feasible but not easy to do. Indeed, if something becomes too hard to do, players start being frustrated and give up. This delicate balance between easiness and difficulty is discussed by Csikszentmihaly who states there is a margin before considering a task is too easy or too difficult and stay entertaining. This margin is called the “flow canal” as represented in Figure 36.

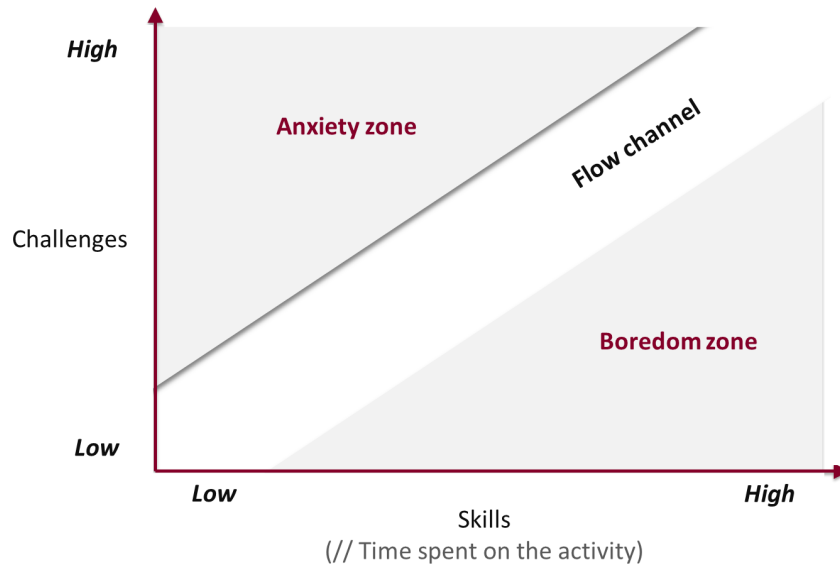


Figure 36: Flow canal according to challenge and skills (Csikszentmihalyi, 2002)

Csikszentmihalyi explains that as someone practices an activity, one's skills improve so move to the right on the Figure 36 and may leave the flow channel. As represented in Figure 19 (Chapter 3), learning rate depends on the trainee profile and may be more or less important. If nothing happens, if no new challenge appears, the activity becomes boring and requires new elements to be more challenging to go back in the flow channel. On the other hand, if the activity is too difficult, it generates anxiety as long as the one practicing has not enough experience and skill. Those experiences and skill may be acquired by perseverating (even if giving up is more probable) or by practicing less difficult activities.

Schell notes that keeping someone in a flow state is difficult as the game must provide adapted challenge all along the players' progression. Usually, difficulty balance is ensured by providing more and more challenging opponents, for instance in successive levels as in video game. Such system allows to provide an adapted experience for every player: novice players will spend more time than experienced ones who can finish fast a level to get to the next ones. Nevertheless, only skilled enough players – who may be novice at the start of the game and progress by persisting all along – reach the end of the game. There is debate on how skilled players must be at the end of a game and if it is a bad or a good thing that end's requirements are high. Indeed, difficult end game provides a special accomplishment, a reward, to persistent players but, on the other hand, frustrates many others who will probably give up before the end (Schell, 2008). However, commercial and critical success of difficult video-game license, such as *Dark Soul* (Miyazaki, 2001) or *Cuphead* (Moldenhauer & Moldenhauer, 2017) shows that difficult games have an audience. Moreover, how the difficulty increase is also an important matter. Even if it may seem more immersive for a player that enemies become progressively more and more numerous and dangerous, without gap between levels, it is actually more rewarding that "tense and release" cycle followed in the game, with new challenges succeeding player's improvements for instance. These cycles make the game less monotonous with the pleasure

of variety: excitement phase following relaxation phases bring with them the pleasure of anticipation (Schell, 2008) as shown in Figure 37. Note that immersion in games is not necessarily related to the narration but to, as Aarseth states (Aarseth, 2004), game mechanics, explaining why even story-driven games do not often have very original storylines. Then immersion is more related to how the player interacts – through the interface – with one's environment and how it affects its environment to reach challenging goals.

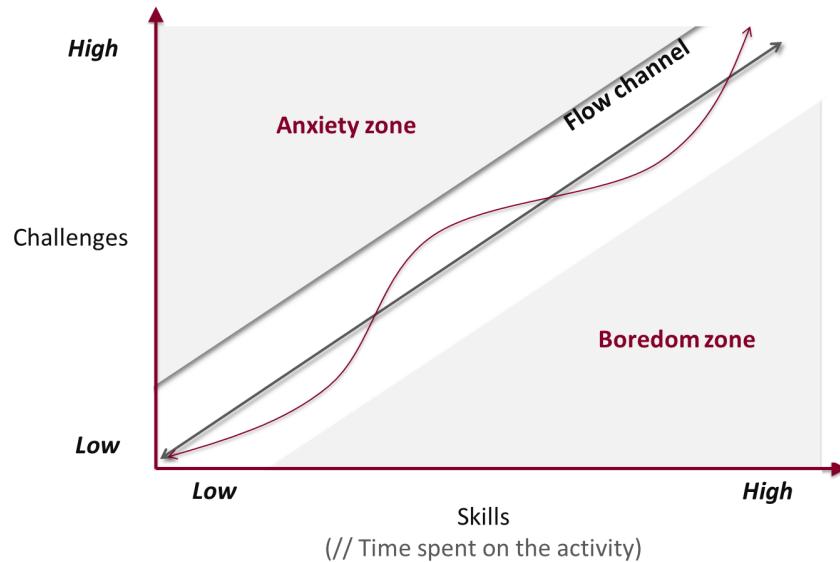


Figure 37: Difficulty progression and flow state

5.4 Industrial point of view

On the other hand, as mentioned in Chapter 4, developing crisis management trainings and exercises is a complex and time-consuming task that requires dedicated knowledge and skills (Limousin, 2017). Moreover, developing practical exercises adapted for agents and their particular needs is even more difficult when the system where they operate is complex (Saad Noori, Comes, Schwarz, & Wang, 2017), which is often the case in these industries. Such trainings exist and are mainly described in literature as oriented to public organizations (Alberta Emergency Management Agency, 2012) or, alternatively, for private companies, but outsourced to consulting firms which have no real interest in publishing on the topic. This common outsourcing reveals a lack of competences in companies that clearly appeared during Expert'Crise training. Indeed, over the 19 companies where trainings were provided and exercises prepared, only 4 of them were used to set up strategical crisis exercises and required Expert'Crise to add a fresh and innovative point of view to organize them. In contrast, about half of them were used to set operational crisis exercises with intervention. Then it shows that, in one hand, exercise culture is not obvious even if regulation impose it and, on the other hand, that operational exercises are privileged to strategic ones. This strong

opposition also appears in emergency planning where operational functions are usually more developed than strategical ones, as developed in Chapter 6.

Also, because organizing exercises in industrial plant is complicated, expensive, and comes with uncertain outcomes, companies may be reluctant to organize such exercises and often exceed regulatory deadlines (European Commission's Joint Research Centre and the Dutch Ministry of Social Affairs and Employment, 2008). Indeed, if European regulation 2012/18/EU known as "SEVESO 3 Directive" requires hazardous companies to test their emergency planning every three years, for instance with exercises and imposes that dedicated services control companies actually respect this requirement – the "Division du Control des Risques Chimiques" (DCRC) for the federal jurisdiction and the "Cellule des Risques d'Accident Majeur" (RAM) for Walloon jurisdiction – these controls do not investigate how exercises are made but mainly focus on emergency planning and internal organization. DCRC's control guideline in particular (Services belges d'inspection Seveso, 2012), even if it is very complete, scanning a wide scope of emergency planning content including operational, strategical and global exercises, does not seem to be applied in companies considering the lack in companies' emergency planning as developed in Chapter 6. Such disconnections between regulations and implementation in companies' organization may be explained by economic stakes involved and, more probably, by the will to focus on other safety components such as preventive organization or equipment and prioritize them before emergency planning. This balance between safety arguments and economic (and political) ones is understandable, especially in old industrial areas where "As Low As Reasonable" principle (Health and Safety Executive, 2011) must be carefully applied to ensure the survival of the economic fabric as well as the protection to the inhabitants. Nevertheless, such approach may strengthen safety culture deficit, carried by bias such as illusion of risk control, comparative optimism, or even defensive work ideology (Dejours, 2016), and lead to a depreciation of emergency planning considered as the least important part of the global safety system.

Therefore, there is a globalized denial – for operatives as well as executives – of the possibility of a major accident in Seveso plants even if non-major accidents possibility is still considered with all their potential consequences that remains moderate, rarely involving for example death casualties. Then – and it is a main characteristic of a crisis – Seveso workers do not anticipate such critical situations and did not evaluate all consequences even when designing their emergency planning which are usually designed for "usual" accident, not crisis ones, as discussed in Chapter 6. Such considerations have several repercussions. First, when these plans must be tested, the companies only test their procedures against moderate accidents that have not a lot of impact on surrounding stakes. Financial and legal issues are especially (and strangely) not weighed. Indeed, on the 19 companies that attended to Expert'Crise trainings only one ask for details on this topic, as if emergency planning and business continuity plan – which may not exist in some companies – were totally disconnected because written by different services. On the other hand, executives wanting to set up an exercise do not seriously consider a critical situation occurring then often minimize consequences or reduce other organizations implications. However, as said in Chapter 1, number of involved organizations and gravity of the simulation must match with the organization's needs and, for organizations few experienced in crisis management, such

setting is probably better. In the end, because emergency planning may be not considered as a priority, it may be difficult for executives wanting to set up and exercises to involve people, especially the management board, in such project and convince them of the relevance of crisis management trainings. Therefore, exercise scriptwriter and design methodology must take into account this global situation to, on one hand, present all potential impacted stakes especially financial ones – with a recall of company's responsibilities in case of disasters to raise awareness on this topic – and, on the other hand, to propose a user-friendly method that may be understood by non-expert decision-makers to involved them into the design process. In the best case, this design methodology should be done directly by those non-expert workers, without requiring any consultant. For this purpose, SHE managers need a simplified methodology to easily set up internal exercises matching their goals and adapted to the company's organization. Therefore, there is a need to streamline the development and exploitation of these simulations to make them more affordable. Then, a solution is to develop them according to a both rigorous and flexible methodology allowing cost-effectiveness, which is the purpose of this document.

One axe to effectively shorten exercise design consists in considering usual companies needs and requirements to build a company typical profile and design an exercises framework that may be adapted to each company matching with the typical profile. Such process goes against the detailing and developing movement that appears in literature, aiming to propose as much pedagogical tools and variations as possible dedicated to specialist scriptwriter but which are not convenient either for designing a lot of exercise or to be handled by novice scriptwriters. It appears, as it will be discussed in the Part 2, that goals and targets requested by industrials for trainings during the Expert'Crise project were usually very similar from a company to another. Such observations lead us to reconsider the fourth objective of the project aiming to build a scenario repository based on the nature of accidents occurring during the scenario. Indeed, accidental sequence strongly depends on the organization and even a fire – which is a simple accident – never happen identically in two different companies. Then such scenario is useless for scriptwriting. On the other hand, because companies – except those experimented in crisis management, requiring dedicated exercises – have usually the same needs, focus points of exercises remain the same from an exercise to another, then exercises' structure is invariant. Therefore, considering that structure stay the same, scriptwriting consists in adapting a generic exercise to the particular organization of the companies and hazards they usually face. Such adaptation work required to understand how the emergency system of the involved company works and how it sets up as well as how an accidental sequence may develop in it. If, for the first requirements, there are several common points in emergency planning system presented in Chapter 6, for the second one, an accident feedback review or discussions with workers of the system may be required as it is discussed in Chapter 8.

5.5 Chapter 5 Resume

As discussed in the Chapter 4, existing design methods for crisis exercises are heavy and time-consuming procedures that involved a lot of plot items requiring dedicated scriptwriting skills to properly implement each element at the correct place to make the scenario both pedagogical, interactive and dynamic. Scriptwriting procedures may be improved through two axes: learn from the game-design process to improve trainings efficiency and analysis common companies' needs to conceive a generic exercise structure that only needs to be adapted to each company's particular situation.

Expert'Crise trainings – as well as other similar trainings, such as those provided by Ecole des Mines d'Ales – are serious games. However, “serious games” stand for a wide variety of activities and does not properly characterize what is done during these trainings. The main problem to provide a more precise definition of Expert'Crise serious games come from the fact there is no consensus on what a game is and, more prominently, how to classify them, with different existing methods and classification grids. Then after a literature review of these methods and elements composing games, we propose our own reference grid to describe games and apply it to Expert'Crise trainings. It appears, as expected, these trainings were close to Live-Action Role Play and then related, as a serious game, to (Live-Action) Learning Role-Playing Games. These kinds of serious games are trainings where trainees play either their own role or other roles – such in cross-trainings – in virtual situations. These trainings are similar to LARP games that do the same things but in a playful purpose. Therefore, elements of LARP game design may be implemented into trainings to improve both their immersion and interaction, which are important in the socio-constructivism approach usually adopted in those exercises. Yet, LARP focuses on several topics that are relevant for Learning Role Playing games such as diegesis, storytelling, difficulty and players' involvement, interaction between players and their environment (including other players) and, to loop games elements to crisis exercise literature, cocreation that is discussed by Fréalles as self-powered scenario for crisis management trainings. Those topics are not particularly discussed in Learning Role Playing Games literature that is legitimately more interested in the effectiveness of such trainings compare to other means. On the other hand, they are by LARP community members who are interested in making their activities more immersive and enjoyable.

Then, it appears, during Expert'Crise project, that companies usually had the same needs, the same requests for their exercises. They were usually novice in emergency planning and required a first validation of their emergency plan or modified it recently and need to check if everything was correctly implemented. Therefore, it was less crisis exercises that was wanted but emergency exercises instead, with almost always the same functions to be tested – usually the first steps of emergency planning – and only on what is written in the plans, with no surprise. Based on that, scenario repository requested for project goals did not appear relevant and designing a generic structure for exercise seems more cost-effective to be implemented in every training, requiring only adaptation to fit the company organization and procedures. Then orientation taken by our design methodology was to propose a generic framework for simulation that may meet main needs observed during trainings. Nevertheless, as existing literature's design methods for crisis exercise,

this methodology still relies on a step-by-step procedure aiming to cover every topic and lead to the scenario. Each step is described in Part 3 in lead to the generic template presented in Annex 6.

Part 2 Conclusion

Main themes of this work were introduced and discussed in the first part in order to provide needed basis to understand the background of this PhD thesis. Especially, the pedagogical framework of Expert'Crise trainings was defined, dealing with competences aimed and how trainees should learn them. Then, the core topic of this document may be discussed and how literature approaches crisis and emergency training design is discussed in this second part.

All constraints on scenario, plot and pedagogical constitutive elements, the structure of the scenario involving trainees through an adapted rhythm and intensity, as well as means to transcribe a crisis scenario into document that stay comprehensive for every stakeholder are important parts of a crisis exercise design that must be mastered by scriptwriter to properly conceive an exercise. Indeed, such elements are directly used in the design process, whatever the number of steps it has. The number of such steps varies from a method from another but all deal with the same topics with more or less details. In the design method described as reference, four steps are required.

It appears, after describing design methodology, that both design method and tools used in such design process are often difficult to implement for non-expert scriptwriters and complex even for specialists.

Then simplification of crisis scenario training design methodology appears to be a first relevant contribution aimed by this PhD thesis. Yet, based on feedback from Expert'Crise trainings, this part shows that trainees' companies' needs statements are often the same, then that it may be relevant to design a common generic template for exercises that only require an adaptation work to fit with each company organization. Such proposition is discussed in Chapter 6.

On the other hand, design methodologies focus on the pedagogical purpose of the training and not on trainee's experience, how they live and feel the serious game. Yet, it is through that experience trainees may modify their mental pictures and, by this process, learn according the constructivism approach. In contrast, experience is considered as central in game design then it appears relevant to relate crisis management serious games to actual games and find bridges to build between these two domains. It required first to build a reference grid based on game characteristics to relate Expert'Crise serious game to other games and, through this comparison, it appeared that this serious game was a Learning-Role Playing Games, close to Live-Action Role Playing games. Therefore, based on this analogy, several LARP domain's concepts were reviewed such as diegesis, storytelling or players' involvement and their interactions with other players and the environment. Those topics provided elements that will be implemented in this design methodology contribution to improve trainees' experiences, then trainings efficiency. Such proposition is discussed in Chapter 8.

Part 3: Contribution to a Design Methodology for Crisis and Emergency Training

Crisis and emergency trainings held during the Expert'Crise are, as discussed in Chapter 5, Learning Role Playing Games then have several features characterizing games. These features belong to four main categories (Klabbers, 2003): (1) rules including the type of games and its mechanisms, (2) supports used or required for the game, (3) the context of the games meaning both its purpose and in what environment it set, and (4) players including their own characteristics such age, number or profiles. In crisis Learning Role Playing Games, pedagogical components belong to the context and rely on players to choose adapted pedagogical target. Then, to properly conceive a Learning Role-Playing Games exercise, it needs to define these rules, medium or support, context and players. Yet rules and medium are defined by the category of game chosen for the training – here close to LARP games – but, on the other hand, context and players vary depending on the company. Therefore, before considering developing a scenario for the exercise, these two elements must be properly defined with the company and will allow to build the diegesis for the exercise.

That is the reason why the methodology proposed and developed in this work is split into two main parts. The first one analyzes needs and wishes of the company as well as its emergency system to propose a pedagogical and organizational framework for the exercise. Then, the second part consists in working inside this framework to develop exercise contents according to pedagogical targets aimed. These two parts are not isolated from each other, and the development may step from one to the other depending on the progress of the pedagogical engineering and the reactivity of industrial contact person. In addition, the methodology is iterative, so each step is looped several times, especially the first ones. This way, it ensures a good understanding of the expectation of industrials and their needs. The methodology proposed consists in seven steps as shown Figure 38.

The methodology's structure itself is not especially innovative and scan the same elements than existing methodologies (Alberta Emergency Management Agency, 2012) with a special focus on chemical industries. However, it pictures how the design process was led during the Expert'Crise project and remain convenient to deal with new and original content for exercise design developed during the project and presented in this part, grouping steps into chapters as follows:

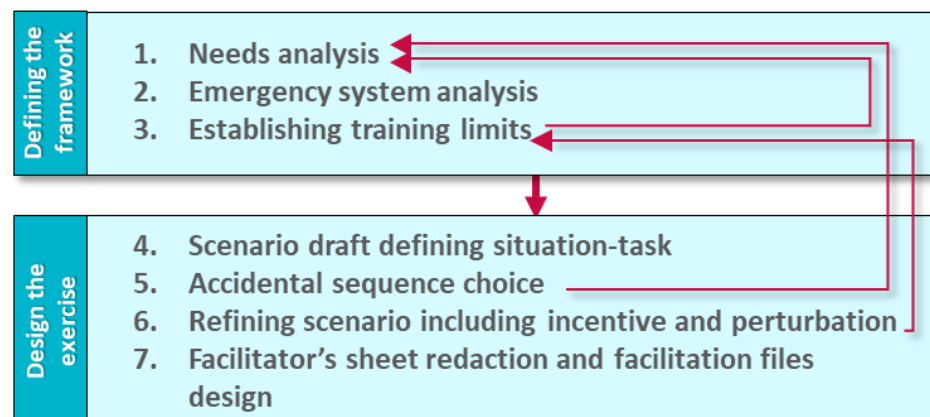


Figure 38: Structure of the emergency exercise design methodology

The **Chapter 6** groups steps 1 and 2 of the methodology. It explains how companies' needs were gathered during Expert'Crise project then presents common needs and requests encountered. As introduced in Chapter 5, this chapter draws a generic company needs profile based on exercises held that often tested the same functions of emergency plans. On the other hand, these emergency plans are reviewed and common points as well as differences are raised to build – besides company needs profiles – a generic Seveso company emergency plan profile, that (partly) transcribes how these companies are prepared to critical situation.

The **Chapter 7** – corresponding to the steps 3 – deals with the limits of the simulation. These limits are both geographic, hierarchic, functional and pedagogical. They allow to properly build the diegesis of the simulation by choosing what is simulated and what is not as well as how trainees are expected to interact with their (simulated or not) environment. Therefore, interactions are an important matter of this chapter and focus on how to make trainees' experience the most immersive possible.

The **Chapter 8** includes all the steps of the second part of the methodology. It details the scriptwriting process both relying on literature introduced in the first part and on the experience of the 19 scenarios developed during the project as well as on feedbacks from companies for improvement of the methodology.

The complete design process is illustrated in **Annex 6** by an example of application of the method presented in Chapter 8 for the case of a generic Walloon Seveso company having common training needs as well as common emergency planning features as discussed in Chapter 6. Such example aims to provide an exercise base for companies in order to help them in designing their own exercise either by directly transposing it in their organization with little adaptations or by developing it in order to make it fit with their needs.

Chapter 6 **Needs and emergency planning, starting points of the design process**

In order to properly design a training for a company we have to know what is expected and needed by the organization. Therefore, needs statement is a usual part of the marketing prospecting process. Actually, prospecting was an important part of the Expert'Crise project and consists in finding companies having interests in following courses on emergency and crisis management concluded by an immersive crisis simulation. Over the 103 Seveso companies in Wallonia constituting the scope of the project, 58 were contacted by mail or phone when it was possible. On these 58 contacted companies, 25 never answered, 21 were interested, 6 were interested but cannot implement such trainings at short or medium terms then postpone it and 6 were not interested in such training program. In the end, and as said in Chapter 2, 19 companies participated in trainings and 15 in an exercise. Prospecting splits in two phases: first, a mailing and phoning phases aiming to screen potential interested companies followed by a second phase composed of a meeting with an executive of the organization and aiming to detail needs and expectation of the company. Then a training program proposition dealing with discussed needs is sent to the organization and, if it is accepted, the prospection process ends. It is directly followed by a review of the emergency planning of the company then organization's needs are discussed again in light of this new information to refine them and clarify what is expected by the company. This preliminary work, done together with executives of the organization, set both targets aimed by trainings and its context. However, it appears during the Expert'Crise project that this process often brings similar outputs. Indeed, companies had more or less the same targets for their emergency planning tests which are also similar on several points.

Therefore, Expert'crise project specialized its training to specifically meet these requirements and conceive a common framework for exercises. However, it matters, before presenting this framework, to describe the profile of clients it targets, what needs it is designed to fulfill and emergency planning expected in these companies.

6.1 Need Analysis

After the prospecting phase, the presentation of the project and the agreement of the company to participate in the training, a meeting is scheduled to extensively deal with needs and expectations of the firm. This first meeting aims to have a first scope of the training company expectations including target audience identification, resources that can be used and operational and/or global goals, without considering yet the scenario and, *a fortiori*, the accidental sequence. Operational goals stand for parts of emergency plan— function or missions – that must be tested such as evacuation, intervention or warning chain. The purpose of this kind of goals is not to teach something to workers or to improve their competences but only to test a function of the plan – that may be fully automatic – to assess if it works as expected or not, and in that last case to identify reasons why. On the other hand, global goals stand for long term improvement goals such as improving reactivity, coordination, internal or external communication. Therefore, pedagogical goals belong to global goals as they aim to develop collaborators' competencies so their long-term efficiency. Trainings goals, usually discussed in literature, consist in global goals while operational goals are closer to an industrial audit that assess the emergency system compliance to company's standards.

Goals of the collaboration are stated by an executive of the company that may have little knowledge on crisis management or pedagogical targets related to crisis exercise then may only want to assess company emergency system – i.e. only set operational goals – without aiming more global goals. Moreover, this contact person may have training preconception which may lead directly to practical solutions that not meet company needs. Therefore, it matters to clearly present what is possible during the exercises, targets that may be reached – without introducing all of them – and outcomes that may be expected.

Then, as every design process (Haik & Shahin, 2010), the needs statement step has to be carefully processed to gather what the client wants, what this one needs and propose a product matching with these last ones. In order to propose such solutions matching with client real needs, training designer must consider what is expressed by the contact person but also the situation of the company in regard to crisis and emergency management, then designer can propose pedagogical or operational axes the contact person may not be aware of. Following tables (Table 19 and Table 20) resume in some words needs stated by companies during this phase. Because expectations stated were scattered, often blurred and mostly with operational targets, we had to translate these stated needs into pedagogical targets, considering the emergency system of the organization and its safety culture to design exercises. Note that companies expressed their needs without having access to the pedagogical targets repository so there is no influence of these targets on needs stated by companies.

Table 19: Needs stated by companies for exercises held between 2015 and 2019

Company	Needs stated by the company
A-B-C	The three companies of the industrial zoning wanted to test their coordination in the case of an emergency involving all of them. They also wanted to test several emergency functions: evacuation, onsite intervention and coordination of each company's emergency team, as well as crisis management and coordination at a strategic level including mandatory communication, especially to authorities.
D	The company wanted to assess the reactivity of its emergency system at night, when no executives are on site. Therefore, communication and information pooling abilities were especially aimed as crisis unit's members arrived one after another in the crisis room.
E	The company wanted to test their emergency plan, especially operational emergency actions, and assess on-site interactions with firemen.
F	The company wanted an external point of view to help them scriptwriting a scenario for its annual crisis exercise. Strategic actions were especially aimed including interactions with firemen at operational level as well as at strategical level.
C	The company wanted to test its brand-new emergency plan, designed following the first exercise. Then operational actions were assessed to evaluate internal firemen training and tactical management.
G	The company wanted a support to organize their annual emergency, jointly with the training firm coaching their internal firemen. Then, exercise mainly aimed operational functions.
H	The company proceeds to a complete review of their emergency plan including Expert'Crise trainings and concluded with an exercise testing new knowledge and skills, with a focus on tactical and strategical functions
I	The company wanted to test both their first operational action and medium-terms strategical actions. Several points of their emergency plan were targeted: the warning chain, the warning of firemen and their welcoming, evacuation, coordination between onsite operations and strategic management level, and major chemical accident dedicated instructions.
J	The company wanted to test their emergency plan with a special focus on coordination with firemen and policemen in a small-scale exercise to test strategical actions and, then, generalize the exercise processes to other sites.
K	The company – that is not SEVESO – wanted to test their emergency plan beyond what they already implemented (local test, one function tested at each time) in a global exercise with emergency services. Therefore, exercise focus on coordination and communication as well as the global warning chain and the head-management's involvement.
L	The company wanted to test their emergency planning - especially strategical functions - in the case of a total evacuation, without any resources available for crisis management at strategical level.
M	The company wanted a support to design an exercise different from what they were used to do, with a different process and different targets. A particular focus on cognitive and behavioral bias occurring into a crisis unit was particularly requested.
N	The company wanted its emergency plan to be reviewed and – after correction and implementation – to test it. Both onsite evacuation and external crisis management with a focus on communication and coordination was requested.
O	The company implemented a local emergency plan at dedicated points of a critical infrastructure. Then, it wanted to develop these plans, organize trainings and proceed to several trainings at small scale. In the end, a full-scale exercise, involving firemen and their equipment was planned with the support of Expert'Crise to test the new emergency plan and assess interactions between the company and firemen at local, operational and tactical levels, especially for the warning chain and the welcoming.

Table 20: Needs stated by companies for exercises cancelled

Company	Needs stated by the company
P	The company wanted to train its crisis unit with Expert'Crise courses that should be followed by an exercise. Therefore, the main purpose of the exercise was to assess new knowledge and skills by setting situations requiring to use them.
Q	The company wanted to test first emergency actions such as warning chain, evacuation, internal firemen actions and crisis management. Evacuation, first recon and firemen welcoming were important focus points.
R	The company wanted to test Seveso crisis unit, disconnected with Business Continuity Plan management however more detailed, and evaluate coordination of management with guard posts. Global coordination, warning chain and raising awareness were especially aimed
S	The company wanted to improve its emergency system by training internal firemen and operational workers. Therefore, the exercise mainly focused on firemen actions.

Based on these stated needs and the review of emergency planning, a main pedagogical axe is chosen amongst the five Tena-Cholet repository's axes presented in 3.3. This choice provides the primary direction for the exercise design, defining central topics of the scenario and group of competences aimed. Then one or two secondary pedagogical axes are chosen to thicken the scenario, providing other themes and topics to deal with, adding realism and possible outcomes. At the end of the Expert'Crise, Lapierre repository supports the exact same process instead of Tena-Cholet's one, with a finer definition of pedagogical targets, defined as missions easier to observe and represented in Table 7. Nevertheless, to resume all translated pedagogical targets into a homogenous form, the following analysis only relies on Tena-Cholet repository, mainly because it was the most used during the Expert'Crise project to choose pedagogical targets aimed in exercises. Therefore, if there is no influence of the target repository on needs stated by companies, there is still a bias induced by this specific repository because targets were chosen from it, with no possible deviation or modulations.

For each exercise, a table was filled with main and secondary pedagogical axes selected and, on these axes, pedagogical targets aimed. This pedagogical target may be skill, knowledge or attitude in a KSA approach as discussed in 3.3. As this table aims to identify most requested pedagogical axes and target, primary and secondary axes are distinguished, first ones are noted with a "2" while second ones are noted with a "1", meaning – because these values will be summed – a primary target has twice the importance of a secondary one, as represented in Figure 39.

Pedagogical axes and targets are treated separately. At the end of pedagogical axe's line, in gray, all values are summed and divided by the sum of all pedagogical axes to assess the relative weight of this axe among others ones. Meanwhile, at the end of each target's line, all the values are summed and are divided by the sum of other target's line value in the considered pedagogical axe to assess the relative weight of each target inside the pedagogical axe. The sum of the line is also divided by the sum of all lines, from all pedagogical axes, to represent the relative weight of each target amongst all others.

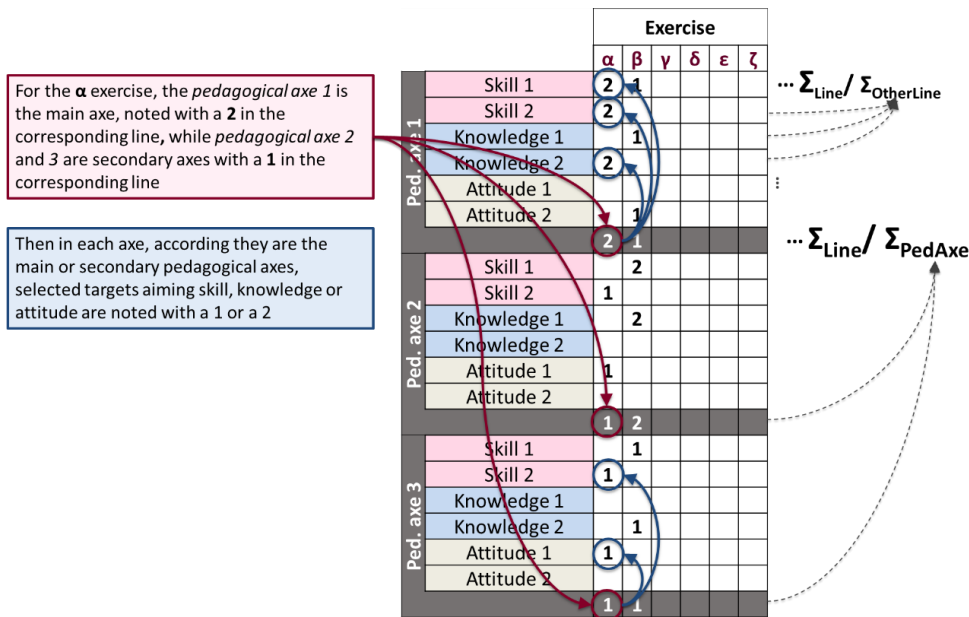


Figure 39: Needs analysis explanations

With this methodology, it appears that the five pedagogical axes of the Tena-Cholet's repository was not requested evenly, as shown in Table 21: Operational Response Management gathers 13 points – or 23% – being selected as main axis 9 times and 2 times as second axis ; Crisis Unit Management gathers 32 points – or 57% – being selected as main axis 15 times and 2 times as second axis ; Effect Management gathers 1 points – or 2% – only being selected one time as second axis ; Short, Medium and Long Terms Vision gathers 1 points – or 2% – only being selected one time as second axis and Crisis Communication gathers 9 points – or 16% – being selected 9 times as second axis. As “Effect Management” and “Short, Medium and Long Terms Vision” axes were not selected a lot during Expert'Crise project, they will not be deepened in the following of the analysis.

Table 21: Pedagogical axes requested during Exper'Crise Project

	Exercise																Total	%	Nb of time as 1st axe	Nb of time as 2nd axe	
	D	E	F	C	G	H	I	J	K	L	M	N	O	P	Q	R					S
Operational Response Management		1		1	2	1		1		1	1		1		2	1	1	13	23%	2	9
Crisis Unit Management	2	2	2	2	1	2	2	2	2	2	2	2	2	2	1	2	2	32	57%	15	2
Effect management													1					1	2%	0	1
Anticipation	1																	1	2%	0	1
Crisis Communication			1			1			1		1	1	1	1	1	1		9	16%	0	9
Total																		56			

On the other hand, for pedagogical targets of Operational Response Management, Crisis Unit Management and Crisis Communication, both to keep a representative enough panel of goals and to limit the number of items, only targets that gather 7% and more of their pedagogical axes were considered. With these filters, 21 pedagogical targets (over the 63 of the repository), representing 71 % of all the pedagogical target score – i.e. the sum of all target lines – from all pedagogical axes are identified as the most common needs. These pedagogical targets are represented in Table 22 with their percentage among all the pedagogical targets.

As it appears that “Crisis Unit Management” is over represented, the target of 7% of pedagogical axes allows to raise targets from secondary axes that would be overwritten otherwise.

Therefore, it appears that, during the project, companies expected mainly the same things from exercises: the evaluation of the warning chain and operational first actions in a very prescriptive view of safety management, and management awareness rising through crisis unit management – with role and mission identification, data collection and representation process or giving orders – or crisis communication targets. The previous 21 pedagogical targets allow to match most of the companies’ needs even if more specific demands may require to review pedagogical repository to find more adapted targets. The recurrence of these needs stated by companies and related pedagogical targets lead the project Expert’Crise to specialized in order to comply with these requests.

Table 22: Most requested pedagogical targets

Operational Response Management	Crisis Unit Management	Crisis Communication
Determining operational response (3%)	Available data collection (7%)	Collecting broadcasted information (1%)
Adequacy of resources (3%)	Clear Representation and Summery (6%)	Message construction (2%)
Planification and monitoring of actions taken (2%)	Giving order and instructions (5 %)	Choice of addresses (2%)
Exclusion area, block and check point, substitution routes (2%)	Definition of the roles and missions (7%)	Reporting (2%)
Knowledge of available resources (1%)	Fast decision-making (4%)	Message consistency (1%)
Prioritization of goals (3%)	Ability to share information (8%)	Ability to make spontaneous and on requesting transmission (2%)
Priorities setting (2%)	Cooperation (8%)	Persuasion (1%)

Skill

Knowledge

Attitude

Nevertheless, even if this specialization aiming to meet companies’ needs for testing and improving their emergency system appears to be adapted, a question remains unanswered: why companies have these same needs? Actually, theses needs’ statements may be the symptoms that crisis LRPG are too elaborate for some companies that do not

have neither emergency readiness and safety culture to set such exercise. Indeed, it appeared, for several companies, that lighter exercises could have been more adapted because their emergency plan was either non-existent or correctly implemented but with stakeholders that do not know what to do during an emergency. Then, other training solutions may be proposed, inspired by theatrical practice such as run-through repetition, especially speed-run where actors only move on stage – opposed to the Italian (or Russian) where actors only deliver their lines – to figure where everyone is supposed to be and how they are supposed to communicate. Further, these rehearsals may be proposed every time an evacuation exercise is organized to avoid emergency team and interventionists evacuate casually, which happened several times in exercises. Such trainings are more adapted than table-top exercises where operational problems may not directly appear and are less time and resource consuming than full-size exercises while keeping the onsite movement and interactions. Nevertheless, as both readiness and safety culture are difficult to objectively assess, this hypothesis should be validated to proposed new trainings adapted for this situation.

After this first meeting stating needs of the company, theoretical courses can be scheduled with information needed to adapt them to companies or trainees' profile, if it is required. During this meeting, transfer modalities – e.g. non-disclosure agreement (NDA) – of emergency documents such as reflex sheets, emergency plan and maps are discussed. In addition, when it is possible, the safety report (European Parliament and Council, 2012), and general operating rules are requested by scriptwriter to have a wide vision of how the company operates. These documents allow to analyze the company's emergency system which is the next step of the methodology.

6.2 Emergency system analysis

Designing a crisis or emergency exercise adapted to a company required to know how this company is supposed to run during an emergency. Therefore, it requires to study emergency plan and related procedures which is the second step of the methodology. The purpose of this analysis – besides reviewing – is to process these documents into a mental picture of how the emergency system works. However, because hazardous chemical industries may legitimately have reluctance to transfer such document without non-disclosure agreement, it matters to propose a formal framework to proceed to such exchange, possibly with a generic NDA. Even with this kind of agreement protecting against disclosure, companies may be hesitant to share all their procedures, arguing it is not necessary to provide all documents, it is heavy to transfer or the contact person not having access to all plans. Therefore, working with scarce input data is common and information gathered from the company internal documentation must then be discussed with executives both to fill gaps induced by the lack of documents and to distinguish what is written in plan and implemented, what is written in the plan but not implemented, and, in the end, what is not written in the plan but however implemented. Then, also because prescriptive plans are rarely exhaustive, a second meeting with the contact person is needed to clarify or verify some points. This meeting may be held with other executives or technicians of the companies to have a better description of their role and seize differences between the

prescriptive plan and what they would do during an emergency according to their experience, their working procedures and habits. Therefore, it is possible to have a representative picture of how the emergency system could be expected to work during an emergency.

Moreover, it appeared that emergency plans from Seveso companies are similar (Duhamel, et al., 2017), with separated operational onsite management and strategic management in a crisis room. However, to develop a standard canvas for Seveso companies' crisis exercises, it requires to describe more precisely this common structure of emergency plans. Then, during Expert'Crise project 19 emergency plans were analyzed but 2 of them belong to critical infrastructures, too different from Seveso companies, especially because they do not have the same regulatory requirements, so the following analysis relies on the 17 Seveso companies' emergency plans. These plans are very different from each other, depending on the nature of the company, its size and the number of workers, if it is upper or lower Seveso tiers, and – even if it is difficult to assess – the safety culture in the company. Length of plan is, in particular, heterogenous: from six pages for the shorter emergency plan to several hundreds of pages for the longer ones. Therefore, to proceed a clear synthesis of these various emergency plans and deepen the analysis, a homogenous framework, that may apply to each plan, is required and a three levels of analysis framework is chosen: warning chain, internal firemen, and crisis management. Warning chain study grid consists in the succession of step from the first sensor/observer of the situation to the call to emergency services and the crisis management mobilization. On the other hand, internal firemen and crisis management analysis is made according the following structure:

- | | |
|--|--|
| <ul style="list-style-type: none"> • Operational intervention / Internal firemen <ul style="list-style-type: none"> ○ Composition of the team & Comments ○ Number of criticality level related to the gravity of the event ○ Missions & Comments | <ul style="list-style-type: none"> • Crisis management <ul style="list-style-type: none"> ○ Composition of the team & Comments ○ On duty manager ○ Recall System (Y/N) ○ Mission & Comments |
|--|--|

As the full data base, screening all emergency plans is extensive, only its summary and analysis appear in this paragraph while the raw database is available in Annex 2. This review first proceeds **operational level** then studies **crisis management** and concludes with how **warning chain** work.

It matters to precise that emergency plans analysis required to simplify data to allow to compare them with another. Indeed, because all these plans are very different in structure, format and length, it requires to find a common canvas matching with most of them. Then, because the reading grid had a certain precision – allowing to cover most of the emergency plans' topic without being too heavy – some data, details too specific to fit in the canvas, get lost and do not appear in the following analysis. However, such approach is required to proceed to such study, dealing with various unformatted documents.

Operational emergency level is composed by four kind of stakeholders working onsite or in dedicated place according their mission: intervention operators, evacuation leader, first

aid leader and guard. The Table 23 resumes operational emergency level composition precisising name of each function, percent of companies that have such function in their emergency system and commenting values and functions. Note that one of the most difficult parts of processing a summary of several companies' emergency plan is to find generic denominations to name each function so names in the following table are the most common ones even if variations exist.

Table 23: Operation emergency level composition

		Denomination	% of companies with this function (or similar)		Comments
Operational level	Composition	Onsite Interventions	Leader of Intervention	100%	← Every company has at least someone, onsite, intervening, possibly only assessing the situation
			Intervention operators	82%	← Companies often have a small intervention team. Even if they do not actively fight the situation, they can help firemen and safe installation.
				18%	← Intervention team may be supported by other function such as electrician or maintenance manager
				6%	
		Evacuation	Evacuation leader	94%	← Evacuation is a basis of emergency management and it's a function widely present in emergency planning
				18%	
		First aid	Rescuer	47%	← Half of companies have rescuers in their team and integrate them in their emergency planning
		Guard		35%	← Guards may either only proceed security function or, in other hand, proceed more complex mission, as intervention operators (even if security is outsourced)
				6%	

The review of this level's composition reveals that the vast majority of Seveso companies have, at operationnal level of their emergency plan, at least an evacuation leader and an intervention chief supported by operators. These operational team members proceed emergency response actions that will be described in the following paragraph. Rescuer and guard, on the other hand, even if they appear in several plans are not representative enough of how companies organize their emergency system.

Moreover, it matters to precise missions of this operational level. Missions distribute in seven categories with and additional uncategorized class : (1) evaluation, alarm/alert triggering and evacuation, (2) safing, perimeter setting and intervention by internal firemen, (3) calling 112 and management, (4) welcoming and assisting firemen, (5) counting and reporting casualties, (6) counting people after evacuation, and (7) controlling access. Similarly, to composition, missions are represented in Table 24, near the global category and with the percentage of companies having the corresponding mission (or similar) in their emergency plan. Comments complete the analysis for line requiring it.

Table 24: Missions of operational emergency level

		Cat.	Mission	% of companies with this mission (or similar)	Comments
Internal firemen	Mission	Evaluation, alarm or alert triggering and evacuation	Evaluation	100%	← Evaluation is the first step of an emergency process and every company do it.
			Triggering alarm /Starting Evacuation	71%	← The more often, someone triggers alarm or, at least, confirm the alarm. Nevertheless, some companies only rely on automatic alarm trigger.
			2 nd Trigger / Confirmation	24%	← Some companies require a 2 nd /3 rd alarm trigger, especially if the first one is from a sensor.
			Evacuation point choice Evacuation of specific population	12%	← It may seem a little proportion but most companies only rely on an alarm system to evacuate workers then move them according to the situation
			Confirmation	6%	
		Safing, perimeter and intervention by internal firemen	Intervention / Setting firemen device	59%	← Almost 2/3 of companies try to intervene on accident. It is both a lot and few considering hazards of some companies
			Safing all or part of installation	53%	← 76% of companies do it, <u>merging what is done at operational and strategic level</u> . Moreover, safing may not be integrated in emergency planning but still operate by workers as part of their own working procedures.
			Meeting and coordination with internal firemen	35%	← Coordination between operational and strategic level appears in both procedures, therefore this value is underestimated, see also Table 26
			Isolating an area or establishing a perimeter	24%	← As well as intervention, establishing a perimeter is common for internal firemen. Nevertheless, it may not appear in procedures and only relies on firemen trainings.
			Safing/Evacuation of specific devices	24%	
			Alerting other companies	18%	← This mission often depends on the strategic level
			← Some – 2 companies on 17 (12%) – do nothing in the intervention field and some other – 4 companies on 17 (24%) – do very little, only one item of the previous list.		
	Mission	Calling 112 and management	Calling 112	76%	← Calling 112 is one of the first steps of emergency planning. Nevertheless, some companies do not integrate it in their plan, fully rely on their automatic system and/or "forget" to call.
			Calling management	65%	← Often a call is given to managers who also may be alerted through a recall system or evacuation horn. Nevertheless, in that case, they must be proactive to find information.
		Welcoming and assisting firemen	Meeting and leading firemen	71%	← 88% of companies do it, <u>merging what is done at operational and strategic level</u> which appears more representative of the reality. Although, 1/4 of company does not plan it which can lead to difficulties to meet and to give precious information to emergency services
			Staying available for firemen. Providing information	24%	← 53% of companies do it, <u>merging what is done at operational and strategic level</u> . It is not so much considering that it is a very important mission of Seveso companies' crisis cell.

		Cat.	Mission	% of companies with this mission (or similar)	Comments
Internal firemen	Mission	Counting and reporting casualties	Evacuation and first aid	29%	← First aid is not very common in emergency plans as only 1/3 of companies mention it.
			Reporting name of casualties	12%	←
			Calling management	12%	← This call does not relate to an “alert call” but aim to tell management how many people are injured/dead and their identity.
		Counting people after evacuation	Printing list	18%	← 29% of companies do it, <u>merging what is done at operational and strategic level</u> . Although, it remains a little proportion and may explain recurrent problems with evacuation in Seveso companies
			Counting worker	18%	← 29% of companies do it, <u>merging what is done at operational and strategic level</u> which Although, it remains a little proportion and may explain recurrent problems with counting evacuated workers in Seveso companies
		Controlling access	Controlling access	24%	← 35% of companies do it, <u>merging what is done at operational and strategic level</u> . It is a little proportion but companies often have outsourced guards doing it on a regular basis.
		Other	Other	12%	

Therefore, if a mission is considered as representative if at least 40% of companies have it in their procedures – letting benefit of doubt and assuming company may do something which is not written in its procedure – 7 missions may be retained:

- **Evaluation, alarm or alert triggering and evacuation**
 - Evaluation (100%)
 - Triggering alarm / Starting Evacuation (71%)
- **Safing, perimeter and intervention by internal firemen**
 - Intervention/Setting firemen device (59%)
- **Calling 112 and management**
 - Safing all or part of installation (53 %)
 - Call 112 (76%)
 - Call management (65%)
- **Welcoming and assisting firemen**
 - Meeting and leading firemen (71%)

As evaluation is one mission of the operational level, it matters to detail the rating scale operational team has to characterize an event. Yet the number of steps a scale have is a good mean to determine its accuracy. The average number of steps is 2.5 with a standard deviation of 1.0. More precisely, 10 companies on 17 (58%) have 2 criticity levels defined as the alert level requiring to stop activities and prepare for evacuation, and the alarm level usually requiring workers to evacuate. On the other hand, 6 companies (35%) have more than 2 criticity level, from 3 to 5, that precise the gravity of the situation.

Therefore, the generic operational emergency management of a Seveso company is composed of an intervention leader supported by an intervention operator and an evacuation leader. This team must first evaluate the situation then, if required, trigger alert or alarm and

start evacuation. Meanwhile evacuation proceeds under evacuation leader watch, intervention team must safe the installations – or make it safe by operators before they leave their workstation – and alert firemen as well as management. Then, intervention team may start intervention according their training, they may for instance set up firemen devices to ease emergency services work when they arrive. In the end, once firemen arrive, an intervention team member must welcome them, lead them onsite and present them to the situation.

On the other hand, **crisis management** is usually handled by several persons in a dedicated room, often a meeting room. The strategic management plan describes up to 8 functions, often carried out by several crisis managers. The only function founded in all plans is Executive officer (or Site manager, On-Call executive or other similar name). Indeed, crisis cell composition and functions held may considerably vary from an organization to another as shown in Table 25. This table states for each function, the percent of companies that have such function in their emergency system and comment both values and functions. Note that – as for operational level and even more pronounced at strategical level – the main difficulty was to find generic denominations for each function.

The average number of crisis management team members in our sample is 4.9 with a standard deviation of 2.8. Its generic composition is an executive officer, a first officer supporting this last one, a communication manager, a SHE manager and someone to take note and realize secretariat task. The largest crisis unit observed had 11 persons in it and the smaller one, only one person. Eleven companies (65%) have a functional crisis role attribution and other ones rely on their usual hierarchical distribution.

Table 25: Crisis management, strategic level composition

		Denomination	% of companies with this function (or similar)		Comment
Crisis Management	Composition	Executive officer	100%	←	Every company has at least one contact person supposed to deal with the situation. This function is more or less important according how many other crisis managers support it.
			24%	←	Some companies have a back-up for this function, different from the "First officer" function.
		First officer	41%	←	This "wingman" function is a direction support function which may assume communication, secretariat or contact with firemen depending of the situation and the crisis unit composition.
		Communication Manager	59%	←	Communication is often a dedicated function assumed by one person or more.
			12%	←	As communication is a heavy task that required numerous human resources, several reinforcements may be planned
			6%		
		Secretariat	41%	←	Secretariat is a common function in emergency planning when a functional crisis cell is set up (which is not always the case)
			12%		
		SHE Manager	35%	←	SHE Manager is not an emergency function but a normal operating function. It usually appears when a crisis cell is composed of manager board without functional crisis role attribution.
			6%		
		Technical Manager	29%	←	Technical manager is a support function that provides technical information to crisis and/or make the connection between operational and strategical level.
			6%		
		Logistical Manager	18%	←	Logistics is a rare support function that appears in some emergency plan and provide information to crisis unit.
		HR Manager	12%	←	HR are often mentioned as an important part of crisis cell but it appears that they are not so present in emergency planning in Seveso companies
		Others	29%	←	Often other support functions such as security, first aid leader, computing support, may come in reinforcement

Moreover, similarly to the operational level, it matters to precise missions of this strategical level. Missions distribute in eleven categories with and additional uncategorized class: (1) alerting authorities, (2) interaction with firemen, assistance to operational level and providing resources (3) media and internal communication, (4) alerting other managers and the corporate level, (5) first aid, counting casualties and contacting with families, (6) alerting neighbor (companies and/or people living around), (7) secretariat functions, (8) evacuation, (9) anticipation and strategic decision making, (10) dealing with insurances, and (11) controlling access. Missions are represented in Table 26 with the global category and the percentage of companies having the corresponding mission (or similar) in their emergency plan.

Table 26: Missions of strategic crisis management level

		Cat.	Mission	% of companies with this mission (or similar)		Comments
Crisis Management	Missions	Calling authorities	Calling authorities (generic mission)	94%	←	Besides being mandatory, calling main authorities appears in most emergency plans. Yet, some recent Seveso companies or very small ones do not integrate it (yet) in their plan.
			Calling CGCCR	76%		
			Calling DCRC	76%		
			Calling SOS Pollution (or DPC/DPE)	71%		
			Calling RAM cell	18%	←	Alerting local political representant appears to be common in emergency planning
			Calling Communal representant	41%		
			Calling Provincial representant	24%		
			Calling Essencia	18%	←	Essencia is the Walloon chemical industry association.
			<i>Specific actions</i>	24%	←	Specific actions related to alerting authorities may also be engaged such as sending someone at the city hall
		Interactions with firemen. Assistance to operational level. Providing resources	Briefing with operational team	47%	←	As said in Table 24, briefing with operational appears both in operational and strategic level procedures. It is not very common but, only 59% of companies proceed to intervention then it remains consistent.
			Choosing intervention strategy or help internal firemen	24%	←	Among companies intervening, a half have strong enough relations between operational and strategic level with the last ones supporting the first.
			Welcoming, leading and assisting firemen onsite	29%	←	88% of companies do it, <u>merging what is done at operational and strategic level</u> . Therefore, it is common.
			Providing information or resources	41%	←	53% of companies do it, <u>merging what is done at operational and strategic level</u> . It is not so much considering that it is a very important mission of Seveso companies' crisis cell.
			Safing of installation and 112 call verification	35%	←	76% of companies do it, <u>merging what is done at operational and strategic level</u> . Therefore, there are complementary actions from strategic and operational level to do such critical tasks.
		Media and internal communication	Preparing first press statement	53%	←	Considering these two items, 76% of companies plan to communicate with medias. It is an important proportion then company are aware of the importance of this topic.
			Ensuring communication with medias (question; welcoming...)	59%		
			Organizing press point/meeting	24%		
			Ensuring internal communication	29%	←	Internal communication appears to not be a top priority for crisis management with possible consequences of workers providing unsuitable press statements.
		Alerting other manager and corporate level	Alerting internal stakeholders (managers, department...)	53%	←	This kind of alert is not always needed: everyone may be alerted through automatic system or horn and does not require a dedicated action.
			Alerting corporate level	47%	←	Note that concerned company may not have corporate level

		Cat.	Mission	% of companies with this mission (or similar)	Comments
Crisis Management	Missions	First aid, counting casualties and contact with families	Getting information on casualties	35%	← This proportion is strangely low considering workers may get wounded during their normal activities. Although this procedure may be separated from emergency planning because it is more used.
			Giving or coordinating first aid	18%	
			Contacting casualties' families	35%	← If information on casualties are gathered, families are contacted.
		Alerting neighbors (companies and/or people)	Communicating with neighboring companies	53%	← This proportion is high revealing a will – even if it is not effective – to collaborate in industrial zonings during emergency.
			Communicating with civilian neighbors	6%	← At the opposite, communication to neighboring population is considered as the mission of the city crisis unit and not the company's one.
		Secretariat	Taking and filtering phone call	18%	
			Gathering and reporting information on a shared support	35%	← Even if secretariat functions appear in most emergency plans, its missions do not make consensus. Reporting is the most common actions mentioned.
		Evacuation	Printing list and/or triggering alarm	18%	← 29% of companies do it, <u>merging what is done at operational and strategic level</u> . Although it remains a little percentage considering it is a basis emergency function.
			Ensuring evacuation	18%	← It is a little proportion and we may suppose worker evacuate themselves in most companies.
			Ensuring everyone have evacuated and/or count worker	18%	← 29% of companies do it, <u>merging what is done at operational and strategic level</u> .
		Anticipation and strategic decision making	Anticipating evolution and/or impacts	24%	
			Taking strategic decisions and facilitate crisis cell	18%	← Strategic proactive decision making is not very present in emergency planning that are more reactive than proactive
		Insurance	Dealing with insurance	12%	
		Control access	Controlling access (if not at operational level)	12%	← 35% of companies do it, <u>merging what is done at operational and strategic level</u> . As said, companies have often outsourced guards doing it on a regular basis
		Other		12%	

Therefore, considering a mission is representative if at least 40% of companies have it in their procedures, 12 missions may be retained:

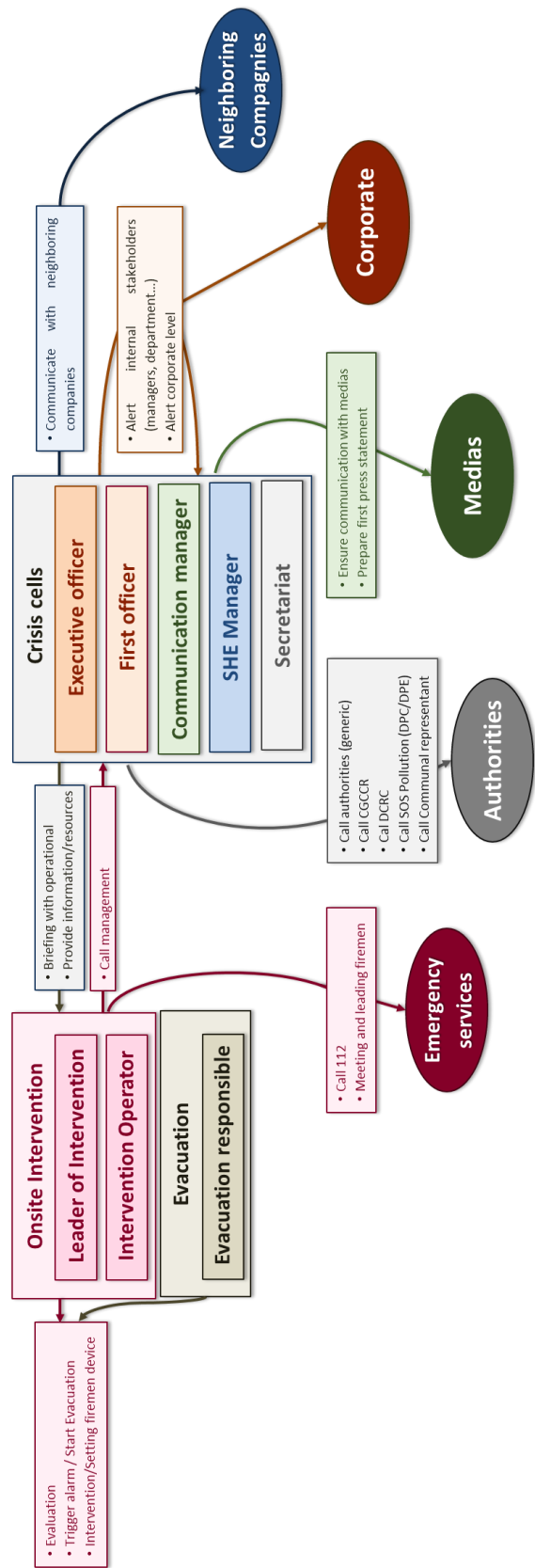
- **Calling authorities**
 - Calling authorities (generic) (76%)
 - Calling CGCCR (76%)
 - Calling DCRC (76%)
 - Calling SOS Pollution (or DPC/DPE) (71%)
 - Calling Communal representant (41%)
- **Media communication and internal communication**
 - Ensuring communication with medias (question; welcoming...) (59%)
 - Preparing first press statement (53%)
- **Interactions with firemen, Assistance to operational level and Providing resources**
 - Briefing with operational team (47%)
 - Providing information or resources (41%)
 - Alerting neighbors (companies and/or people) (53%)
 - Communicating with neighboring companies (53%)
- **Alert other manager and corporate level**
 - Alerting internal stakeholders (managers, department...) (53%)
 - Alerting corporate level (47%)

It appears that strategic crisis cells missions, even if they all have a common core, are much more various than operational ones. Indeed, considering all emergency plans, for operational level, only 21 different missions were found (and 7 were selected as representatives) while at strategic level, 34 different missions were found (and 12 selected as representative). Then, operational missions are limited but focused on some well-defined topic while strategic mission are more numerous and various, even if some missions obviously are at the center of all emergency plans.

Therefore, the generic strategic emergency management of a Seveso company is composed by an executive officer, a first officer, a communication manager, a SHE manager and someone to take note and realize secretariat tasks. This team must – as a first and most common tasks – call authorities including CGCCR, DCRC, SOS Pollution and, possibly, local political authorities. Meanwhile, other internal stakeholder as well as corporate level must be alerted according the situation. Then crisis management must prepare communication with and to medias – usually in a reactive mode – by dedicating someone to these interactions and preparing a press statement. This same person – or site manager or first officer – must also contact neighboring companies to alert them of the situation and, possibly, ask them to safe their installations. These actions are done at the same time as communication with operational onsite who provide information on the situation while strategic level give them instructions, information and resources.

At the end of these two levels analysis, the Figure 40 resumes how operational and strategic level are composed and how they interact. Missions they have to proceed are also mentioned as well as external stakeholders involved.

Figure 40: Generic Seveso crisis management system summary



Then, as shown previously, crisis management systems observed in Seveso companies are different from what literature depicts. Actually, only major functions of what is described in literature are present in these companies' emergency plans. These functions constitute an emergency standard system that is completed by supplementary functions when this system grows – especially with more crisis team members – and is developed. Indeed, crisis and emergency managements come in a wide variety in companies that have not always necessary resources to implement a full-size emergency system as described in literature. Nevertheless, these companies improve their systems and plans – with more or less engagement according to safety culture and management impulse – and plans to reach an adapted protection level and a proper reactivity in case of crisis.

Among all missions mentioned in emergency planning, **warning chain** is one of the most important procedure and, on the 19 missions retained in the previous analysis, 13 of them related to alerting or calling stakeholders. Yet, warning chain may significantly vary from a company to another then warning sequences of all companies have been analyzed to raise common points and differences. As the companies Q did not provide enough documentation to perform this analysis, it was not analyzed. Instead, another company – noted as T – was analyzed, this company provides its emergency plan to be reviewed but it was not possible to organize a training with it. Ten steps have been identified in warning chain and noted with an “X” if the emergency plan mentioned it or a “≈” if this step is mentioned but in an interpretable way, and numerically count as a half step. Steps may repeat and, in that case, are counted as two separated steps working as a back-up in the procedure. Moreover, the number of steps before calling the 112 and a manager is counted to represent how long it takes to warn both emergency services and management. Note that, as for mission, the transposition into a common form of all warning chain – written in unformatted document – required to simplify data so several details do not appear in the analysis.

Table 27: Warning chain steps summary

	Company	A	B	C	D	E	G	H	I	J	K	L	M	N	P	R	S	T	% of company with...
Warning chain	Observer	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	100%
	Internal call	X		X	X		X	X	X	X	X	X	X				X		65%
	Check onsite	X			X	X	X	X			X	X	X	X	X	X	X		71%
	Call 112	X	X			X		X	X	X	X	X	X						53%
	Trigger alarm	X	X				X	X	X	X		X			X		X	X	59%
	Or automatic trigger										X	X			X		X	X	29%
	Internal call	X	X	X	X	X			X	X	X		X	X		X		X	71%
	Call 112 (if not done yet)			X	X		≈			X				X	X	X	≈	X	47%
	Internal call			X	X				≈						X		≈	X	29%
	External call		X	X	X										X				24%
																			Average steps...
...before calling 112		3	1	3	4	2	4	3	2	2	3	3	3	3	4	3	5	4	4,0
...before calling managers		1	3	1	1	3	1	1	1	1	1	1	1	2	5	2	1	3	2,8

Table 27 provides an overview of warning chain and especially allows to states that a warning chain has a medium length of 5.4 steps with a standard deviation of 1.0. Moreover, in average, 4.0 warning steps – standard deviation of 1.0 – are required before emergency services were called whereas, there is only 2.8 steps – standard deviation of 1.2 – required to call managers. Therefore, managers are called right before emergency services and they usually call or make call 112.

To complete information of this table, 65% of companies have someone on-duty always present onsite and 71% of companies have a recall system alerting managers that an emergency occurs whatever the time of the day or their locations. Strangely these two parameters are not related to shift done in the companies: some, working day and night may have no recall system or on duty manager whereas day shift only companies may have one and vice-versa. Nevertheless, even if this table shows which steps are the most common, it does not represent how these steps followed each other's, which is, actually, the most important information in a chain. Then these data were proceeded into a graphic showing how information processes along the warning chain.

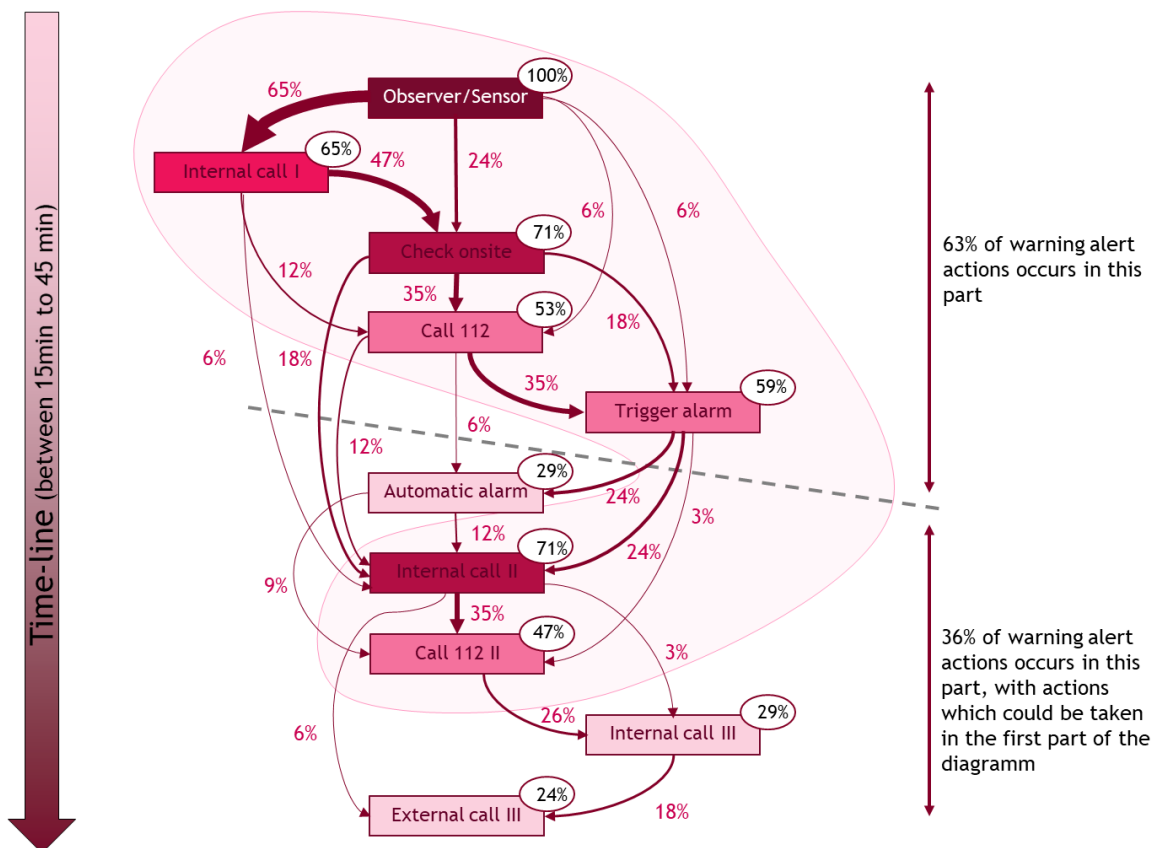


Figure 41: Warning chain process

This graphic must be read from the top to the bottom, following the time-line that may last from 15 to 45 minutes according to the situation. Arrows thickness is an anamorphosis representing the proportion of companies' warning chains following this path, it is completed by the adjacent corresponding value. Each rectangle represents a step, the darker it is, the more common it is amongst emergency plans and, similarly to arrows, this information is completed by the value at the right corner of each rectangular.

Counting all steps of the Figure 41 and reporting it in the Figure 41, it appears that most warning actions are done in the first part of the graphics, above the gray line, with an average of 3.4 steps (standard deviation of 1.0) for a warning chain medium length of 4.0. On the other hand, below the gray line, few actions are made with an average of 2.0 steps (standard deviation of 1.3) with a strong impact of the "Internal call II" that consist – for 65% of companies – in leaving the warning process to start the emergency process (with the following internal or external calls). Nevertheless, for 35% of companies this part of the diagram remains in warning chain and is followed by a call to emergency services. That means that, for about a half of companies, calling emergency services comes after several actions, communication and verifications while for another half, it is one of the first tasks. Usually, from what was observed during Expert'Crise project, the more a company takes time to alert emergency services, the less confident it is in its emergency planning and decisions operators can make so required from managers to check the situation themselves before calling for help to avoid false alarms. However, such mindset may make lose important times during a crisis situation and significantly impact how the situation can be managed in medium and long term.

6.3 Chapter 6 Resume

Designing a crisis or emergency exercise for Seveso companies required both to understand what they need and how they work under critical circumstances. A review of needs stated during Expert'Crise project was proceeded to raise the most common needs of Seveso companies. It appears that companies mainly required 21 pedagogical targets evenly distributed in 3 of the 5 pedagogical axes of Tena-Cholet repository that count 63 pedagogical targets. Moreover, it appears that the "Crisis Unit Management" axe is almost always use as a central topic of exercise while "Operational Response Management" and "Crisis Communication" axes provide secondary pedagogical targets according companies' requests. Therefore, exercises held during Expert'Crise project always deal with the same core topics, the same goals to fulfill, with minor deviations on secondary axes. As situation-tasks, constitutive elements of pedagogical scenario, depend on those targets, the structure of the scenario stays very similar from an exercise to another because the start point remains the same.

Even if companies' needs were the same, if the way they work during an emergency is too disparate, exercises would be very different. Yet, after analysis 17 emergency plans of Seveso companies, it comes that they are close on several points. Indeed, if they may be very divergent on the importance of the emergency system set up, with important differences in size of crisis team or intervention team, these systems are always built around

a core system composed of a team of several managers in a crisis room, supported by a small onsite team. Moreover, missions of these teams are more or less the same from a company to another even if bigger emergency system tends to deal with more missions than smaller ones. These missions essentially focus on assessing the situation and alerting all different stakeholders – managers, emergency services, corporate level and authorities – before welcoming emergency services and support them as well as the company can. Then, because alerting stakeholders is an important part of emergency planning, it seemed relevant to deeply study warning chain and it appears that, even considering individually this specific mission, there are important common points between plans. Nevertheless, two categories of companies appeared: those alerting emergency services soon and those that required several steps before alerting them. These two groups match with two kinds of approaches in companies depending on their readiness against crisis: most ready companies alert emergency services soon and possibly cancel the alert if it is not required whereas less prepared companies take time to check if it is not a hoax.

Therefore, Seveso companies' emergency system are similar in many points and this common structure is convenient and allows, when studying new emergency system, to easily build a mental picture of how it should be run based on an existing framework. Indeed, it matters to precise that, even if emergency systems are close they remain different and it is not possible to override the emergency planning review step without risking to miss critical differences. Similarly, even if needs are usually the same, it is not conceivable to override this step either. Nevertheless, common points between companies allows to go faster on these steps, and adapting the generic template to little deviation of particular plans. It may be relevant, once the emergency plan is reviewed, to reassess the needs of the company to ensure a good mutual understanding. Indeed, since the emergency system was analyzed, company needs are more understandable and pedagogical targets matching with them can be proposed with more adequacy.

Chapter 7 **Establishing Training Limits to Build a Consistent Diegesis**

Once the company's needs and its emergency system are well understood, the **third** step of the methodology, consisting in establishing borders of the sub-system tested during the exercise, may start. To properly draw the borders of the desired system, it matters to determine, based on previous reviews, how the global system will process during an emergency situation to isolate the sub-system then figure out how this last one will evolve during the simulation and how it will interact with the defined borders.

If this step requires to know how the emergency system of the company works, it does not heavily rely on stated needs and is mostly related to the audience involved, workers that should be trained. Depending on target audiences and how emergency system may be expected to work, a second category of audience is defined: the peripheral audience. Those persons are direct interlocutors of the target audience and play an important role in the concerned emergency sub-systems but they are not directly aimed by the training. Therefore, they must be implemented in one way or another – if possible – in the simulation and are a facilitation support that may play an input/output interface role.

Once borders of the simulation have been properly drawn, it matters to assess interactions that the target audience will have with the simulation's border and how or, in other words, what means will be used to interact with this interface. Peripheral audience is a first interface that can be used but other means must be identified such as phone, mail or sound devices. Especially, communication means that will be operated by facilitators to inject information in the sub-system must be clearly identified. Communication means and how they will be used in particular have a high importance for the exercise because it is through them that facilitators both build the diegesis – then it directly influences how immersive the simulation will be – and lead the exercise to its pedagogical goals. As said, the diegesis must be as realistic as possible to provide an adapted environment to train for emergency management. However, there are limits that cannot be overcome for material or organizational reasons, so diegesis must be designed according these restraints – possibly by “cheating” a little with staging “tricks” to hide some details – to conceive a relevant experience for trainees.

Moreover, because Expert'Crise trainings are LRP, diegesis is built through interactions, as in LARP. Then, it matters to anticipate and develop interactions to provide adapted information to trainees. Yet, information must be relevant, immersive and make sense in the context of the company. That is one of the reasons why peripheral audience is relevant. Indeed, these stakeholders are those providing information during an actual

emergency and they know the context of the company then deliver information in the most natural and accurate way. Then, using other means of communication than those stakeholders for an exercise could appear as weird or do not make any sense. On the other hand, indirect interlocutors such as medias, political stakeholders, administrative authorities and emergency services are also identified according to the company's needs and facilitators simulate them during the exercise according to the scenario developed.

Nevertheless, if Expert'Crise's members are used to simulate an accidental situation, peripheral audience are not. Therefore, they must be mentored by a facilitator telling them how to interact with the target audience to provide them the proper information but according to company's usual means – phone, walkie-talkie, WhatsApp group or other – and the wording they would use in a real situation. Similarly, the target audience must also be drilled to understand how interactions with the facilitators proceed. Indeed, even if interactions are supposed to be the more natural possible, it is required to explicit communication means used and how. In particular, a sheet with phone numbers and e-mail of external stakeholders simulated by facilitators is usually displayed in crisis room and in rooms where the target audience is expected to be and trainees must be informed about it to properly called facilitators instead of real stakeholders. Therefore, presentation and explanations related to this sheet as well as other immersive device and interfaces should be explained to trainees before the simulation or, if it is not possible, during the exercise by facilitators or observers despite the fact it reduces immersion.

7.1 Establishing Training Limits

Based on the needs of the company and how its emergency system is supposed to work, people that will be involved in the exercises may be selected. Two approaches are possible: either choose workers that should be trained during exercise or, on the other hand, choose functions that should be tested then called employees that must ensure these functions. Whatever the approach used, expected output is the people that must actively participate in the training. Different functions – then different categories of workers – may be tested during the same simulation with different kind of exercises adapted to their needs and interacting with each other. For instance, operational workers may train on a practice-based exercises while strategical team members train on a LRPG receiving inputs from the practice-based exercises. It matters to choose what category of exercise and how realistic they will have to be or, at least, have an idea of the different pool of trainees that will be separated before anticipating interactions between trainees because they are strongly related. Choice of adapted exercises for each audience relies on pedagogical and operational targets aimed as well as resources the company wants to involve in the exercise. Indeed, if the company only wants to mobilize the onsite chief of internal firemen besides the emergency management team, a practice-based exercise completing the LRPG on emergency management is not implementable and a tactical table-top appears to be more relevant. During the Expert'Crise project, LRPGs were always used for management teams whereas table top or drills/practice-based exercises were used for the operational level, depending on available workers and wills of the company. Specific interfaces were set up

according to the nature of such exercises and targets of the exercise and can be a reduced model simulating onsite operations, leaded interviews with intervention leader or sub-crisis unit managed by a facilitator. Such simulations aim to give to the target audiences the most immersive experience including correct information flows and realistic interactions with stakeholders. On the other hand, sometimes, the operational level was totally out of the exercise's scope, and their workers only belong to the "peripheral audience" as defined below. In that case, they were mentored by facilitators and inject inputs to the aimed sub-system – usually to crisis unit's members – both based on the scripted scenario and their expertise. Note that executives supporting the scriptwriting process cannot participate in the exercise or in a lesser extent than other workers. This step must take into account availability of each person, one's possible backup as well as one's place and function in the emergency system to set a date for the exercise. Indeed, as for every design process and project, it matters to schedule the exercise as soon as possible to properly organize the development of the exercise.

Once players of the serious game are clearly identified and how they will be distributed in the different kind of exercises has been decided, people, organizations, documentation and devices they may have to interact with must be identified as represented in Figure 42. Interactions between aimed functions must also be assessed, especially if they take place at different locations, as between onsite operations area and strategic management room which, moreover may train with different kind of exercises.

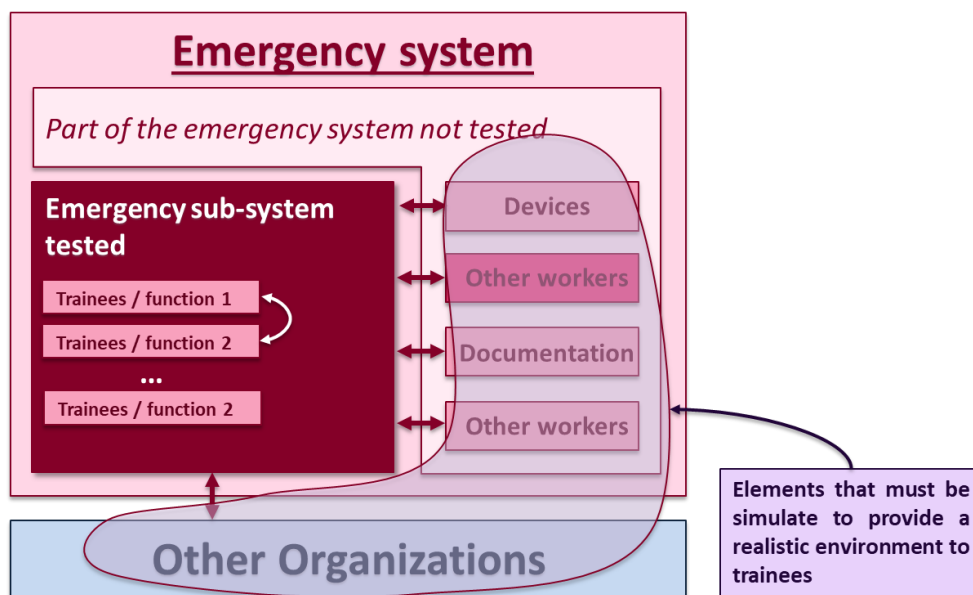


Figure 42: Target audience interaction first scoping

Therefore, all elements identified in Figure 42 must appear in a way or another in the exercise to propose a consistent environment and diegesis. Among these elements, workers who should interact with selected functions but do not belong to that target audience constitute a second category of audience, called here “peripheral audience”. This audience must – if possible and according company’s organization – participate in the exercises to interact, in the same way they would do during a real situation, with the target audience according facilitators directives. Then, they support facilitators by transmitting scripted elements to the target audience with the adapted wording and company’s references. Peripheral audience corresponds to the “low animation” levels in Fréalles’s description of facilitation of crisis exercise, with information inputs coming from lower hierarchal levels – compared to target audience – except it is supported by trainees and not by facilitators (Fréalles & Tena-Chollet, 2017). Nevertheless, because the training does not focus on them, it is not necessary to provide them a realistic and consistent environment then they play a blended role between facilitators and trainees. Indeed, these workers still learn something about crisis and emergency management even if they are less active than the target audience. Therefore, it matters to identify relevant workers who could play a role during the exercises and check if they are available at this moment. Note they may have little interactions to do, peripheral audience members may be mobilized for only a part of the exercises and they may go back to their usual activities after having held their emergency role. If possible, it is preferable that peripheral audience were mentored by a facilitator when performing their dedicated actions. Nevertheless, even if peripheral audience members may have little to do, letting time for facilitators to manage several of them at the same time, in some case it is not possible to all mentor them. In that case, peripheral members must be clearly drilled with adapted documentation to make them sending the correct information without giving too much detail, at the right timing and according the proper modalities – proactively, passively, and so on – as defined in the script.

On the other hand, communication means, documentation and other devices must be taken into account to identify channels that may be used to send or receive information from trainees. Some devices – such as industrial control panel or sensor alarms – cannot be modified for an exercise then staging “trick” must be implemented to simulate that those interfaces provide the adapted information, consistent with the diegesis. Moreover, other interface must also be considerate such as windows or the distance from the operating site allowing trainees to move near the accident or letting trainees heard what happen. Similarly, “tricks” may be required to be implemented to enhance realism of the exercise. Those “tricks” are detailed in the following paragraph.

Once those first borders of the simulation established inclining audiences, their dedicated exercises and interaction they could have, locations where they are supposed to be or where they could go must be assessed. In Seveso companies, the crisis room, the disaster area, the guard post and control room(s) are usually the main relevant areas for exercises. Nevertheless, according to the activities of the company and its wishes, areas may be added or removed. In the usual case of an emergency or crisis management exercise without any operational test, the global setting can be represented as in Figure 43. In this figure, peripheral audience, normally located in different places may be grouped in only

one room and managed by a facilitator who control all internal communications – the big red arrow – that would occur in real situation following the blue arrows between the different centers of emergency management. Other facilitator(s) simulating external organization and their communication – the gray arrows – allow to fully isolate the target audience in a controlled scenario as described in Chapter 5. On the other hand, in an exercise involving different pools of trainee located at different places and, possibly, working with different kind of exercises, facilitators do not control communication between those different pools of trainees, represented in Figure 44 with a blue double-side arrow. Therefore, this setting is closer to a self-powered scenario even if, *in fine*, inputs are controlled by facilitators through peripheral audience or other interface and gather outputs directed to external organizations through communication devices (but not internal outputs that can aimed another group of the target audience in another room).

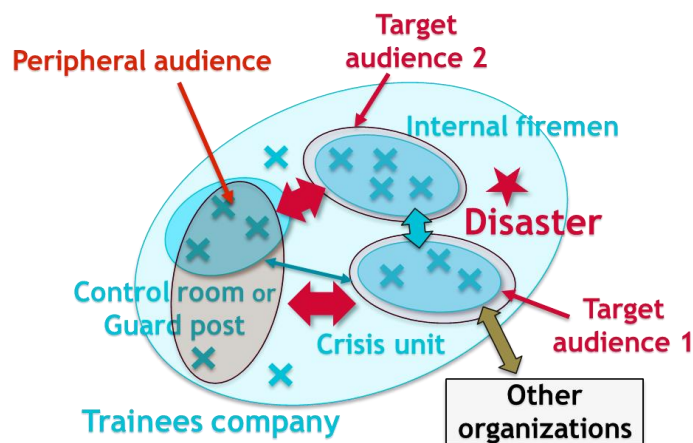


Figure 44: Audiences, locations and communication in an exercise involving both strategic and operative level

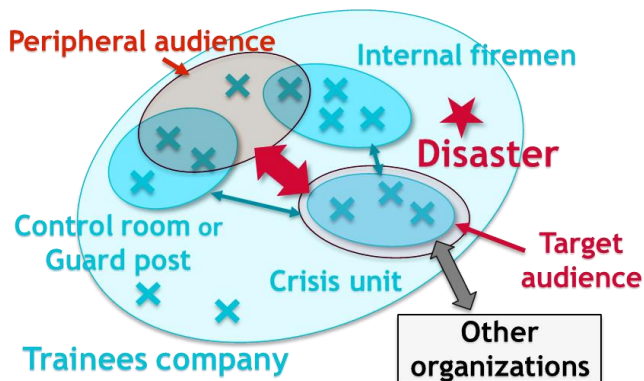


Figure 43: Audiences, locations and communication in a crisis management only exercise

These figures must be related to material arrangements used during Expert'Crise project and represented in Chapter 2 (see Figure 16). These explanations generalize what was implemented during the project and raise concepts that may be implemented in various exercise settings.

Based on these considerations, a map of the situation in the company may be drawn, describing useful areas for the exercise, areas where movements and actions are expected, empty area that can be used for the facilitation room and areas where business can continue as usual during the exercise. This map allows to picture trainees, as well as facilitators, global distribution in the plant and their possible movements during the exercise. Figure 45 represents such map for a theoretical example and shows the transcription from a real situation to the exercise situation, according exercise based on a controlled or self-powered scenario.

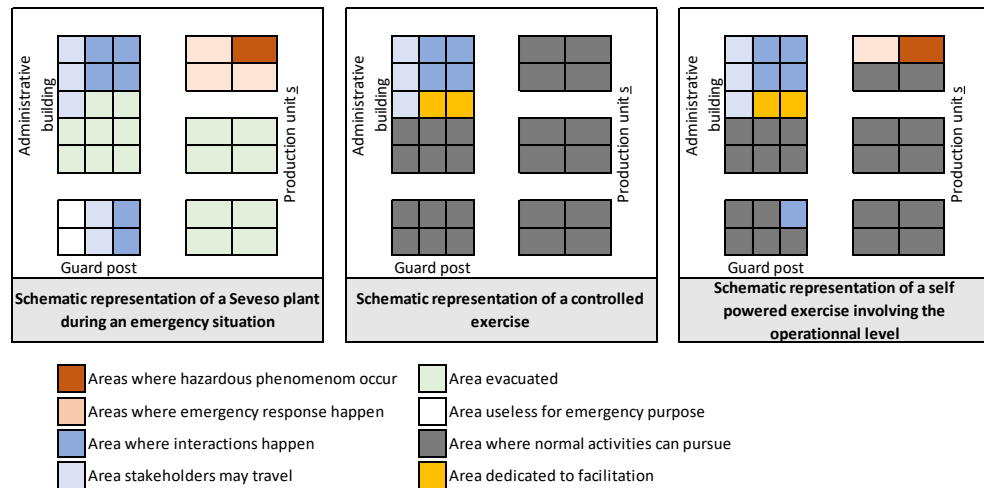


Figure 45: Representation of area used for an emergency or crisis exercise setting according to the nature of exercise

The last border that should be defined, is the duration of the exercise. This limits strongly depends on the needs of the company and an exercise may last from less than one hour if the company only wants to test its warning chain to several hours if several functions must be tested, with emergency action onsite. In Expert'Crise project, the longest exercise last 4 hours and the shorter 45 minutes with an average of 2 hours. Indeed, longer exercises are possible to organize but require heavier logistic and resources (material and human) the project had not.

Once all boundaries of the exercises are clearly defined and interfaces identified, it matters to deal with information that will be transmitted through these interfaces and means available to build a realistic enough environment that must be credible during the exercise. In other words, how a diegesis can be built to match requirements of the simulations.

7.2 Building the diegesis through trainees expected interactions

Establishing trainings limits is an important task, mostly because it allows to draw a line between what belong to the exercises and what do not. Moreover, it sets a framework that can support the scenario and help to script it. Nevertheless, this support is not the only thing required to stage the scenario. Indeed, it only deals with logistical topic – who, where, with what devices and so on – and not with how trainees will experience the training, representation they will proceed and, in fine, how realistic they will feel the simulation. These questions related to the diegesis of the exercise and partly rely on the previously defined framework. However, it matters to define means that can be used to build a proper diegesis.

First of all, as briefly introduced in the last paragraph, all trainees do not require the same degree of immersion, especially peripheral audience. Therefore, according group of trainees and their pedagogical target, an assessment of how much realist exercise be is done. The more targeted an audience is – meaning the exercise mainly focus on these workers – the more realistic the exercise must be. Other trainees will experience the simulation with a lesser degree of immersion, mainly because available human and material resources are always limited and it is not possible to provide a fully realistic environment to every participant, even in a full-size simulation which is the closest to a real situation. In Expert'Crise trainings, because the target audience was mainly the management board in charge of dealing with strategic crisis management, exercises were designed to provide the most realistic and immersive environment for these trainees whereas others trainees – internal firemen or guard for instance – had less immersive environment.

Based on degree of immersion required for each category of trainees, the adapted facilitation mode may be defined. Two kinds of facilitations are distinguished here: **direct** and **indirect** facilitation. **Direct facilitation** consists in directly tell to trainees what happened standing near them, describing the virtual situation in the real environment and asking what they want to do. This interaction is non-diegetic as seen in 5.3.1, facilitators do not belong in the diegesis and information they give relates to elements in a heterogeneous state, and especially macro and meso interaction, for instance a building on fire spreading in the diegesis. Trainees are themselves in a heterogeneous state and not only because of possible philosophical interactions but because the facilitators ask them what they want to do and precise if they can do it or not, according boundaries of the simulation, so they are limited in their practical interactions and cannot act like in real situation. Then, this kind of facilitation is not very immersive as facilitators are always present during the exercise as an interface between the diegesis and the real environment. Therefore, it is only adapted for peripheral audience, letting a little more freedom to trainees that a full-scripted guideline but it may also be adapted for tactical table-top or run-through exercise with onsite operation chief in the situation where no emergency response test is required by the company. However, such facilitation corresponds to the classical approach in paper and live-action role playing games with a referee ensuring the diegesis remains consistent. **Indirect facilitation**, on the other hand, consists in sending information to trainees through

communication means or immersive interface in a fully diegetic way. It means that facilitators simulate other stakeholders and interact with trainees playing the role of these stakeholders. Such facilitation mode corresponds to “high animation” in Fréalles’ description of crisis exercise facilitation (Fréalles & Tena-Chollet, 2017). Moreover, macro and meso interaction are described to trainees not with a non-diegetic interaction as in direct facilitation but with a practical interaction through peripheral audience or through feedback from a facilitator calling or sending e-mail and playing the role of a stakeholder. However, as the number of facilitators is limited, they usually have to play several roles which may reduce realism as the same voice response to several calls to different stakeholders. In this mode of facilitation, non-diegetic interactions are avoided and environment proposed is designed to be the more immersive and realistic possible. Nevertheless, with such facilitation, scripter must consider every possible interaction – especially with internal documents – to keep all the simulation consistent. Indeed, it matters that, during the simulation, trainees could use every possible document or devices without wondering if it belongs to the diegesis or not.

For instance, while using an emergency sheet explaining what they have to do, trainees should not wonder if phone numbers to call are real or simulated and if they really have to call these numbers. Then, this document must have been either modified – possibly with visible modifications to ensure trainees it belongs to the diegesis – or must not be available at all. Moreover, trainees must be informed of the limits of the exercises to be sure they do not go beyond them. Preparatory meeting, before the exercise, is described in the last paragraph of this chapter. Indirect facilitation – allowing a better immersion – was led during Expert’Crise project according to the framework described in Figure 46.

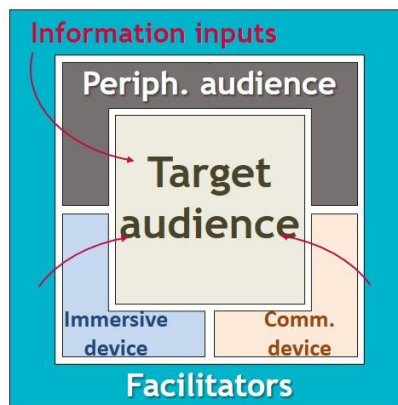


Figure 46: Audience, simulation device and information flow

In this framework – representing a controlled scenario even if a self-powered scenario would work the same way but with several target audiences in the gray square – all information inputs, as well as output not represented here, are kept under the control of facilitators who use peripheral audience, immersive a communication device to manage exercises without directly interacting with trainees in a diegetic way.

Then, based on this framework, the diegesis can be built. It means that the virtual world where the accident occurs can be developed, overprinted on reality and transmitted to trainees through the previously described system. Usually, during the Expert'Crise project, accidental situation was first described by a facilitator either to a part of the target audience involved in a table-top, a run-through or a practice-based exercise and named "mentored target audience", or to a member of the peripheral audience. Then the facilitator ensured the warning chain was correctly triggered, especially if the trainee that receive the accidental description belonged to the peripheral audience and was not a focal point of the exercise. Then, once the target audience properly mobilized, if first inputs were given to an operational target audience, feedbacking generated itself from the progress of emergency responses and little new description from the facilitator. On the other hand, new inputs were given to the peripheral audience and feedbacks was pushed by the facilitator to have the right timing and the correct level of details. If someone from the target audience who not directly facing the situation want to come in front of the situation – as in reality, even if it is not the more relevant action to do – two options are possible: on one hand, this trainee may come onsite under a direct facilitation or, on the other hand, facilitation – through the target audience – may argue it is not relevant to come or that may be dangerous without the proper equipment. Globally, trainees from the target audience that should stay fully in the diegesis may require to leave the diegesis for a reason or another and be in direct contact with the facilitation without any trouble if it is clear for them that they change of facilitation mode and partly leave the diegesis. Nevertheless, it may be difficult to make industrial worker believe in a fictitious situation and repeatedly coming then leaving the diegesis may compromise their immersion.

Enhancing trainees's immersion, besides using usual company devices, communication way and interaction, also involves some staging trick. On this subject, an analogy can be made with theatrical scenography. Indeed, it consists in building a scenery where trainees will evolve as actors and, the same way scenography use cardboard environment to improve immersion, it may be relevant to use tricks such as smoke-producing devices, alert horn or other sound and light device to simulate events and strengthen realistic feeling of trainees who are actors but also spectators of the simulation. During Expert'Crise project, the most used devices were mobile Bluetooth speakers simulating surrounding events such as explosion or firemen truck horn. However, other devices were also used such as smoke-producing sticks simulating leakages or a tablet simulating the control panel of an installation with a live reactivity to emergency response action done by emergency teams. For this last example, development of such tool required time as well as resources, especially control panel print-screen, and is not reusable from an exercise to another so this experiment was only conducted once and was welcomed by trainees that could interact with the surroundings in a realistic way despite the presence of a facilitator managing the use of the tool. Besides, documentation modifications as described above were also used with, for instance, for an exercise, fake truck deliver simulated including all files related to the content of the truck or the identity of the driver. Nevertheless, those tricks do not require to be fully realistic with a homogenous diegesis and can only be representative or symbolic with a heterogeneous diegesis, the same way an accessory – such a hat or glasses – is enough

to understand a same actor plays different characters. On the other hand, despite all immersive devices used during Expert'Crise project, it appeared that some senses are too difficult to simulate. If auditive and some visual inputs are relatively easy to implement in exercises, smell and haptic perception cannot be stimulated during an exercise. Yet those senses may be very useful on a chemical plant during an emergency as those sense allows to perceive hazard in these situations. Indeed, and although it is not recommended, several substances are odorous and their smell may indicate a leak. Similarly, in case of fire, the thermal perception is a clear information of where it is safe to stand and it is difficult to transmit orally such information.

Nevertheless, even with immersive devices or explanations, trainees may have difficulties to figure the situation. This difficulty may be explained by the perception workers may have of such trainings. Indeed, they may be reluctant to “suspend their disbelief” and immerse themselves in the diegesis because exercise may be perceived as a disguised test requiring to be in complete control or, on the other hand, as one more safety exercise which is not really important. Such perception strongly depends on the safety culture of the company and its background in regard to emergency exercises. Moreover, trainees may considerate – as said in Chapter 3 – facilitators are not legitimate and what is described is not possible. This mistrust, strengthen by a global incredulity for the possibility of a severe emergency or a crisis, lead trainees to not believe in the scenario proposed by facilitators. Nevertheless, with some exceptions, even without a proper immersion, trainings go well but are less efficient on several topics, detailed above.

7.3 Anticipate interactions

As written in the previous paragraph, diegesis is built through interactions between trainees and facilitators. Therefore, it matters to forecast these possible interactions to avoid trainees run off the diegesis by asking questions with unprepared responses, requesting resources that should be available but are not in the diegesis or by doing unplanned actions with unpredicted consequences. However, anticipating all possible actions of a group of people is almost impossible, especially between each member of this group. Therefore, only interactions that get in contact with elements of the surrounding or the world of the diegesis and which are in a heterogeneous state are discussed. In other words, all interactions involving an action from facilitators must be planned to ensure that during the exercise each interaction had been enough prepared.

Anticipating such actions rely on emergency planning as well as on meetings with executives and technicians that must have described expected reactions of each stakeholder and systems. Nevertheless, it matters to assume that those systems could not work, or not work properly to assess other possible reactions and, possibly, in the next steps of the method, implement ways to correct non-action with support and reminder stimulus. Hopefully, interactions with the diegesis remains more or less the same from an exercise to another: the same stakeholders are involved, the same questions are asked and the same responses are provided.

Stakeholders usually involved are:

- **Emergency services**, note that some companies have a direct phone number of the local firemen or police station and may call them directly but it is not the normal procedure for emergency call
 - 112 call centers
 - Local firehouse direct phone number
 - Local policemen direct phone number
 - Civil Protection, that should not be mobilized by industrial companies but by firemen or local politic officials.
 - Hospital, poison control center, burn center and other specialized health center
- **Authorities' center and officials**
 - **Federal crisis center:** *Centre Gouvernemental de Coordination et de Crise* (CGCCR)
 - **Federal Occupational health agency:** *Direction générale Contrôle du bien-être au travail* (CBE) and *Direction de Contrôles des Risques Chimiques* (DCRC)
 - **Regional environment agency:** *SOS Pollution, Cellule Risques Accidents Majeurs* (RAM), *Direction de Police et de Contrôle* (DPC/DPE)
 - Local administration services and politic official
 - Provincial administration services and politic official
- Neighboring companies
- Press and media
- Corporate level
- Critical infrastructure (electricity, gas...) and other support companies (insurance companies) or organization (Nuclear or biological control)

Those stakeholders represent a large part of external contacts a company may have during an emergency situation. Their phone number, mail and/or other means of contacting them are gathered on a sheet displayed where trainees are expected to be as mentioned in the previous paragraph. An example of such sheet is replicated below in Table 28. These phone numbers are meant to connect trainees with facilitators playing the role of the stakeholders.

Table 28: Contacts sheet provided to trainees

Calls to external organizations are simulated. Following list indicates phone number and mail you may require during the exercise.			
	Simulated stakeholders	Phone numbers	Fax / E-Mail
Emergency services	112 call centers	Phone number example #1	Example.mail@example.com
	Local firehouse direct phone number	Phone number example #2	
	Civil Protection		
	Local policemen direct phone number		
	Hospital, poison control center, burn center and other specialized health center		
Authorities center and official	Federal crisis center: <i>Centre Gouvernemental de Coordination et de Crise</i>	Phone number example #3	
	Federal Occupational health agency: <i>Direction générale Contrôle du bien-être au travail and Direction de Contrôles des Risques Chimiques</i>		
	Regional environment agency: <i>SOS Pollution, Cellule Risques Accidents Majeurs and/or Direction de Police et de Contrôle</i>		
	Local administration services and politic official	Phone number example #4	
	Provincial administration services and politic official		
	Neighboring companies	Phone number example #5	
	Press and media		
	Corporate level		
	Critical infrastructure (electricity, gas...) and other support companies (insurance companies) or organization (Nuclear or biological control)		
	Others		
<p><u>When calling, please mention the name of the organization you wish contact.</u></p> <p>If you want to call an organization that does not appeared in the previous, call the phone number related to the « Other » line.</p> <p>For sending an e-mail, mention the name of the organization you want to reach in object.</p>			

Nevertheless, there is always a possibility that a stakeholder needed during an emergency situation by the trainees' company does not appear in the provided sheet. Then, to let trainees the ability to contact everyone that could be useful in such situation, an additional contact line is added to the sheet under the "Other" name. The main problem related to such line is that trainees may request a stakeholder that is not anticipated in the scenario and facilitators answering this phone call (or e-mail or other) must be both reactive and comfortable with improvisation. Moreover, every modification of the diegesis must be transmitted to all other facilitators to keep the exercise consistent.

Such staging trick, because it is heterodiegetic, is not very natural and trainees may forget it and have doubt about what is simulated and what is not. Therefore, as said, a briefing of how the simulation proceed and how trainees can interact with the simulation must be done. This meeting with trainees does not require to be long and thirty minutes may be enough. Its content must focus on the nature of the exercise, insisting on the fact that

some actions are really done while others are not and precisising which ones are really done. Therefore, limits both functional, geographical and in realism must be stated to avoid trainees run out of the simulation or expect something that is not planned. Then the briefing must precise audiences involved and how much they are, especially if they belong to the peripheral audience. Moreover, for this last audience, explanation on how the mentoring with the facilitators will proceed must be given to clarify the degree of freedom each trainee will have. In the end, interactions and interfaces must be described, especially the difference between direct and indirect facilitation as defined in the previous paragraph, and the different stakeholders related to each kind of interaction: direct facilitation for peripheral audience and operational members of the target audience, or indirect interaction for the crisis management target audience supported by the contact sheet as described before. Presence of observer with trainees must also be stated to warn trainees of other persons in crisis room.

On the other hand, direct interaction both between facilitators and peripheral audience, between peripheral audience and target audience and between members of the target audience and the external organization must be assessed. Globally, facilitators describe the diegesis to the peripheral audience or to the mentored target audience and ask them how they react in that last case. Because such interactions are mainly operational, they are descriptive, relating to the nature of the event and to the emergency planning system that must cover all actions someone can do: movement, action or communication to do (alarm trigger, safing, first emergency response, call to make...) and so on. More precisely, facilitators may describe the physical situation – fire, odor, smoke – to a witness and then to internal firemen, they may depict the control panel and the state of the unit's alarms to control room operators or they may indicate to a guard at the entrance of the site if journalist or officials are here and what they ask. Interactions between the peripheral audience – or the mentored target audience – and the target audience, usually occurring in the crisis room in Expert'Crise trainings, consist in one hand to transmit information received from facilitators to executives so they can make informed decisions and, on the other hand, received instructions as well as technical information from these executives. Executives may also ask operatives to come to the crisis room for a face to face interaction. Such interactions are possible but the peripheral audience has to come back with the facilitator after some time to have new information to transmit. The target audience may also interact with different external stakeholders that have different needs, authority and towards whom the company does not have the same requirements and duties. Those stakeholders may be categorized into 7 groups: (1) emergency services, (2) administrative authorities, (3) political authorities, (4) press and other medias, (5) corporate level of the involved company, (6) support companies that may help the impact organization to deal with the emergency and (7) surrounding asset such as neighboring companies. Transparency in communication to these different stakeholders may significantly vary and be the more complete, clear and fresh possible when destined to the corporate level and emergency services while information may be partial, blurred – sometimes with a part of doublespeak even if lied are mostly avoided – and not refreshed often when destined to medias or political authorities. Interactions between target audience members must be estimated to

anticipate all possible requests they may formulate both to the operational level and to external stakeholders but it is not necessary to state their frequencies or intensity, only topics they may be raised is enough. Note that these topics will be conditioned by inputs designed in the following of the methodology then it may be relevant to reassess interactions after that.

Assessing possible interactions between audiences and facilitators also allows to size the number of facilitators and observers as well as caption and immersive devices needed for the exercise. In the best situation, peripheral members are mentored by one or several facilitators according they are in the same room or in different areas and, on the other hand, each external stakeholders' group – usually related to one single phone number – must be managed by one facilitator. Similarly, the global management of the exercise may be supported by a facilitator. Expert'Crise trainings usually work with two to six facilitators and two to a dozen of observers but this number was more often availability driven than pedagogically driven. Therefore, different roles had to be managed by the same persons. Especially, several external stakeholders were simulated by the same persons depending on if they have a lot of action to do or not. The same way, simulation mastering was done besides peripheral audience facilitation. Nevertheless, even if lack of facilitators appeared some time with exhausting exercises, simulations usually run correctly being understaffed.

Therefore, once interfaces between trainees, the environment and facilitators are defined, context and players are set and the LRP is operable. A first exercise draft describing this framework as well as pedagogical target aimed can be submitted to the company for approval, and the scripting process initiated.

7.4 Chapter 7 Resume

Designing a crisis or emergency exercise requires to set a solid framework, considering material requirement and availability, within script can be written. Therefore, this chapter aimed to describe how to build such framework based on needs and wished of the trainees' company, what means can be used to set up a diegesis and how to anticipate interactions between the surrounding and trainees to evaluate diegetic and non-diegetic responses that must be brought to trainees to make those interactions work the more realistically possible.

Establishing the framework of exercises starts with the definition of people involved in the simulation and with the identification of what they are in contact with during an emergency situation. Therefore, technological interfaces as well as human and sensitive interfaces must be assessed. These interfaces allow to identify a second group of trainees, not directly aimed by the training but although needed in such exercises: the peripheral audience. This audience is in direct contact with the target audience and may be helpful for exercise management by playing an interface role between facilitators and the target audience, completing inputs facilitators want to inject in the diegesis with context information they master because they work in. However, these workers cannot constitute the only interface with the target audience and other means must be identified. Besides direct interaction with facilitation, both immersive and communication equipment may be

implemented in exercises. Nevertheless, those devices may only stimulate some sense and haptic feel or smell input can hardly be used in such simulation.

Target and peripheral audience do not have the same interactions with facilitation because they do not require the same level of immersion. Therefore, two facilitation approaches are distinguished: the direct facilitation – face to face interaction between trainees and facilitators – and indirect facilitation using interfaces to transmit information to trainees in a diegetic way and avoiding interaction between facilitators as facilitators – i.e. who do not play a role in the diegesis – and trainees. Direct and indirect facilitation inputs must be anticipated in the design of the exercise. Then all potential interactions must be forecast as exhaustively as possible. Yet, interactions stay approximately the same from an exercise to another. Indeed, the same questions are raised and similar responses may be given both from operational level related to questions about the nature of the accident, hazards, emergency response to implement, its progress or evolution of the situation and from upper hierarchical level related to questions about communication to medias and politics, nature and severity of the situation or information to be transmitted to surrounding inhabitants and possibly their evacuation. Moreover, specific questions may be raised because of scripted inputs sent in the diegesis by facilitators then are controlled by them even if those problems still need to be anticipated. Therefore, both these usual questions and those directly related to the script may be easily anticipated. Nevertheless, as it is not possible to fully anticipate all reaction from trainees, some open doors must be proposed to let trainees be innovative even if it requires, from facilitators, reactivity and improvisation skills.

Besides designing the framework and anticipating connection and interaction between trainees, such work allows to allocate the correct number of facilitators, observers and immersive and capture devices for the exercise. Once all resources required, input and output interface and audiences are identified, scriptwriting may finally start.

Chapter 8 **The Scenario: Designing an Interactive Story to Achieve Pedagogical Target through situation-tasks**

Once the framework is defined, the scenario can be developed, it is the **fourth** step. A scenario explains the diegesis of the exercise while developing the sequence of inputs to the target audience, and should lead this last one to pedagogical targets (Limousin, Chapurlat, Tixier, & Sauvagnargues, 2016). A scenario is a succession of inputs, as lines of text in a theatre or movie script, but it also states possible reactions. Therefore, a crisis or emergency exercise scenario is closer to an RPG scenario than to a movie scenario and is built around several steps – character to meet, places to visit or action to do – that structure the story and should be reached but without drawing the path between these steps and letting trainees the freedom to take shortcuts (or longcuts). A scenario has no need to be too developed to be efficient. Indeed, the more details it has, the more rigid it is, and the less freedom trainees will have. Yet, freedom is required to let trainee experiment and properly learn in a (socio)-constructivism approach. Based on pedagogical targets expressed by the company, knowledge and competences are selected from repository presented in Chapter 3 then generic situations staging competences are considered. The relevance and the ease to stage each situation are evaluated in order to choose the more adapted situations for the exercise. This first association between knowledge and situation are called proto- “situation-task”. A situation-task is the central part of these exercises and aims to “force” trainees to do an action (the task) under special circumstances (the situation) through serious game interface and using its specific gameplay. The task is a mean to involve trainees in a reasoning process harnessing knowledge targeted (Pastré, Mayen, & Vergnaud, 2006). Once all knowledge, skills, and competences that will be aimed by the exercise are identified, they are grouped into pedagogic bloc associated with a generic situation, eventually including first information input ideas, directly related to the background of the company.

These pedagogical blocs are structuring elements that base the scriptwriting. After defining them, it requires to choose the accidental sequence before writing the global script of the exercise. It may appear that choosing the accidental sequence only at this step is a bit late and that such choice should be one of the first ones. Nevertheless, postponing this choice late in the design process aim to focus, during first steps, on pedagogical purpose of exercise and its feasibility. Then, the scenario must serve pedagogical goals, and exercise must not be accident-driven. Moreover, trainees’ company representatives may have a good idea of what accident they want to simulate and may push exercise design in this direction.

Therefore, scriptwriter must stay focus on pedagogy, needs statement and what must be tested while suspending accidental choice for later in the process.

Once all elements structuring the script are defined, it “only” needs to estimate the timing of each situation, each pedagogical block, scripted in a 15-minutes meshing. This meshing is refined into a second step in a 5 minutes meshing until every line requiring an input or an action from facilitators are defined and find a place in the scenario. In the end, facilitators sheets are extracted from this global script to provided them an adapted support for facilitation. Such sheets constitute one of the most important scenario documents and must be developed with as much caution and care as maps, papers and digital file required for inputs. Once all these are documents designed – and proper briefings given – the exercise can be done.

8.1 The situation-task: hinge of simulation

At the center of scriptwriting process, situation-tasks are remnant elements of the EBAT even if they are a bit different from “events” of this approach, being more focus on several punctual inputs leading trainees to proceed specific actions than on a global situation that lead them to do these actions. Developed by Tena Cholet and introduce in Chapter 4 such pieces of script are the hinge of the scenario that articulate around them. They are main pedagogical elements that drive trainees to competences that should be learned.

Yet, “situation-tasks” are difficult to design as they require to connect competences with actions that involve them. More precisely, it consists in identifying actions that call a cognitive process that involved itself competencies aimed by the trainings. Yet, such relations are neither surjective nor injective – a situation may relate to several tasks and vice-versa – then it may be hard to identify the wanted relations between adapted competencies and action couples. Therefore, before designing precise situation-tasks, generic situations matching with usual steps of emergency management – such as warning chain, recon of the disaster, welcoming firemen and so on – are defined. Then, all competences they could involve are identified and those belonging to the scope of the training are gathered. This first connection between generic situations and packs of competences is called a proto-“situation-task” that still required to be refined to properly identified tasks and situations. From these proto-situation-task, more precise actions involving aimed competencies are isolated – for instance, providing an information to someone or make a decision – then the context leading to these actions is identified and inputs building the context are noted. Inputs leading trainees to proceed the wanted action are called incentives and aimed to push trainees to do the action. On the other hand, actions from the proto-situations-tasks which are not wanted for the exercises because they are irrelevant considering pedagogical targets must be associated with support inputs as defined by Limousin and introduced in Chapter 4. Then, trainees may focus their cognitive resources on wanted actions to do then on competencies aimed to be developed. Therefore, there are several elements that related to each other in this process and represented in Figure 47: competence aimed, cognitive process, actions or tasks to do, output of this action and incentives calling for them. This complete chain occurs in a context where situation-task

are staged and which are defined with the proto-situation-task according to the position of this pedagogical bloc in the script.

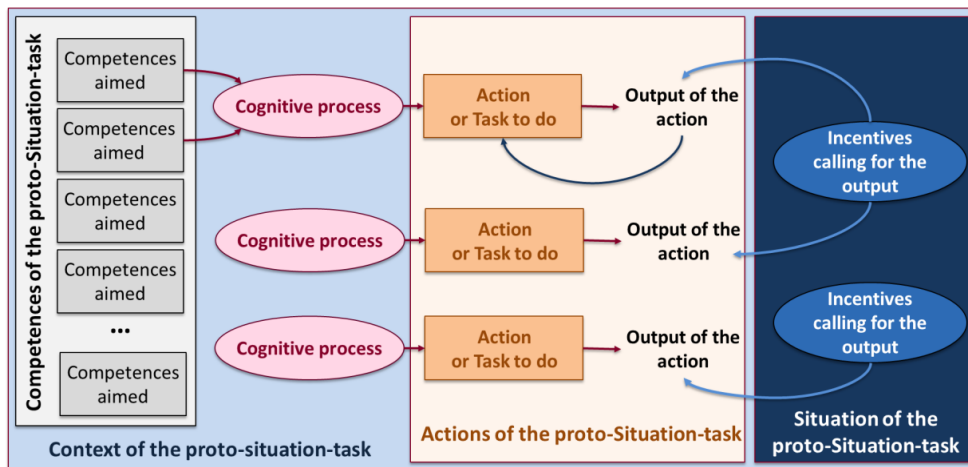


Figure 47 : Situation-task chain, Proto-situation task and context

It matters first to identify competence or competencies aimed, as several competencies may be involved in a situation-task. Then scriptwriter must identify a task, an action and/or cognitive process that could involve such competence. It may be searching for a solution, making a decision, communicating and transmitting information from a stakeholder to another, manage a situation or a group of people and so on. There is actually no comprehensive list of all actions that may be done during an emergency that involved dedicated crisis and emergency competences and it would be inefficient to develop such list as all these actions are not relevant for the pedagogical design process. Nevertheless, Lapierre repository, linking competences with specific tasks that involving them, may be used (Lapierre, 2016) even if it is not extensive and if other actions matching with competences may be found.

However, this repository only states tasks and does not precise the context where the task should occur. Then a repository based on Lapierre's one was developed relating competences, actions and situations staging them and which can be directly implemented in the script. Because crisis and emergency expert profiles are not common in companies which participated in Expert'Crise project set exercises, tasks that exclusively relate to such profiles were put asides to focus on the most common tasks. The main difficulty to conceive such repository consist in choosing the more adapted accuracy in describing staging situation. Indeed, it is useless to describe a specific situation that is only fitting for a specific exercise or task while a more generic description may cover much more tasks and more pedagogical target. On the other hand, too generic situations do not constitute a help for scriptwriter who cannot relate such description to an actual situation that may occur during one's exercise. That is the reason why warning chain, recon of the disaster or welcoming firemen was not selected, they are both not specific enough and too generic: the situation "warning chain" do not state the nature of the information received and only refers to the

beginning of the exercises. Moreover, the same way it would be inefficient to develop a comprehensive list of all actions that may be done during a crisis exercise, it is useless – and probably impossible – to define all situations that may be scripted in them. Therefore, considering that and based on Tena-Cholet repository then on Lapierre one's, a list of situations that may be scripted in crisis exercises has been developed. This list of 34 situations is not exhaustive but was tested in exercises' design process as constitutive script elements and each situation is related to Lapierre pedagogical targets in a table shown in the Annex 5. The list – present in Table 29 – is divided into three columns, the first one with only numbered situations, the second one states stakeholders involved and the last one is the description of the situation, usually what the involved stakeholder does. Note that some situations do not involve stakeholders and may only be inputs coming from the surrounding or direct interactions with facilitators. In that case the two last columns are merged. Involved stakeholders may be: Authorities including public and administrative authorities but also the corporate level of the company, Medias including social medias, Emergency services with sometimes the precise service involved, Insurance company, Internal firemen, technicians and/or operators, Non-Governmental Organization, Experts, Neighbors with in some case the type of neighbors involved and a uncategorized class named "Others".

Table 29: Scriptable situations for pedagogical purpose in crisis exercises in industries

N°	Stakeholders involved	Description of the situation
1	Authorities/ Media/ Emergency services/ Neighbors/ Others	Request information on the situation (the accidental sequence, consequences, evolutions...) and/or about actions taken by crisis unit
2	Emergency services/ Internal firemen or operators/ Experts/ Neighbors (industries and inhabitants)	Provide information on the situation but according to different point of view depending on the source or the recipient of the message and possibly being inconsistent ones with others.
3	Emergency services (firemen)/ Internal firemen or operators	Provide information on the present situation onsite
4	Authorities/ Emergency services (firemen)/ internal firemen/ Neighbors	Provide information and/or question the crisis unit about the situation on topic such as involved hazards, their position, or the odds of such event
5	Authorities/ Medias/ Internal firemen	Question the crisis unit about regulations, legal and juridical aspect of crisis management and crisis group's competencies on such topic and/or propose a support.
6	Auditive or visual inputs injected in a diegetic way by the facilitation and reflecting an evolution of the situation such as explosion, a warning signal...	
7	Authorities/ Medias /Emergency services/ Internal firemen	Question the crisis unit about its emergency planning, ask for precisions on some points, and possibly request it
8	Call/ Face to face interaction/ Auditive or visual inputs: Evolution of the situation with or without following characterization: fast, complex, with numerous inputs, worsening or improving the situation	
9	Authorities/ Emergency services/ Internal firemen or operator/ Other	Provide information and/or question the crisis unit about issues possibly impacted or threatened by the situation, their position and how to protect them
10	Authorities/ Internal firemen, technicians or operator	Propose, suggest or provide support or help either for operational task or on communication problems
11	(Public) authorities/ Media/ Emergency services/ NGO/ Expert/Neighbor	Input, call, mail or face to face integration that challenge or contradict information provided by the company or its representation of the situation.
12	Authorities/ Internal firemen or operators	Request decision-making /taking or a support (either fast or not)
13	Authorities/Medias	Call, mail or face to face interactions requesting information, press statement or a contact point/person
14	(Public) authorities/ Internal firemen /Neighbors (industries and inhabitants)	Variation in the workload – increase or decrease – for all the crisis unit or for some sub-cells. Tasks related to this workload may belong to another specialty that the sub-cell one's, or not being adapted
15	(Public) authorities/ Internal firemen /Neighbors (industries and inhabitants)	Question the crisis unit about actions they can do in order to, for instance, protect material and/or human issues
16	Authorities/ Media/ Emergency services/ Insurance/ Internal firemen or operators	Call or other inputs referring to a specific piece of information either previously stated by the crisis or discuss with a team member. This information may relate to the crisis, its management or its chronology, and possibly based on the monitoring system of the crisis unit.
17	Technical or communication problems for the crisis unit, sub-cells or simulated stakeholders (onsite operators for instance that cannot provide feedback anymore)	
18	Authorities/ Hospital/ Emergency services/ Other:	Inputs – such as auditive or visual inputs as explosion sound or ambulance horn sound/light – related to casualties either wounded or dead, and possibly asking or providing information on this topic.
19	Inputs or situation related to the length or the time of the exercises: long simulation, at night, at lunch time, during a change in shift...	
20	Direct non diegetic inputs from facilitators to redirect trainees on an obvious or a (supposedly) reflex action	
21	All stakeholders	Call or other reaction in case of lack of communication from the crisis unit. Inability, refusal or no answer/help from stakeholders if the crisis unit does not ask the proper interlocutor (organization or contact person) for a task. Several stakeholders may contact several sub-cells to simultaneously deal with their specific problems.

N°	Stakeholders involved	Description of the situation
22	Authorities/ Medias/ Emergency services/ Internal firemen or operators	Propose or required operational or strategic targets
23	Emergency services (firemen)/ Internal firemen	Introduce or deal with pieces of information relate to event, intervention or other element(s) that may worsen or improve the situation and/or propose several actions based on this information
24	Complex situation or problems requiring to be managed by all the crisis unit or a large part of it in order to propose a common scheduled solution, innovative or not.	
25	Media, including social media	Inputs (call, direct interactions or other, depending on the setting) related to crisis information such as its current situation. Information may be true, partial, or false.
26	Authorities	Ask if the crisis unit have already communicated or written a press statement and/or demand to do it
27	Presence of curious onlookers and/or medias possibly malicious. Their presence may or may not be directly introduced to the crisis unit through inputs.	
28	Authorities/ Medias/ Emergency services/ Neighbors (industries)	Use of a specific language during interactions in order to make the crisis managers ask for reformulate and/or to induce a bad understanding to force the crisis unit to ask for precisions
29	Authorities/ Media /Emergency services/ Internal firemen/Other	Provide or required confirmation on a blurred, uncertain, partial or wrong information coming from outside the crisis unit
30	Authorities / Emergency services/ Internal firemen	Require forecast or anticipation related to incoming events or possible evolutions
31	Medias/Authorities/Emergency services/Internal firemen or operators/ Others	Important number of inputs focused in a short time, possibly on one single sub-cell
32	Emergency services (Police)/NGO/ Others	State views opposed to the crisis unit one's showing lack of transparency in crisis unit communication
33	All stakeholders	Inputs of several pieces of a shattered information to different team members of the crisis unit, with lacking pieces of information, contradictions (or not) and, possibly, questions from sub-cells to help the team making sense with them
34	Authorities/ Media/ Emergency services/ Internal firemen	Time limits imposed requiring to organize the crisis management according to this constraint

Based on this repository, a situation calling an action, task or thinking process related to one or several targeted competences is chosen. Note that the outputs of the considered action may be helpful to find the adapt situation to stage actions in. Indeed, outputs are reasons why actions and tasks are done and these outputs are themselves required for a reason: someone asks for it, the company has a legal obligation to do it, authorities request it and so on. Therefore, these last reasons – stakeholders requesting things for instance – may be used to define incentives leading trainee to wanted tasks. Incentives may have different nature depending on outputs expected: demands from hierarchical level, hints from operational level leading to the problem or candid question raising the main matters. Note that incentives are more detailed and processed later in the methodology, in 8.4.

Cognitive processes harnessing aimed competences to achieve action delivering expected outputs, must be clearly identified as well as resources required to perform such actions and interactions that are involved in order to list them and prepare these elements in the script. Usually, such process goes through the following steps: identification of the problematic, gathering information and data, development of solution(s), choosing the more adapted solution consisting in the decision-making process, implementing solution and ensuring the solution is adapted and produce the expected effects. Scriptwriting must follow

phenomena (3), perturbation (1-3) and situation-task (6) were chosen following Limousin's recommendations as discussed in Chapter 4. After that, based on meetings with SHE manager, several pedagogical targets were identified in this axe and some other in "Crisis communication" axe in order to complete the exercise and give it more consistency.

Main axe - Crisis unit management pedagogical targets:

- | <u>Skill</u> | <u>Attitude</u> |
|--|------------------------|
| • Definition of the roles and mission | • Information Pooling |
| • Giving orders and instructions | • Fast decision making |
| • Archiving and monitoring actions taken | • Cooperation |
| • Resources committed coordination | |
| • Available data collection | |

Secondary axe - Crisis communication pedagogical targets:

- | <u>Skill</u> | <u>Attitude</u> |
|------------------------|---|
| • Reporting | • Message consistency |
| • Choice of addresses | • Ability to make spontaneous and on request transmission |
| • Message construction | |

Crisis unit missions selected, according to these pedagogical targets, were the following ones, from Lapierre's repository:

- **12 – Hazard assessment:** Knowing the consequences
- **42 – Response's resources and backup management:** Study actions' feasibility
- **64 – Crisis cell activation:** Manage the crisis unit
- **65 – Crisis cell activation:** Organize information transmission
- **81 – Information transmission management –** Manage information transmission
- **82 – Information transmission management:** Gather information
- **101 – Keeping a shared mental picture of the situation:** Make regular status reports
- **102 – Keeping a shared mental picture of the situation:** Use shared medium
- **111 – Teamwork coordination:** Coordinate sub-cells
- **112 – Teamwork coordination:** Make team decision
- **133 – Media monitoring:** Answer to media questions
- **162 – Communication with authorities:** Write a message
- **163 – Communication with authorities:** Make regular status reports

These competencies were used to fin the proper proto-situation-task that could stage them. In this preliminary design step, only generic situations were chosen and related to competences aimed. This process produces 6 pedagogical block – proto-situation-task – where generic situations are linked with the competences to specially target in the following design process. However, and as said, the matching grid developed for Expert'Crise is not extensive and competences may be staged in situations not mentioned in the grid. For the P company, some competences were staged into situations unrelated to them in the grid and are noted with a ** in the following list:

ST1 – Operators provide information on the present situation onsite in order to trigger the warning chain, mobilize stakeholders and start a recon of the situation by internal firemen through reflex procedures and organization related to it. This situation-task involves following competences:

- 12 – **Hazard assessment**: Knowing the consequences
- 111 – **Teamwork coordination**: Coordinate sub-cells

ST2 – Call, face to face interaction or Auditive inputs stating an evolution of the situation with or without following characterization: fast, complex, with numerous inputs, worsening or improving the situation. This situation-task aims to force trainee to look for regular feedback from onsite internal firemen to keep up to date and communicate cautionary. Moreover, it involves following competences

- 82 – **Information transmission management**: Gather information
- 162 – **Communication with authorities**: Write a message

ST3 – Firemen deal with pieces of information relate to intervention that may worsen or improve the situation and propose several actions based on this information aiming to put trainees in a decision-making situation where they have to take a decision with little information and time. This situation-task involves following competences:

- 42 – **Response's resources and backup management**: Study actions' feasibility
- 111 – **Teamwork coordination**: Coordinate sub-cells
- 112 – **Teamwork coordination**: Make team decision

ST4 – Medias, Authorities and Emergency services generate an important number of inputs focused in a short period of time but dispatch to several sub-cells and requiring a coordination between team members to ensure a proper and consistent communication with each stakeholder and pooling information. This situation-task involves following competences:

- 64 – **Crisis cell activation** Manage the crisis unit
- 111 – **Teamwork coordination**: Coordinate sub-cells
- 102 – **Keeping a shared mental picture of the situation**: Use shared medium
- 162 – **Communication with authorities**: Write a message

ST5 – Authorities and Media request information on the situation (the accidental sequence, consequences, evolutions...) and about actions taken by crisis unit aiming to force the crisis unit to communicate to these stakeholders under an appropriate timing. This situation-task involves following competences:

- 65 – **Crisis cell activation**: Organize information transmission
- 101 – **Keeping a shared mental picture of the situation**: Make regular status reports
- 102 – **Keeping a shared mental picture of the situation**: User shared medium
- 133 – **Media monitoring**: Answer to media questions**
- 162 – **Communication with authorities**: Write a message

ST6 – Authorities calling or having other reactions depending on how the company communicate with them, especially in case of lack of communication. Several stakeholders may contact several sub-cells to simultaneously deal with their specific problems. This situation-task aims to force training to make trainees communicate regular feedbacks to some stakeholders and involves following competences:

- 81 – **Information transmission management** – Manage information transmission
- 163 – **Communication with authorities** – Make regular status report **

Once pedagogical blocks are defined, steps of the scenario are specified but how they arrange in the script remains undetermined. In other words, points of the storyline are drawn but the line linking them is not. It is the purpose of the next paragraph – even if it remains in the **fourth step** of the methodology – to explain how they organize and to develop them a little to give consistency to the scenario.

8.2 Scenario draft defining situation-task

A scenario consists in the sequence of inputs that both builds the diegesis in trainees' mind and lead them to pedagogical targets by developing a simulated accidental situation. Nevertheless, as previously discussed, crisis exercises scenarios are closer from Role-Playing Game scenarios than from theatre or movie scenarios. These last ones have scripted almost unchangeable text lines while the first ones are composed of several points of interest – characters, places, events, items and so on – that players/trainees must reach to make advance the plot. Therefore, it may seem inconsistent and/or useless to script a story line because trainees may go from a point of interest to another in the order they want, without chronological or logic sequence. Nevertheless, in order to design interactions with each one of these points of interest, it matters to script the story that must be told, underlying these interactions. Several options are then possible, here classified from the less interactive to the more one:

- Interactions are independent and not time dependent: players evolve in a still-life, possibly with a background to discover or where interactions and gameplay alone are sufficient to be enjoyable
- Some interactions relate to each other in one or several independent storylines but are not time dependent: players follow a plot from the beginning to the end through a sequence of interactions and may jump from a storyline to another while “pausing” previous ones, each story “wait” the player to pursue. The global diegesis may be impacted by player's actions but each storyline remains playable (with possible inconsistencies).
- Some interactions relate to each other in one or several independent storylines and each one is time dependent: players follow a plot from the beginning to the end through a sequence of interactions and must end it before starting another one or give-up with possible consequences. Moreover, some storylines may appear or disappear after a scripted amount of time if the player has not started

them. In other words, stories advance with or without the players and diegesis evolve by itself, possibly modified by storylines played outcomes.

- Every interaction may have a consequence on other interactions in a global plot underlying every interaction and depending on time as in a real world. Nevertheless, as it is almost impossible to take into account every interaction a player may have in the diegesis, several strategies are used to make it possible:
 - Only some interactions impacting the global diegesis while other have no or little impact may be implemented.
 - Consequences of interactions may be gathered in the chapter (act or sequence) drawing a player's profile and whose next interactions in the diegesis will depend on this profile. Moreover, according to the player profile, different variations of the original main plot may be triggered with possibly different ends or interaction possibilities.
 - Side-story – different from the main plot – consisting of a sequence of interaction depending both on the player's profile and one's previous interactions in this particular side-storyline may also be implemented. Such storylines may appear or disappear according to the playtime and/or the player's profile.

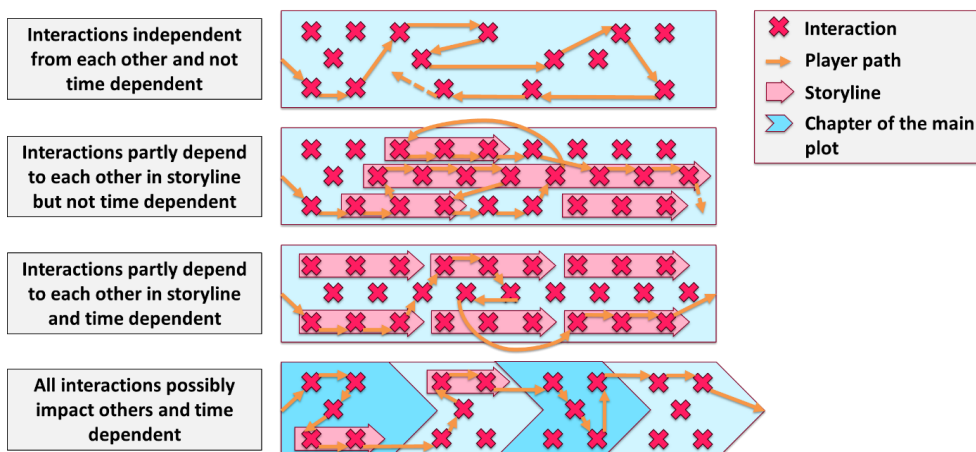


Figure 49: Scripting interactions in storylines, four possible structures

After having tried to implement the fourth structure in Expert'Crise's exercise and stated it was difficult and time consuming to develop such exercises, the third approach for story scriptwriting was selected as the best compromise between realism and scripting feasibility. However, Expert'Crise's crisis scripts tend to be the closer as possible to the fourth structure and have a global plot that advance whatever trainees do – crisis evolves with or without trainees' actions as in a real situation – and try to have the more interconnected interactions as possible to make the simulation more realistic.

Therefore, a scenario is not linear – trainees have several choices – but, on the other hand, continuously advances taking into account trainees' actions. Then, it matters to define

a framework carrying this script progression. Two main domains were used to define this framework: how emergency situations usually proceed and how stories are scripted in main artistic domains. Emergency situation was studied through literature reviews of several accidents and meetings with both industrial executives who had to deal with such situations in the past and emergency services officers. On the other hand, scriptwriting study mainly relied on Christopher Vogler method which is widely used in cinema, theatre or game-design (Schell, 2008) scriptwriting. Vogler is a Hollywood's screenwriter who wrote cinema scriptwriting guidelines (Vogler, 1998) based on Campbell's monomyth (Campbell, 1949). His guideline was massively used in Hollywood production since then and little production do not rely at least partially or indirectly on it. The Hero's journey is a three act structure organized around the transition from the common world to the unnatural/uncommon world where the protagonist of the story becomes a hero. While Campbell described and analyzed myths staging heroes doing quest through god or mythical creature domains and standing out from it morally and physically improve by those events, closer to gods than before, Vogler uses the structure built by Campbell to write a prescriptive method for scriptwriting story. Therefore, even if Campbell works do not gather a wide consensus among anthropologists and mythologists, being criticized because of its biased analysis (Ellwood, 1999) and the lack of relevance of such comparison between myths (Crespi, 1990), Vogler relied on his work to design his own method which met an important success among scriptwriters, and was then used to write many artistic pieces of work, it becomes a keystone in scriptwriting.

Therefore, the hero's journey was adapted to match with the crisis theme. Yet, crisis and myths have a common point: they both appear impossible. Then, it was not too difficult to transposed mythological and fantastic events into accidental sequences. In this new structure, there is no more hero passing from human world to gods or fantastic world but crisis unit passing from normal operational situation to an emergency or crisis situation. Therefore, the different steps of the hero's trip were adapted to fit with crisis process as seen in Table 30.

Table 30: Hero's journey step and crisis management process comparison

Hero's journey step		Crisis management process	
Departure	Call to adventure	First step of the warning chain.	Warning chain
	Refusal of the call	Disbelief or minimization of the crisis. Fear to leave the normal operation mode.	
	Supernatural aid	There is no supernatural aid in crisis process. Nevertheless, during exercises, facilitation can play this role.	
	Crossing the first threshold	Awareness of the gravity of the situation. Emergency plan "engagement" and reflex procedures.	
Initiation	The belly of the whale	Information and action flooding. Difficulty to picture the situation correctly.	Crisis management
	The road of trials	First decision-making and awareness of operational difficulties.	
	Meeting with the goddess	Meeting with emergency services and information exchanges.	
	Woman as a temptress	The temptation to not act anymore, letting all actions to emergency services.	
	Atonement with the father	Communication with authorities, medias and higher hierarchic level.	
	Apotheosis	Expectation of change, improvement or the end of crisis. Domino effect, if any.	
Return	Refusal of the return	Expectation of recurrence, domino effect or unexpected consequences. Stay alert.	Back to normal
	The magic flight	Last communications to authorities and media with, eventually press conference. Checklist verification.	
	Rescue from without	Other stakeholders close their crisis units and emergency services leaves plant.	
	Crossing the return threshold	Report and debriefing	
	Master of the two worlds	Crisis unit closing	
	Freedom to live	End of the sequence	

Then pedagogical blocs are integrated in this framework of how a crisis in industrial environment evolves. Therefore, based on the length of the exercise, this first representation – shown in Figure 50 – give a view of how the exercise will process and possibly fill gaps in the script. Indeed, Vogler's guideline purpose is not to provide an automatic method for mass-writing scripts for uninspired scriptwriter but to propose a scheme to follow in order to structure an existing script idea to enhance it and give it more consistency.

This scheme aims to picture how the exercises will proceed and when the pressure on trainees will be the more intense. Then it depicts both exercise dynamics and its rhythm that must not be homogeneous along the simulation but must increase progressively – possibly with a medium peak – until the climax then decrease as seen in Chapter 4. The arrangement of each blocs is important because it influence dynamics and stress during the exercise in addition to encourage the resolution of some problematic before others (Limousin, Chapurlat, Tixier, & Sauvagnargues, 2016).

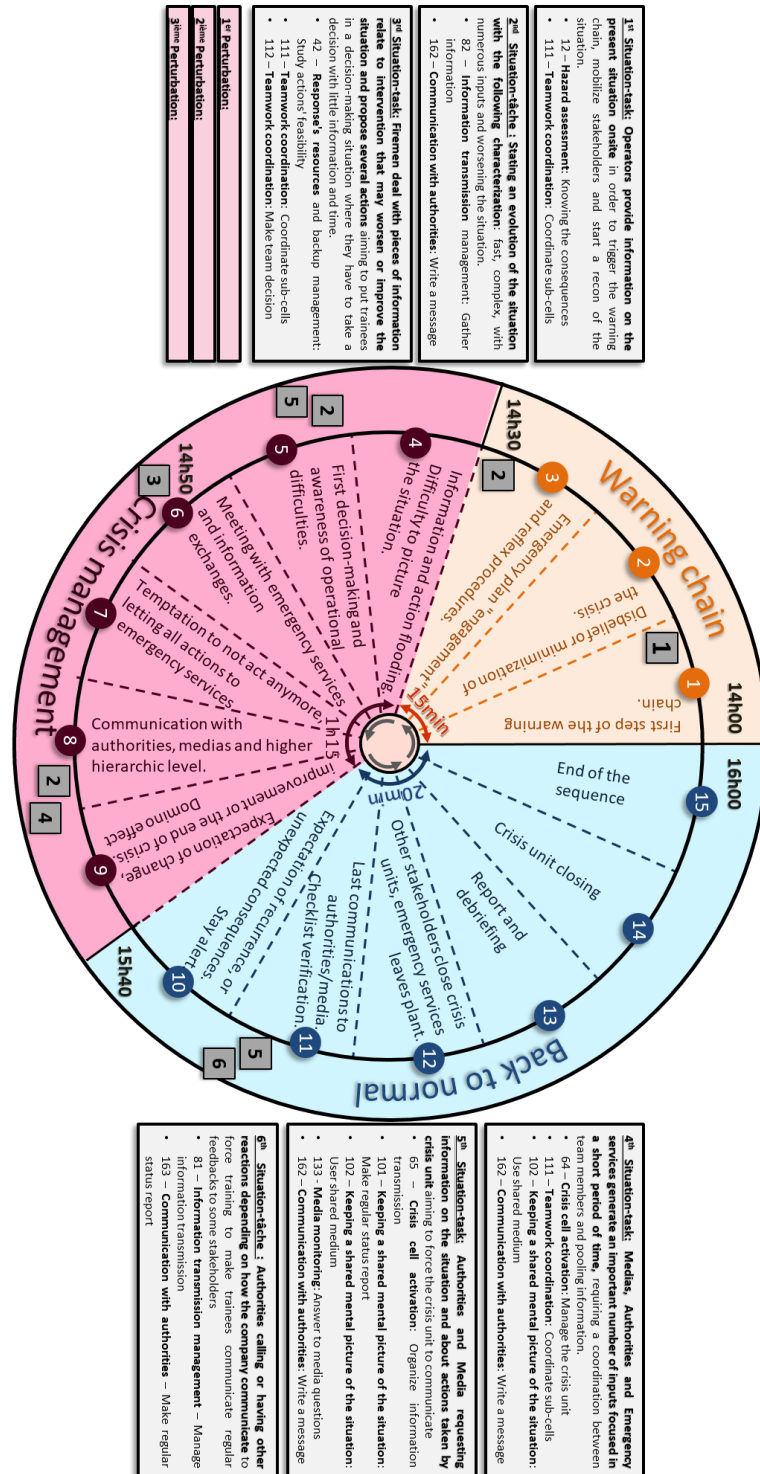


Figure 50: Pedagogical blocs in the Hero's journey

In order to conclude this fourth step and before choosing the accidental sequences, pedagogical blocks must be reorganized and expanded with prototype idea of scripting, especially with incentives and/or perturbations completing situation-tasks and potential point of inflection in the scripting. The previous representation gives a global representation of the scenario and its dynamics but is not really efficient to actually script events, leading some moment of the scenario to be oversaturated – and impossible to facilitate – while others are completely empty. Then a 15-minutes meshing scripting framework – illustrated by Table 31 – is set and pedagogical blocs are implemented in it according to the Hero's journey representation but with taking some distance with it to equilibrate and “make the script breath” (and then the facilitators during the exercise). Note that some sequences may not be related to a “situation-task” especially during introduction, transition, conclusion or build-up period and, in that case, they both aim to improve realism and let the trainees deal with previous problematics and, possibly, anticipate incoming ones.

At this point, further developments of the situation-tasks are not possible without defining the “plot” of exercise, i.e. the accidental sequence which is the purpose of the fifth steps of the method.

Table 31: Block chronology of the exercise

Time block	Pedagogical bloc	Pedagogical target	Incentive / Perturbation
14:15	Operators provide information on the onsite situation to trigger the warning chain, mobilize stakeholders and start a recon of the situation through reflex emergency procedures and their related organization	Testing reflex emergency procedures Hazard assessment: Knowing the consequences Teamwork coordination: Coordinate sub-cells	Pushed information with little details and possible pulled information more complete. Scattered information and evolving situation
14:30	Inputs state a fast and complex evolution with little information, worsening the situation and forcing trainees to look after regular feedbacks from onsite internal firemen, to keep up to date and communicate cautionary	Information transmission management: Gather information Communication with authorities: Write a message	Audio inputs showing a serious evolution of the situation. Casualties or Pollution (possibly not related) Information request by stakeholders' input
14:45	Firemen deal with intervention that may worsen or improve the situation and propose several actions aiming to put trainees in a decision-making situation where they have to make a decision with little information and time.	Response's resources and backup management: Study actions' feasibility Teamwork coordination: Coordinate sub-cells & Make team decision	Request or question from internal firemen chief and fireman officer Lack of action or decision worse than an inadequate action
15:00	Medias, Authorities and Emergency services generate an important number of inputs in a short period of time but dispatched in several sub-cells that require coordination between team members to ensure a proper and consistent communication with each stakeholder and information pooling.	Crisis cell activation Manage the crisis unit Teamwork coordination: Coordinate sub-cells Keeping a shared mental picture of the situation: Use shared medium Communication with authorities: Write a message	Inputs related to the consequences of the evolution of the situation or ongoing action. Causalities or Pollution Reminder stimulus related to communication.
15:15	Authorities and Media request information on the situation and actions taken by crisis unit aiming to force the crisis unit to communicate to these stakeholders under an appropriate timing.	Crisis cell activation: Organize information transmission Keeping a shared mental picture of the situation: Make regular status reports & Use shared medium Media monitoring: Answer to media questions Communication with authorities: Write a message	Shattered information in the crisis unit and wide scope of demand: pollution, casualties, production matters, technical unemployment, pressure for media communication etc...
15:30	Inputs state a fast and complex evolution with little information, worsening the situation and forcing trainees to look after regular feedbacks from onsite internal firemen, to keep up to date and communicate cautionary	Information transmission management: Gather information Communication with authorities: Write a message	Pressure from stakeholder (media or authorities) with an ultimatum to have answers. Possible media backlash if no answers
15:45	Authorities call or have other reactions depending on how the company have communicated with them. Several stakeholders contact several sub-cells to simultaneously deal with their specific problems.	Information transmission management – Manage information transmission Communication with authorities – Make regular status report **	Evolutive situation inducing a need to make regular situation points to stakeholders Need to explain such evolution, justify why it was not avoided and why communication was slow, imprecise or changing Mediatic harassment vs. Authorities silence
16:00	Back to normal / End of the sequence		

8.3 Accidental sequence choice

Previous steps of the methodology consist in designing a context where participants may train on dedicated competences required by the company. Nevertheless, the context is not enough to make an exercise but also need to be realistic to involved trainees in the simulation. Indeed, a crisis exercise with only situation-task would appear as very artificial because only pedagogical targeted situations would be staged concealing all other crisis situations, especially those related to the nature of the accidental sequence. It would be like telling a story with numerous blanks or ellipses. Therefore, crisis exercise must deal with an accidental sequence that represent the plot of the story told by the simulation but which has no direct pedagogical purpose and only serve as a support for situation-tasks. Then the **fifth step** consists in selecting, with the contact person, the most adapted accidental sequence for the exercise. As said in the first step, this contact person may be specific with the nature of accidental sequence wanted, having an accident-driven perspective of exercise design.

The accidental sequence includes the causes of the accident, the accident itself, dangerous phenomenon associated including domino effects, and people, environment, equipment or affected structure (Debray & Salvi, 2005). In the situation where the contact person has no idea of accidental sequence matching with pedagogical targets, scriptwriter may rely on several sources to find an adapted disaster. First, the repository developed by Tena-Cholet and expanded by Limousin – introduced in Chapter 3 – may be used in order to identify the nature of events that may appear depending on the nature of hazard onsite. Moreover, specific review of accidental feedback literature related to processes or substances used by the company, especially its own internal accident reports may be a valuable way to find possible accidents on the site. However, for crisis exercises, it matters to think “out of the box” to find an event that may cause a crisis and was not already identified by executives. Then, in order to identify critical events, it matters to follow a different path than those usually used to identify possible disaster in risk analysis. Therefore, working “backward” may be relevant, following the accidental sequence from issues impacted to hazard involved. Main issues of the company may be assessed besides its hazards: what does it need to produce – utilities or raw material for instance – or to continue the activity at long terms? What are the possible impacts of a mediatic exposition on this kind of business? How much the company relies on its Information Technology infrastructure to operate? What are the relations with authorities? Do the companies comply with its legal requirement? These questions do not target hazards of the organization, but topics around them that can be impacted. Indeed, better plots for crisis exercise rely where risk managers had not investigated yet to surprise them in an unexpected accidental sequence. Therefore, it may be more efficient to identify an issue that may cause serious damage to the company than hazardous phenomena that were already studied by the SHE team and consultants. Similarly, to hazards, Limousin’s issues repository may be used to determine issues that may be involved in the exercises. It is possible to establish how – as well as how much – these issues can be impacted with an inductive thinking process, the

opposite of the usual deductive “What if” process used in risk analysis, from consequences to causes.

Accidental sequence should lead to “situation-tasks” and should be justifications for inputs, helping trainees to do wanted tasks. Then, the choice of specific issues or phenomena must be driven by pedagogical targets. Establishing a perimeter during a disaster involving leakage of a gaseous and hazardous substance may request to use a simulation software or find results of previous simulations in a report done years ago while, on the other hand, wounded workers sent to hospital may request a communication to families with proper adapted HR procedures.

Once phenomena and issues are identified, an accidental sequence involving them must be determined. In order to describe the more realistically possible the initial situation, meetings with operators, technicians and process engineers is the best way to proceed to gather all available information about possible evolutions – especially domino effect that may occur – as well as safety devices implemented. Nevertheless, as it may be difficult to gather all these persons, two paths may be followed: gather as much information as possible to provide them to trainees during the exercise or design an accidental sequence where the causes of the emergency are not obvious. Indeed, precise context and reasons of the disaster may be overshadowed and crisis team may directly face the accidental situation. Real reasons of an accident are often discovered some times after the crisis or emergency management and, during an exercise, it only matters that accidental situation appears as realistic enough. Therefore, there is no need to deeply analysis consequences of the fictional accident, even if it may help to estimate consequences based on physical models and simulation. In the situation where an analysis is required and company stakeholders are not available, literature’s simplified models of the involved hazardous phenomena are usually enough to estimate global outputs of the fictional disaster.

The initial accidental situation is the start point of the scenario and it is possible to script how events may be expected to follow each other during the exercise based on the fictional disaster, emergency planning of the company and meetings with both executives and operators that may have adjusted the prescriptive plan and, especially reflex sheets which are valuable sources – if they are actually used – to draft possible reactions of stakeholders.

8.4 Refining Scenario including incentive and perturbation

The **sixth** step consists in scripting events one after others in order to build a complete and consistent scenario almost finalized. Based on fifth step’s table – the Table 31 – incentives as well as perturbations are expanded for each situation-task and a precise timing is writing staging these inputs with a facilitator assigned to sending each one of them and output expected for each input. For each time sequence, situation-tasks and pedagogical targets related are reported so the purpose of each sequence and reasons why specific task were chosen is not forgotten. Then, inputs leading trainees to do the wanted task are chosen. Nevertheless, the choice of relevant and efficient inputs is not easy. Indeed, they must lead to the task to do, but in a realistic – meaning strongly dependent of the organization – and non-obvious way to keep trainees focused and in a “flow” state as discussed in Chapter 5.

It is the reason why proto-situation-tasks designed during the fourth steps should already integrate first staging ideas to start this process with some beginning elements of scriptwriting.

As said in 4.2.2, each situation-task stages the resolution of a problem by participants which can lead to different solutions as shown in Figure 48. Problem-solving involves to gather competences targeted by the needs analysis in order to proceed the wanted task. Moreover, it requires for scriptwriters, to stage the problem in a dedicated situation that rely on inputs sent to trainees which are also the basis of the diegesis to be formed in their minds. The situation is usually implied by dangerous phenomenon or its consequences such as a wounded person or damaged equipment. Moreover, the trainee's reasoning process can be helped by incentives (e.g. municipal authority asking for a press statement) as well as it might be slowed down by perturbations that keep the simulation challenging for trainees. More extensively, Limousin's stimulus repository described in Chapter 4 may be used to classify inputs: **situational** stimulus describe the environment, **support** and **reminder** stimulus help trainees to go through emergency situation – the first one by “outsourcing” tasks that do not related to targeted competences and the second one by reminding trainees to do a specific task – and, in the end, **challenge** and **event** stimulus that make problem-solving more difficult either by adding new tasks to do or by simulating crisis features such as stress. Then, it appears that three main categories can be used to simplify scriptwriting: situation, incentive and perturbation stimuli.

Then, in order to design those stimuli, it matters to rely on interfaces that will be used during the exercise – characterized in the third steps of the methodology – and will support injection of inputs. The most adapted and realistic way to inject inputs in the crisis cell must be chosen according both to stakeholders or events stimulated and information transmitted by the inputs as well as its pedagogical purpose. For instance, information related to the evolution of the situation may be sent either by a brief call from chief of internal firemen requiring to call back in order to have more information if internal communication is targeted, by a fireman officer coming in the crisis room to have supplementary information about installation if coordination between stakeholders is targeted, or by a sound designed to simulate the event if crisis room's proactivity is especially aimed. Direct interactions between the target audience and facilitation are avoided as much as possible and carefully managed because facilitator may influence target audience and decrease the relevancy of observation as the environment is less realistic. Nevertheless, in some situation, it is not possible to fully separate facilitation and target audience. In that case, interactions are limited – with only some fact presentation for instance – and are taken into account for further analysis.

In order to illustrate this step, let considerate the first pedagogical block of our previous example, as the situation-task involved operators providing information to trigger emergency system, the most probable interfaces used would be either walkie-talkie, smartphone, onsite alarm trigger or face to face interactions. Actually, in this company, in case of accident according to emergency planning, witness must call the chief of internal firemen. Then, the content of the input must be extended with a subjective description of the disaster with little concrete information according to incentive idea identified in step 4.

However, if trainees contact themselves other onsite stakeholder or witness, they will have more detailed information.

Table 32: Precise chronology and input timeline

Time block	Situation-task	Pedagogical target	Incentive / Perturbation	Facilitator sheet	Precise timing
14h00 - 14h15	Operators provide information on the onsite situation to trigger the warning chain	Testing reflex emergency procedures Hazard assessment Teamwork coordination	Pushed information with little details and possible pulled information more complete. Scattered information and evolving situation	On-site facilitator	14h00: Call from witness to internal firemen chief with little information 14h00/5: If check information, feedback with more complete information 14h15: Warning confirmation by a second witness. Major accident.

Therefore, in this example, two inputs are identified plus one reactively to a trainee action. The first one aims to trigger internal procedures and initiate the emergency confirmation process that should result in contacting different operators onsite to have complementary information. If such contacts are taken, details of the situation are given according to the second input. Whatever crisis team's reactions, because the crisis does not wait, a third input validating the situation comes 15 minutes after the first one, confirming the situation and forcing emergency planning to set up. Indeed, it appeared during the Expert'Crise project that trainees in industries may be reluctant to use their emergency procedures – even when they know it is an exercise – and it may be useful to force them into the exercise. Such inputs are some sort of incentives but it means that the company failed to set its emergency organization on time. However, because it is not possible to realistically make the warning chain last forever to make the crisis unit properly processes their warning chain until setting all their emergency systems, it is required to set the crisis unit in a forced emergency situation where hazard of the situation is obvious. If the hazard is not obvious enough or not confirmed in the script, some companies could stay in normal operation mode until firemen arrived onsite. As shown in this example, there is no need to stage a lot of inputs to involve a complex thinking process. On the other hand, some script elements continue from a situation-task to another. For instance, if too much information is provided at the beginning of the exercise, it would be difficult to script a lack of information later, in a following situation-task, or it would require to implement a domino effect or an evolution of the situation while staging a Chekhov's gun (Burt, 2008) is more efficient in scriptwriting.

Once 15-minutes timing is established, a more precise timing with a 5 minutes meshing is established and inputs, incentives, perturbations as well as expected trainee's reactions and facilitators recommended reactions are specified in a table as shown in Table 33 with the first hour of the previous example. There is no need to over saturate trainees with inputs if it is not the purpose wanted. Indeed, communication between participants dispatched inside the organization – especially from and to the peripheral audience – will be important independently of inputs. Therefore, little input can have a lot of implications and numerous

reactions from participants. This precise table is used to write the global script then it is only a scripting tool and pedagogical targets as well as incentives or perturbations ideas do not have to be repeated here.

Table 33: Developed meshing scenario with inputs and expected outputs

Timing	Situation-task	Input	Facilitators	Expected Output
14:00	Operators provide information on the onsite situation to trigger the warning chain	Call from witness to internal firemen chief with little information and ask him to come in facilitation room	On-site facilitator	Internal Firemen Chief comes in facilitation and possibly trigger the alarm system
14:05		Depiction of the situation with very little information, possibly only alarms on	On-site facilitator	The Internal Firemen Chief calls Main Emergency Manager, possibly trigger firemen alert and crisis team alert
14:10		Main Emergency Manager alerted and get informed of the situation (More information if call/call-back himself Internal Firemen Chief)	On-site facilitator	Setting of the crisis room. Possibly evacuation decision-making
14:15		Important aggravation of the situation with little information. One casualty (no precise information)	On-site facilitator	Setting of the crisis room. Evacuation. Means of intervention identification
14:20	Inputs state a fast and complex evolution with little information, worsening the situation and forcing trainees to look after regular feedbacks	Emergency services incoming	On-site facilitator	Depend on when alert to emergency services is sent and information transmitted
14:25		More precise description of the situation and actions that can be taken. Operators – simulated – onsite ask for backup	On-site facilitator	Help provided with advices, specific orders and document/engineering support
14:30		Internal and external firemen ask for information about an intervention to do (feasibility or hazard)	On-site facilitator	Decision taking or not
14:35	Firemen propose several actions that may worsen or improve the situation aiming to put trainees in a decision-making situation	Incentive or stressing input to push the crisis unit to provide a decision or response	On-site facilitator	Decision taking or not
14:40		According crisis unit decision (or indecision) consequences of the situation	On-site facilitator	
14:45		Emergency services' feedback on the situation	On-site facilitator	Information pooling
14:50	Medias, Authorities and Emergency services generate an important number of inputs in a short period of time dispatched in several sub-cells requiring coordination	Call from guard post about worker counting and media trying to have information on the situation	Guard post facilitator	Information pooling and use shared support for noting such information
14:55		Calls from several journalists	Media	Short answer. If absolutely no information provided, fake news created.
15:00		Worsening or modification of the situation. A dead casualty.	On-site facilitator	Information pooling and use shared support for noting such information

Note that, in this fine meshing, the first situation-task does not state specifically reactive inputs as previously mentioned. Indeed, because this table aims to support the writing of the scenario, describing the sequences of active inputs, such inputs do not have to appear here and will be scripted beside the second input description – related to the “a minima” consequence of the initial input – with details on under what circumstances they should be sent.

This table is the last one before the script began to be formerly written. Indeed, tables are efficient to gather numerous information in little space but are not to write long sentences describing situations and interactions in details. That is the reason why, after having used Main Scenario Event List as discussed in 4.4, it appeared to us it was not the most adapted tool for scripting interactions. Therefore, a hybrid approach between MSEL, theatre script and paper RPG game scenario was developed. Such script consists in several paragraphs related to a time sequence. Usually, one paragraph deals with a time sequence but several paragraphs may precise what happen during a same time period. Sentences are written in indicative mood if they related to facilitators action that must be done or in conditional mood if they related to trainees’ actions that may happen depending on trainees’ decisions. Moreover, because scripting human unplanned interactions involved a lot of uncertainty, timestamps are more or less exact. Then, in order to let some level of freedom to facilitators, script refers to timestamps according an exact form “At 00h00” when referring to a precise event facilitator must inject at a precise timing or an approximate form “Around 00h00” when inputs depend on trainees’ action or may be delay of some times without trouble. Indeed, facilitators are in (in)direct relation with trainees so are more able to tell if the script is well-adapted for them or if it requires to be adapted than the scriptwriter, month before the exercise, so it appears that they should have the last word on exercise facilitation and inputs as long as the exercise remains consistent and pedagogical. On the other hand, facilitators must provide feedbacks to other facilitators or to the exercise’s supervisor if inputs are delayed in order to adapt all the script and keep it consistent.

Script paragraphs are composed of several elements which usually follow the same framework: a facilitator does an action represented by a verb – in a limited list – usually targeting a trainee. Therefore, it matters, as it should have been done during the third phase of this methodology, to have a clear list of facilitators and trainees including target audience and peripheral audience. Moreover, the places where facilitation may be required – so where trainees may come as discussed in Chapter 7 – must also be listed as facilitators may have to go there to meet peripheral facilitators or provide information. Actions facilitators may have to do can be resumed in 5 groups of verbs:

- Contact someone or compose a phone number
- Provide an information, say something to someone, read or make a description of a situation to someone
- Ask something to someone, inquire what the trainee should do in such situation or help a trainee through questions
- Move somewhere and/or present one-self to trainees and details on how exercise will proceed

- Agree, temporize, validate an action, and/or indicate it is simulated or not

Three first categories of interaction consist in the facilitation's core actions including information inputs to target audience while the last two categories consist in "control" actions aiming to ensure that the exercise proceed correctly and trainees remain in the limits set during exercise design. Although this previous list is not intended to be exhaustive and other actions may be done according to the needs of the exercise.

In order to illustrate how scripts are written, the first 30 min of the previous example is reproduced here:

"Exercise will start at **14h00** with a call from **Onsite Facilitator** to ##### for the **Internal Firemen Chief** explaining there is a leak of an unidentified substance on a rack above retention n°## then requiring to come in the **facilitation room** for the exercise without passing by an alarm panel.

Then, when **Internal Firemen Chief** will arrive in **facilitation room**, **Onsite Facilitator** will make a description of what can be seen on control panel. Internal Firemen Chief should, in reaction, trigger the alert by calling the ##### starting his message by "*This is an exercise*" and precising onsite facilitation take place in **facilitation room** (and not onsite). If **Internal Firemen Chief** forget these two elements, **Onsite Facilitator** will demand to precise them during the call. Then, **Internal Firemen Chief** should want to investigate what happen onsite and, in that case, **Onsite Facilitator** will agree to this request and mention that this part is simulated on a map. Moreover, if **Internal Firemen Chief** want to contact operators working nearby the place of the accident, **Onsite Facilitator** will ask who precisely and say it is not necessary to actually call them then, according to the function named by the **Internal Firemen Chief**, **Onsite Facilitator** will read a more precise description of the situation.

Once nearby the accident (on the map), around **14h10**, **Onsite Facilitator** will make a description of the situation: a liquid jet leak from the rack above retention n°## with an important pool is on the ground, in retention ## and ##. After this description, **Onsite Facilitator** will ask safety measures **Internal Firemen Chief** wants to implement and how, especially depending on internal firemen – simulated – involved. At this moment, **Internal Firemen Chief** could want to contact emergency services. In that case, **Onsite Facilitator** will introduce the phone number repository to contact adapted facilitators playing the role of emergency services.

Little time after **Internal Firemen Chief** arrived in **facilitation room**, **Internal Firemen Chief** should meet the **Main Emergency Manager** who should come in **facilitation room** (or contact Internal Firemen Chief by phone or walkie talkie) and ask for a briefing of the situation. During this meeting, **Onsite Facilitator** will indicate that the pool suddenly takes fire and internal firemen had to go back to stay safe. After one-minute, **Onsite Facilitator** will indicate #####, a fireman gets intoxicated or, *according to how well emergency management proceed, seriously burnt (First perturbation).*

Around **14h20**, **Internal Firemen Chief** and **Main Emergency Manager** should agree on triggering alarm and sending a more complete internal message, especially to identify

refuges that must be avoided and call emergency services for an ambulance and, **if it has not been done**, ask firemen help for the disaster.

Around **14h25**, **if they had been alerted soon enough**, first emergency services will arrive. **Guard post facilitator** will indicate to **guards** that firemen trucks just arrived and, some instant after, **Onsite Facilitator** will simulate their arrival with a sound file played on a Bluetooth speaker. Then, **Onsite Facilitator** will play the role of the firemen officer to simulate the interaction with **Internal Firemen Chief** and **Main emergency manager** and listen their briefing of the situation. During this briefing, the firemen officer will ask the nature of burning substances in order to identify the proper way to fight fire with the less hazard possible then will inquiry possible evolution of the situation before questioning operative methods recommend with such substances and resources available, especially water supply, and issues to protect in priority. **If emergency services have been alerted late**, **Onsite Facilitator** would ask **Internal Firemen Chief** what orders he give to internal firemen to mitigate the disaster and protect equipment.

Meanwhile, **Main emergency manager** should contact **Site manager**, **Communication manager** as well as everyone required in such situation and he should ask them to come in **crisis room** where **Main emergency manager** should go right after that. When **Main emergency manager** will leave **facilitation room**, **Onsite Facilitator** will demand to not make round-trip between this room and **crisis room** too often because **facilitation room** simulate onsite situation and is supposed to be further than its actual position. He will explain that the next time someone come in this room, a temporization will be set to simulate the distance.

Around **14h30**, **Onsite Facilitator** will say to **Internal Firemen Chief** that the leak on the rack juts end – **except if actions were implemented before**, especially the end of truck unloading – but the fire keep burning. **According to actions taken**, **Onsite Facilitator** will complete the description by saying that a tank nearby gets damaged by the fire and leak.

Meanwhile, **Media Facilitator** will call the ##### for the crisis unit and introduce one-self as Sud Press then will question the crisis unit about the situation. Facilitators playing a journalist role will focus on chemicals involved in the disaster and their potential impacts on surrounding population, saying neighbors smelled unpleasant, sharp odors. “

Note that the previous text is written following a dedicated format with the use of colors or bold on some part of the text. Such layout aims to help facilitators to read efficiently the document, focusing attention on important of each paragraph. **These format rules are explained in 8.5 paragraph.**

Once the script is written, it is submitted to company's contact persons for validation and possible modifications. Such step may be supported by a meeting between scriptwriter(s) and company's representants as well as other workers not involved in the exercise but who may provide their expertise on how the industrial system as well as their colleagues may react to the proposed scenario and suggest possible modifications for the script. However, at this step, it matters that modifications only impact scripting details and do not reshape the framework of the exercise. Indeed, this framework was designed during the previous steps depending on exercise's pedagogical targets and do not require to be

modified if these targets remain the same. The script written here is the final and complete exercise's scenario which will not be modified during the next step. Therefore, it matters that stakeholders agreed on this script at this step and it may require several rounds of modifications and more than one meeting to find a consensus on the final scenario. Nevertheless, it appeared during the Expert'Crise project that companies have usually little commentaries to make on scenario and usually agreed with no or little modifications to do. Then, because the next phase consists in making the script operational for exercise facilitation without modifying it, this scriptwriting step is critical in the design process, explaining why several tables preceded it in order to ensure all elements were clearly defined before starting it.

8.5 Facilitator's sheet redaction and facilitation files design

Once the global script is written, start the **seventh** and last step of the design methodology consisting in extracting from the script what is required for exercise facilitation, expend it to be usable and the more user-friendly possible by facilitators, and implemented it in dedicated sheets used during exercise. Main facilitation files are facilitations' sheets written for each facilitator and consisting in the transcription of relevant parts of the script for the facilitator with possibly complementary information. Each facilitator's sheet is different, being adapted for a specific facilitator's mission and only referring to one's actions and how exercises must proceed from one's point of view then possibly stating other facilitators' actions that have an impact from one's perspective. These sheets can be categorized in two groups according to facilitators and audience mentored they are designed for: those dedicated to mentoring peripheral public and give it a consistent – but partial – view of what happen and how they are supposed to react, and those dedicated to distant facilitation, simulating different stakeholders and controlling immersing devices. Therefore, the first category targets facilitator in direct contact with trainees and having to interact actively – and sometimes continuously – with them, playing a role or interacting as a facilitator. On the other hand, second category aims facilitators punctually sending inputs to trainees through the exercise's interface, without directly interacting with them, and always playing a diegetic role.

Facilitators' sheets are composed of three parts. First, they start with an introduction explaining the global context of the exercise, trainees managed by the facilitator, where the facilitator starts the exercise and one's movements during the exercise, and broad lines of the script. Then, the core of the facilitator's sheet is constituted by a script specifically adapted for the facilitator's use and only stating lines related to actions that must be done or inputs that must be injected. In the end, the sheet concludes with annexes including at least a phone number repository and possibly maps, complementary information for interactions with trainees such as fire or dispersion simulation result, or framework aiming to help some interactions, especially mediatic or political ones. Facilitation sheets can also include a question/answer part to help facilitators to answer possible questions from trainees. Nevertheless, these sheets cannot anticipate all questions and reactions from trainees then facilitators may have to adapt the scenario to trainees. Therefore, facilitation

requires from facilitators to have a good ability to improvise in order to readjust the script to trainees' response while remaining in the global path of the scenario. Such flexibility needs, on the other hand, to have a good understanding of the script and of the organization where it sets up. Then, it seems inappropriate to dissociate scriptwriting from facilitation because people who have the better understanding of the scenario are those who wrote it. However, the scriptwriting team may be outnumbered and require support for facilitation then it matters that facilitators who did not get involved in scriptwriting received all information and had time to process it before the exercise. That is the reason why a meeting with facilitators is scheduled upstream to describe how the emergency system work and how it is expected to malfunction, to introduce the script then deepen it through the explanation of each facilitation's sheet and answers facilitator's questions. On the other hand, because all facilitation tasks are not equal, the most critical and difficult ones must be done either by facilitators who participate in scriptwriting or by experienced ones in order to avoid facilitation difficulties. Moreover, some facilitation tasks may be easier to accomplish for facilitators coming from the company, especially because they know how the organization (informally) works and how to contact other workers. Furthermore, even if they usually have little experience as facilitators, they may be the most efficient to refocus trainees because they appear as internal elements of the organization so they may smoothly reorient the exercise.

As discussed, facilitation requires to consider both the scenario and trainees' reactions. Because, it is difficult to make trainee's reactions easier to manage for facilitation, a user-friendly support to display the scenario is a valuable help to assist facilitators. However, facilitator' sheets may have numerous paragraphs and may be difficult to follow during an exercise then a color code was implemented to highlight important elements for facilitation:

- Paragraphs that do directly relate to facilitator's actions are **shaded**,
- Timestamps have the **XXhXX** format and are stated at the beginning of paragraphs,
- Action verbs related to facilitator's activity are written in **bold**,
- Conditions on facilitator's actions are written in **red**,
- Text that must be read by facilitator are written in **red italicized**,
- Elements highlighted are underlined and elements stated for informative purpose only are *italicized*
- Different colors are assigned to each facilitator as well as peripheral audience in order to spot each facilitator's action

Facilitators' sheets writing mainly rely on the content of the previously written global script and consists in extracting from it paragraphs that relate – directly or indirectly – to the facilitator and possibly extend them. Indeed, the global script may be underdeveloped about some interactions and requires to be extended in order to provide enough information to facilitators. Such interactions may seem clear and obvious when first written in the global script but, when implemented in in a facilitator's sheet, appear incomplete or flawed then requiring to be completed. Paragraphs from the global script are transposed into inputs integrated in corresponding facilitator's sheet(s) – one input may impact several sheets – with details related to the medium and the context of injection, especially conditions to send

them to trainees. Note that interactions and main information related to them must be mentioned in the core of the facilitators' sheets – the chronological sequence of inputs to be sent – while details on the interaction may be written in a dedicated annex in the end of the facilitator's sheet in order to make this tool user-friendly and readable enough. Such details may be, for instance, how to react if trainees behave in a specific way, all anticipated actions that trainees may do after an input, what is it planned in emergency plan and what is it expected during the exercise, and so on. On the other hand, all interactions do not require to have annexed details, especially when they are simple including limited interactions with trainees.

Moreover, similarly to lack of details that require to be complete in facilitators' sheets, it may appear during this step that some passages of the script are not consistent and do not work properly considering all facilitator's actions. Indeed, considering each part of a complete interaction may reveal problems that did not appears in the global script. Therefore, modifications must be made in order to correct such defaults and make the script fluent and logical. However, such correction must not imply to deeply alter the script and must on rely on little adjustments on interactions.

The second main purpose of this step consists in designing other facilitation supports, besides facilitators' sheets. Indeed, for several facilitation acts, facilitators need support files in order to perform these inputs in good conditions. Such files may directly help facilitator and be a support for interactions – a map showing where the disaster happened, accidental simulation results showing where it is dangerous to go – or, on the other hand, immersive document facilitator can give to trainees during the exercise and which exist in the diegesis such as photography – possibly modified – of what happen, reports, folders or sheets showing elements trainees would had/see during a real situation and aiming to fill gaps left by the simulation. Such documents may require to be altered in order to show fake phone number or other simulated elements to make the global simulation consistent and realistic. Paper files are not the only ones that need to be designed and pictures, sound or video may also be needed according to the limits set at the third step. Designing each category of files required specific software – usually, open-source software is sufficient for such design process – according to modifications that must be done on elements. Moreover, as discussed in 2.4, even control panel may be simulated through a tablet software – actually an excel sheet providing data display on a screenshot of the panel screen – simulating feedbacks from sensors in the plant. Therefore, a lot of elements may be simulated according to the needs of the simulation and resources allocated to do it.

Once these documents ready and meeting explaining how each facilitator's sheets work is done, exercise is ready to be given to trainees.

8.6 Chapter 8 Resume

While the first part of the methodology consists in designing the framework of the exercise – through (1) needs analysis, (2) emergency system analysis and (3) establishing training limits – its second part consists in working inside this framework and scriptwriting the scenario from pedagogical targets to facilitation elements required to make the exercise

operational. This second part is composed of 4 steps all resumed in this chapter: (4) Scenario draft defining situation-task, (5) Accidental sequence choice, (6) Refining scenario including incentive and perturbation, (7) Facilitators' sheets redaction and facilitation files design.

The first step of this part relies on pedagogical targets discussed in Chapter 6 to draft a first structure for the scenario, mainly through situation-tasks. Situation-task are the engine of the pedagogical process and consist in staging situations where trainees must – or are incited to – do specific actions that involves competencies aimed by the training. Such situation requires several inputs to build a consistent mental picture in trainees' minds and, possibly, encourage or challenge them in doing such task. Designing those inputs are at the basis of scriptwriting as situations from situation-task are points in the scenario that structure all the script. Therefore, it matters to clearly establish situation-task before actually scriptwriting in order to avoid inconsistencies or twists to bring forcibly trainees in those specific situations.

Once situation-tasks defined and the global structure of the scenario established, the fourth step pursues by refining the scenario into pedagogical blocs and stating first staging idea for inputs and possible incentives or perturbations and how to implement them. Then, when it is not possible to refine more the scenario without defining an accidental sequence, the fourth step ends and the fifth one starts.

The fifth step consists in choosing an accidental sequence according to pedagogical targets of the exercise and able to stage situations previously established for situation-tasks. Usually, executive in charge of the exercise has a clear idea of what kind of disasters could be implemented in exercise and it only needs to choose one and adapt it in order it fully meets previously set requirements. In other hand, if no idea rises from executives or technicians involved in the design of the exercise, a review of accidental data-bases review related to similar organizations as well as internal accidents – and incidents – reports is useful to have an idea of what kind of disaster may occur. Moreover, a review of critical issues may also be a good way to proceed and lead, by an inductive process, to accidental sequence that may impact most important issues. Note that if it matters to clearly identify dangerous phenomena involved as well as hazards the crisis unit will have to deal with, (root) causes of them do not really need to be defined. Indeed, during an emergency, real causes of the disaster are never clear and it needs time and investigation to identify what went wrong and lead to the accident. Then, as such investigations are “off-screen” of the exercise, it is not required to define them. However, having an idea of the nature of the event may help to design facilitation supports such as simulation reports because they usually need inputs related to such information.

Once accidental sequence is chosen, the refining process initiated in the fourth step may restart, completing situation-task with more precise inputs – incentives as well as perturbations – and the scenario is extended until the point when a table cannot properly transcribe all script information. Then, during this sixth step of the methodology, the scriptwriting process, detailing every scenario input and expected trainees' reaction is written in a literal format. This transcription phase from a condensed table format to an extended but less dense form allows to precise interactions, their context and how both

trainees and facilitators must interact with each other. When this process ends, the scenario is completed and can be submitted to the company's executives in order to be validated. Such validation may require one or several meetings and modification rounds to adapt the scenario according both to the needs of the companies – which has been stated in the first step of the method and base the scenario design – and how the company works. Although such modifications must not come into conflict with pedagogical targets relying on needs analysis.

In the end, based on the script written in the sixth step, the seventh and last step consists in designing facilitation files in order to support facilitators' actions during the exercise. Main facilitation documents are facilitators' sheets which are an adapted transcription of the global script for one facilitator and gathering all required information to manage the exercise from one's particular point of view. These sheets are divided in three parts: an introduction, the core of the sheet consisting in the sequence of inputs facilitator must send to trainees as well as those from other facilitators that trainees mentored will receive, and annexes aiming to ease and support facilitation acts. Writing facilitators' sheets, because it involves to considerate every part of the script and how it will be implemented, may reveal inconsistencies as well as lacks in the script requiring to adjust the script to make it functional for every facilitator. Besides facilitators' sheets, others files – report, photography, video or sound – may be required according to the exercise's limits set in the Chapter 7. These files must be designed in order to provide a consistent diegesis to trainees and limit dissonances that may appear during such exercises by, for instances, implementing fake phone numbers in procedures matching with phone numbers that must be called during the exercise. Almost every document or support may be designed depending on limits set and resources available. Nevertheless, it matters to find a compromise that allows enough immersion and are not too resources or time-consuming. For the Expert'Crise project for instance, besides facilitators' sheets, one to three sounds were designed, one to three photos and/or maps were prepared and up to two sheets reports – especially simulation reports – were implemented in facilitators' sheets.

Once these documents prepared, and briefing meeting held, the exercise may be set. If facilitators' sheets are well prepared, exercise facilitation consist in following inputs and adapt to trainees' reactions until reaching the scripted end of the scenario. However, training management and facilitation during the exercise still requires specific skills and it may be difficult for neophytes to master such training *ex nihilo*, without any experience in the domain. Here lies one limit of the methodology proposed in this document: it helps in designing exercises, making it affordable for novice, but it does not help in the management of such trainings.

Part 3 Conclusion

The first part of this document aimed to provide global explanations on main topics of work: Crisis management and pedagogy, joined together in the Expert'Crise project which is at the origin of this PhD thesis. This summarized description of these topics was required in order to introduce the state of the art of crisis management training and, more precisely, their design which was carried out in the second part of this document. Then, based on this review and experiences from Expert'Crise project, ways of improvement were raised in this same part, particularly related to game-design and how industrial companies consider such trainings. The two main development axes selected for this work consisted, in one hand, in making these trainings more affordable and easier for companies to implement, and, on the other hand, in improving the interactivity of such training to make them more realistic, more efficient as well as more integrated into company organization. Therefore, this third part aimed to push forward these problematics to bring improvements to the crisis management training designing domain.

In order to make emergency and crisis training more affordable for companies, it appeared that reviewing exercises held during Expert'Crise project was a good starting point. Indeed, such revisions led to analysis needs companies expressed at the beginning of their training process. Those needs appeared to be similar from a company to another and a pool of the most common needs expressed was built. Moreover, beside needs analysis, a comparison of emergency system was proceeded both because the opportunity arose with a relevant – even if not statistically representant – company sample and because similarities in emergency organization are helpful keys to understand how a specific company run under an emergency situation even if its emergency plan is incomplete. Therefore, based on this experience, a design methodology was proposed, starting with the framework where such trainings are held. Emergency planning analysis as well as needs analysis led to consider either who in the organization must be a trainee and what crisis mission must be tested with, as a consequence, interactions that must occur. These elements, beside times and areas' limits define the environment where the scenario must take place. Then, the scriptwriting process may be detailed once this canvas is defined. This process is based on the concept of situation task: a dedicated situation trainees are involved in and that must lead them to perform specific tasks, identified as missions the exercise must test, that involved competencies targeted. The choice of situation is the consequence of the needs and emergency management analysis. These situations-tasks constitute milestones in the script which are developed alongside the scriptwriting process. Once the global structure of the

scenario, including these milestones is defined, an accidental sequence must be chosen in order to provide a reason for the crisis unit to activate and start emergency process. Then, based on the choice of a particular disaster, the script is extended based on what can be expected from each trainee and stakeholder. First, the script is written under a table form, with a 15-minutes meshing, gathering situation-tasks, first incentives and perturbations. Then, it is refined into a 5-minutes meshing that integrate trainees' possible reactions and how the scenario should process. In the end, the script is fully written then is split into the different facilitator sheets constituting the base of exercise facilitation and the main tool they have to carry the exercise.

The methodology presented in this part aim to be the easiest possible to implement but remains relatively technical for a novice. That is the reason why this part concludes with an example of how to use this method on a very theoretical company meeting with the more common needs observed during Expert'Crise project and having the most common emergency planning features. This example aims to be directly used by companies as a start-point for designing their own exercise by adapting it and implementing it in their organization with as little work as possible.

However, even if this method aims to ease the organization of emergency and crisis exercises through the scriptwriting process, it is little help for facilitation. This part of crisis and emergency trainings management remains technical and may be difficult for neophyte to perform without any previous experience. Such difficulties constitute a limit of the methodology which may be hardly overcome by methodology only.

Conclusion

Based on experience gathered from trainings organized in 19 Walloon Seveso companies and ways of improvements coming from game-design field, a scriptwriting methodology for crisis and emergency exercises has been developed and constitutes a significant simplification of existing methods, more suitable for industrial companies' environment. The development of this method was iterative, based on a training project – the Expert'Crise project – aiming no specific research purpose but close to industrial needs and expectations. This proposed scenario framework meets most common pedagogical needs as well as most common emergency organization features. Therefore, it allows even companies, that do not want to involve a lot of resources in developing such exercises, to test their emergency planning and train their teams by proposing scenarios that can be easily implemented.

Moreover, in the continuity of existing methods, most pedagogical features are kept with less customization possibilities in order to streamline the scriptwriting process and make it more understandable for non-expert scriptwriters. This process is divided in two main parts: the first one defines a pedagogical and organizational framework for the exercise while the second part consists in working inside this framework to develop exercise contents according to pedagogical targets aimed. In the first part, company's needs are assessed and its organization is reviewed to define who must be involved in exercises according to targeted needs. Then the interactions trainees could have during the exercise with internal workers or external stakeholders are assessed to build an adapted environment for the training. In the second part, several situations-tasks are defined. These pedagogical components consist in setting a special situation in order to make trainees perform an action and thus involve them in a cognitive process harnessing targeted competences. These situations-tasks are then arranged in a scripting framework inspired by the Vogler method. Once the pedagogical script is defined, the accidental sequence may be chosen and the script written in a table. This first table uses a 15-minute meshing and is refined in order to have progressively more details in the script and more inputs for trainees. Then the 15-minute meshed table is refined in a 5-minute meshed one that also considers possible reactions from trainees in order to anticipate evolutions of the scenario and inputs required to keep the exercises under control, focused on pedagogical targets. In the end, this last table is transcribed in a written script that allows to fully review the scenario and

identify possible lacks. This script is dispatched with little adaptations to facilitators in order to provide them enough information to facilitate exercise.

This design methodology can still be improved and is not intended to be extensive and be able to deal with every training situation in Seveso companies related to emergency and crisis management. Then, tools and helps proposed in this document – especially situations-tasks repository – aim to be generic enough to be easily adapted from a situation to another and complete enough to be directly implementable. However, they are not exhaustive and can be extended to fit more specific situations or include situations not taken into consideration. Then, despite being not extensive, the target of this work is reached, proposing an easy solution to implement trainings in industrial organizations. On the other hand, because the method proposed is relatively simple, it comes with several limitations. First, it is only a conception methodology and it does not focus on exercise conduct or its analysis. Then, because feedbacks and experiences gathered during Expert'Crise project were mainly related to emergency management, this method is more adapted for emergency exercises. Especially, the Annex 6 – which is a dedicated tool for companies to easily design exercise – aims to design (basic) emergency exercise. It could be adapted for crisis management exercise but some elements are not totally adapted. Moreover, for the same reason, this method is more suitable for designing exercises in an industrial environment and, more specifically, in companies using dangerous substances, similar to Seveso ones. Indeed, because the needs and emergency plans reviewed belonged to such organizations, the global analysis should not be extrapolated too much and is probably not adapted for other kind of organization. In the end, to conclude with the limits of the proposed method, because the pedagogical approach used is based on collective learning – who perform the action of a situation-task does not matter in this method because only the realization of the task can be monitored – it is difficult to assess individual competences improvement. In addition, in the Expert'Crise's context where some companies involved have very little emergency culture, it is difficult to state if trainings done really trained workers or if they only raised awareness for a better emergency planning.

Nevertheless, several questions are raised by this work and can be resumed, *in fine*, in one: Is such scriptwriting method enough to make chemicals hazardous companies improve their emergency organization? Indeed, all the purpose of this work consists in improving emergency and crisis management of companies so it matters to wonder if the global target can be reached and how methodology proposed contributes to it.

The first thought that can be developed and was introduced at the end of Chapter 6 relates to the usefulness of such trainings for companies targeted. Indeed, as discussed, an important part of Seveso companies has important lacks in their emergency planning that do not allow them to perform an emergency management in adapted conditions. Moreover, sometimes these lacks lay on a very elemental level such as in the warning chain or the function/mission distribution. In addition,

workers – including managers – in the plant have rarely a good understanding of the emergency plan. With a notable exception of evacuation procedures – which are usually regularly tested – stakeholders involved in emergency or crisis management are often not (well)-trained to the missions they have to perform according to the plan. Therefore, the exercises proposed in this document as well as those proposed in existing methodologies could be too complex for some companies because they implicate that emergency/crisis managers know – at least a little – the emergency plan and they consider that these procedures are correctly designed, including emergency management basics and mandatory actions to do. It appeared, at several times during Expert'Crise project, that companies were not ready to deal with complex situations. Therefore, easier exercise had to be designed, with the same methodology but according to simpler pedagogical targets and more help than what can be expected from hazardous companies. In such case, other kind of exercise can be implemented – and be more suitable – such as run-through or those introduced at the end of Chapter 1. Indeed, even if it was possible to design adapted exercise with the proposed methodology, this one is over-size to design simple run-through exercises which can be easily organized, even by unprepared companies.

Therefore, pointing out that several Seveso companies have defective emergency organization that require easier trainings do not disqualify neither trainings developed in this document as well as their design methodology. Similarly, this document does not disqualify previous scriptwriting methodologies that remain relevant to develop in-depth exercises aiming precise pedagogical target. Then, it is mainly a matter of unfitting target audience with several hazardous chemical industries having a readiness level for emergency or crisis situations below expectations. However, such circumstances seem to be incompatible with the hazard level of such companies which lead to the second thought that can be developed in this conclusion.

Condition of emergency planning in some Seveso companies question the political will to impose a better emergency management to these organizations. As often in risk management, it is more a matter of politics than a matter of scientific or technical limitation. Many reasons can explain such decision – economical, social, political and so on – but they will not be developed further here because it is a complex and sensitive topic. Considering both present emergency planning regulation as well as Walloon Seveso companies' situation on this topic, a gap appears between what is expected and what is implemented in companies. Such gap cannot be filled with a legal answer only and must be supported by stricter control and audit by authorities with the possibilities of actual penalties for companies that do not comply with the regulation. Nevertheless, such decisions set is a political responsibility, related to society's choices and not to technical or scientific possibilities. This work can only contribute by pointing lacks in emergency planning of Seveso companies and by developing tools to simplify the making of emergency or crisis exercises to make them more affordable.

These two developed thoughts – the actual situation of emergency planning in Seveso companies and its political management by authorities – are not scientific matters. Moreover, even if they significantly impact the reachability of the global target which is to improve emergency and crisis management of companies, scientific or technical work, similar to this one, has little chance to improve the situation. Therefore, it matters to focus on others circumstances that could limit companies in implementing emergency and crisis exercises despite having a relatively simple methodology to do it. Then, two main limits of the proposed methodology appeared and emerged at the end of the Expert'Crise project.

First, this document only proposes a scriptwriting methodology but, as mentioned at the end of Chapter 8, it does not help to manage and lead such training. Moreover, conducting an exercise is not an easy task and requires specific competences such as flexibility, adaptivity, creativity, multi-tasking, team management and communication. Even if a properly scriptwritten scenario is a significant help to manage an exercise, it is not enough to efficiently assist a novice exercise manager. However, transmitting this kind of competences is not possible only through a document as this one. Therefore, dedicated trainings are required to make exercise managers able to properly conduct a crisis exercise, possibly through immersive trainings or serious games. Currently, training of novice exercise managers is done through by companionship, with the help of experienced exercise leaders who have managed several crisis simulations. However, such approach is not suitable for the situation of a SHE manager having to manage an exercise without previous participation in an exercise and who need to train oneself in order to do it. Therefore, developing trainings allowing to self-learn could be an adapted solution for such situation and would make crisis and emergency trainings more affordable for companies. In any case, the difficulty to make a neophyte proficient in managing a crisis exercise is a significant limit to make companies organize their exercise by their own.

Second, this document does not deal with the processing of observations and record of the exercise, analyzing problems encountered during the exercise. Indeed, in order to maximize trainings' outputs, an analysis of trainees' actions and behaviors is required to help the reflective process, which is an integral part of the learning and understanding process. Moreover, this kind of analysis is a relevant input for reviewing and auditing the company's emergency organization in order to raise problems and propose improvement axes. Furthermore, analysis and feedbacks after exercise are usually positively received by crisis managers (and other involved stakeholders) who can note that their involvement in an exercise has output and consequences, involving them more in emergency management and increasing their sensibility to such topics. However, crisis and emergency exercises analysis are a complex task that may need more or less work according to purposes aimed. Lapierre, for instance, developed a method to provide a "hot" analysis right after the exercise to directly induce the reflective process (Lapierre, 2016). However, such method, as it is performed in a short time, cannot be an in-depth

analysis and do not raise organizational matters. On the other hand, during Expert'Crise project, another method was used, based on situation-task implemented in the script and targeting each main issues the crisis unit had to deal with to analyze the solving process and identify bias and difficulties encounters (Vandestrade, Dubois, & Van Daele, 2018). Similarly to exercise management, such type of methodology is not easy to carry out: it is a time and resource consuming process requiring to be improved to allow companies to make their own analysis based on feedback of their exercise. However, considering how heavy and complex this analysis work currently is, developing a lighter and/or easier way to process an emergency or crisis exercises analysis would be a significant work.

Moreover, the deeper the analysis method is, the more difficult it is to perform. Considering that a more extensive review of an exercise is more relevant but more resources consuming, a compromise must be found between exhaustivity and cost-effectiveness. Nevertheless, in any case, it would significantly help companies for implementing crisis and emergency exercises and reviewing it by their own, making crisis and emergency training more affordable and with more outputs than it is currently.

In summary, besides political choices related to risk management of hazardous chemical companies, two parts of crisis and emergency exercise domain remain to be developed. Indeed, even if there are always improvement ways for the upstream of the implementation of such kind of exercise, the design of these trainings is a process well-marked. Therefore, it seems more relevant to develop the downstream of this process or, in other words, the management and the analysis of such exercise.

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2018

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Annex 1: Needs Analysis Database

		Exercise																				Total	Nb as 1st axe	Nb as 2nd axe	% of the ped. axe	% of the total
		A B C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S								
Operational Response Management	Determining operational response				1	2			1		1	1		1		2	1	1		11	2	7	16%	3%		
	Adequacy of resources				1	2			1		1			1		2	1	1		10	2	6	15%	3%		
	Planification and monitoring of actions taken						2	1		1		1	1		1		2			9	2	5	13%	2%		
	Exclusion area, block and check point, substitution routes			1						1		1	1		1					5	0	5	7%	1%		
	Feasibility study of actions																			0	0	0	0%	0%		
	Data collection of available resources					1		1											1	3	0	3	4%	1%		
	Routing time assessment			1																1	0	1	1%	0%		
	Backup monitoring						2	1							1					4	1	2	6%	1%		
	Knowledge of available resources																									
	Knowledge of administrative police power																									
	Prioritization of objectives					1	2						1				2	1	1	8	2	4	12%	2%		
	Priorities assertion					1	2					1			1				1	6	1	4	9%	2%		
	Operational Response Management				1		1	2	1		1		1	1		1		2	1	1	13	2	9		Total	17%
Crisis Unit Management	Available data collection			2	2	2	1	2	2	2	2	2		2	2	2	1	2	2	28	13	2	11%	7%		
	Checking and prioritizing information		2			2		2		2			2	2			1			13	6	1	5%	3%		
	Clear Representation and Summery		2	2	2	2	1	2	2	2	2	2	2				1		2	24	11	2	9%	6%		
	Archiving and monitoring action taken															2				2	1	0	1%	1%		
	Determining and prioritizing global strategy		2									2	2		2		1		2	11	5	1	4%	3%		
	Justifying decision											2		2						2	1	0	1%	1%		
	Giving order and instructions					2	1	2	2		2	2		2		2	1	2	2	20	9	2	8%	5%		
	Information pooling		2	2	2			2	2	2				2	2					16	8	0	6%	4%		
	Definition of the roles and missions				2	2	2	1	2	2	2	2	2		2	2	2	1	2	2	28	13	2	11%	7%	
	Resources committed coordination					2			2		2	2			2	2			2	14	7	0	5%	4%		
	Leadership assertion		2																	2	1	0	1%	1%		
	Strategic priorities establishment							2		2	2	2		2	2		1	2	2	17	8	1	7%	4%		
	Ability to delegate							2						2				2		6	3	0	2%	2%		
	Derogate from procedure if necessary				2							2								4	2	0	2%	1%		
	Fast decision-making					2					2	2	2		2		2	1	2	15	7	1	6%	4%		
	Ability to share information		2	2	2	2	1	2	2	2		2	2	2	2	2		2	2	29	14	1	11%	8%		
	Stress management												2							2	1	0	1%	1%		
	Cooperation					2		1	2	2	2	2	2	2	2	2	1	2	2	26	12	2	10%	7%		
	Crisis Unit Management		2	2	2	2	1	2	2	2	2	2	2	2	2	2	1	2	2	32	15	2		Total	68%	

Total	47	
	Total	383

Annex 2: Emergency Plan Analysis Database

Internal firemen									
Company	A	B	C	D	E	G	H	I	
Category	Upper tier Seveso	Upper tier Seveso	Upper tier Seveso	Upper tier Seveso	Upper tier Seveso	Upper tier Seveso	Upper tier Seveso	Lower tier Seveso	
Info level on emergency planning	Good	Good	Good	Bad	Good	Good	Good	Good	
Size	250 to 499	20 to 49	100 to 249	100 to 249	20 to 49	20 to 50	100 to 249	50 to 99	Total
Onsite Operation	Chef d'équipe d'intervention	EPI (3)	1er ESI	Superviseur	Processman	Resp. d'intervention	Responsable d'intervention	Chef EPI	14
	Equipiers d'intervention		ESI	Equipiers		Equipiers de seconde intervention	Equipiers d'intervention	EPI	
	Electrician								
Evacuation	Responsables d'évacuation	Responsable de point d'évacuation	Responsable recensement	?	Responsable évacuation	Responsable administratif (Assistant de direction)	Responsable d'évacuation	Responsables d'évacuation	16
First aid	Secouristes	Secouristes industriels				Responsable 1er soins			8
Guard	Operating room operator	Chef 1er Intervention	Guard	I Guard A Guard		Operator in control room			6
Comment	<p>The operator of the operating room is not on the field as the other firemen and is in charge of communication and coordination</p> <p>The Chef de 1er intervention is not on the field and is a relay for information in the warning chain and coordinate EPI</p> <p>The guard is not on the field and is a relay for information in the warning chain and coordinate EPI</p> <p>I Guard is not on the field, on the other side of the plant. Little team. Not really trained for firefighting. Not all doc.</p> <p>Small company. Some manager are also ESI. Operator in control room is not on the field and is a relay in warning chain. Control room seem to be in crisis cell.</p> <p>Typical. In early phases of the situation, a lot of actions depend of the Responsible d'intervention then the focus is on crisis cell.</p> <p>Responsible du site or Conseiller en prévention may be mobilized instead of Chef EPI</p>								
Nb Levels	3 : Minor/ Serious/ Major	3 : Minor/ Serious/ Major	2 : Alert/ Alarm	5 : 0/1/2/3/4	1	Not formalized. About 2 (Alert/Alarm)	4 : 0,1,2,3	Not formalized. About 2 (alert/Alarm)	

Internal firemen												
Company		A	B	C	D	E	G	H	I	Total	Comment	
Mission		Evaluation with intervention - "Montée en puissance" well integrated	Evaluation of a safety perimeter onsite by EPI	Collection of 1st observers' information by Guard	Evaluation of the situation onsite by Supervisor	Evaluation of the situation onsite by Responsible Evacuation	Evaluate situation	Evaluation of the situation onsite	Evaluation of the situation onsite	17	Evaluation	
		Operator Trigger emergency plan according information available	Choice of an adapted meeting point and evacuation ensure by Chef de première intervention	Evacuation ensured by Supervisor	Trigger evacuation (alarm)	Evacuation of the concerned area	Evacuation	7	Confirmation			
										Confirmation		
Calling 112 and management		Call the 112 (operator in operating room on command of chef d'équipe d'intervention)	Call 112 by Chef de première intervention	Supervisor Call I Guard to alert emergency services through a call system SIREN	Call 112	Call 112	Operator contact hierarchical line	Activate Crisis cell	Call 112 then send someone at the gate to ensure this one is open	13	Call 112	
												(Call responsible - Actually not sure)
				Call management								

Internal firemen										
Mission										
Company	J	K	L	M	N	P	R	S	T	Comment
Evaluation, alarm or alert trigger and evacuation	Evaluation of the situation on a control panel	Evaluation of the situation onsite and decision to trigger PIU	Evaluation of the situation onsite and then trigger alarm	Garde statique send garde mobile evaluate the situation	Operating manager evaluation situation (through camera) and decide to trigger general horn	Evaluation of the situation on a control panel then onsite by the Responsible d'intervention	Evaluate situation	Evaluate situation and let alarm ring	Evaluation of situation (check if a call to 112 is needed)	Evaluation
	Evacuation	Trigger alarm and evacuation		Evacuation and contact with Responsible de batiment	Trigger local horn, try to extinguish and, if not possible, leave	Trigger alarm and choice of evacuation point by Responsible d'intervention			Evacuation of the concerned area	Trigger alarm/Start Evacuation
					Choice of an evacuation responsible by Operating manager then evacuation				Evacuation of contractor	Choice of an evacuation point/ Evacuation specific population
Calling 112 and management	Fill emergency fax then call 112	Call emergencies services	Call 112	Call112 ensured by Garde fixe who also call internal firemen then trigger automatic call system (which inform HSE and cadre de garde)		Call 112 ensured by Responsible d'intervention	Call management team then 112 by Gardes fixes		Call 112	Call 112
	Call Cadre d'astreinte	Call Controleur Principal d'incident			Call a member of management team (Fonction Conseiller)	Responsible d'intervention Call Resp. Gestion des acces and ask him to call Responsible Principal	Call management team then 112 by Gardes fixes		Contact Directeur	Call management

Annex 2: Emergency Plan Analysis Database

Internal firemen											
Mission		Safing, perimeter and intervention by internal firemen									
Company	A	B	C	D	E	G	H	I	Total	Comment	
Internal firemen	Set a safety zoning										
	Safing of installations decided by Chef de première intervention	Safing of installation	Decision to mobilize EPI or technician	Establishing a strategy then intervention according to the situation	Meeting and briefing of intervention team	Safing of all installations	Safing some installations then evacuation	Bypass rain drain to chemical station	10	Safing all or part of installation	
									12	Evacuation of specific devices	
									7	Meeting and coordination with ESI / Intervention / Setting firemen device / Alert other companies	
Welcoming and assisting firemen	Meeting with emergency services and coordination of intervention	Call Y. control room and gate by CPI	Coordination of intervention by 1st EPI	Meeting and interfacing with firemen by Supervisor	Meeting with emergency services and coordination of intervention	Meeting with firemen and leading them on site by Operator	Meeting with firemen, coordination of intervention with Resp. Intervention then with management. Providing info. on weather, nature/amount of dangerous goods to firemen by Resp. Intervention	Provide information on dangerous by filling dangerous good localization on the site file	11	Meeting and leading firemen	
									8	Stay available / Provide information	
Count/report casualties	Evacuation of casualties by (unprotected) EPI										
	Evacuation and first aid										
Count/report casualties	Report name of casualties of casualties of Call management										

Internal firemen											
Company		J	K	L	M	N	P	R	S	T	Comment
Mission		Internal firemen									
		Safing, perimeter and intervention by internal firemen									
		Safing of installation if needed and bypass fire drain									
		Safing of installations									
		Safing of raindrain									
		Safing of installation									
		Decision of the safing taken by Resp. Production									
		Safing Evacuation of specific devices									
		Safing									
		Evacuation of specific devices									
Welcoming and assisting firemen		Safing									
		Safing of installation									
		Decision of the safing taken by Resp. Production									
		Safing									
		Evacuation of specific devices									
		Safing									
		Evacuation of specific devices									
		Safing									
		Evacuation of specific devices									
		Safing									
Count and report casualties		Safing									
		Safing of installation									
		Decision of the safing taken by Resp. Production									
		Safing									
		Evacuation of specific devices									
		Safing									
		Evacuation of specific devices									
		Safing									
		Evacuation of specific devices									
		Safing									
Internal firemen		Safing									
		Safing of installation									
		Decision of the safing taken by Resp. Production									
		Safing									
		Evacuation of specific devices									
		Safing									
		Evacuation of specific devices									
		Safing									
		Evacuation of specific devices									
		Safing									

Internal firemen										
Company	A	B	C	D	E	G	H	I	Total	Comment
Mission	Counting people after evacuation		Print attendance list (Guard) Count worker attendance at evacuation pointResp recensement						13	Print list
	Control access		Checking if site access are controlled by Guard	Take incoming call from stakeholders, media etc... by Afton guard					15	Count worker
									16	Control acces
Other									15	Other
Action scope		83%	83%	96%	87%	83%	83%	83%		
	Almost at the same level as official firemen with similar formation.	Evaluation, safing, ensure safety of evacuation, communication and coordination with firemen, zoning	Evaluation, rescue, intervention and safing Quite wide scope considering the size of the team	Only evaluation et contact with emergency services. Very limited	Evaluation and call emergency services and management then evacuate	Evaluation and intervention. Despite not being numerous	Evaluation, safing and firemen help	Mainly evacuation and 112 alert. Few interventions order but seem to not be well known		

Company		J	K	L	M	N	P	R	S	T	Comment
Internal firemen	Mission	Counting people after evacuation	Checking worker list then evacuation				Print attendance list (Responsable gestion des accès et complotage) Count worker and inform Responsable d'intervention (Responsable gestion des accès et complotage)				Count worker and transmit this information to HR service
		Control access					Stop journalists and postpone communication to an ulterior press point (Responsable gestion des accès et complotage)				Control acces
		Other	Call CGCCR	Call Expert for support if needed							Other
	Action scope	Evacuation and safing. No specific intervention	Evaluate, evacuate and safing.	Evaluation and alert.	Mainly evaluation, evacuation and coordination with firemen. <i>A quiproquo may occurs between firemen and internal firemen</i>	Mainly evacuation. Evaluation is facultative. There is a big difference between what's written and how it is interpreted.	Alert, evacuation, intervention. Wide scope of intervention	Evaluation, alert and evacuation. No intervention. Very limited	Evaluation and intervention if possible. Limited scope	Evacuation and help to firemen. Limited scope of intervention	
			91%	87%	83%	83%	96%	83%	83%	91%	

Company	A	B	C	D	E	G	H	I
Warning chain	Observer/ Sensor	Observer/ Sensor alert EPI or CPI	Observer/sens or (operator in control room)	Observer/ Sensor (operator in control room)	Observer/ Sensor alert Processman send Responsible d'évacuation evaluate situation	Observer/ Sensor	Observer/ sensor/ recall system	Observer
	Opérateur in Contrôle room send internal firemen	CPI trigger alert or alarm	Call to Guard post	Operator inform Supervisor	Processman send Responsible d'évacuation evaluate situation	Call control room or trigger horn	Alert signal and possibly call to Responsible d'intervention	Observer call Chef ESI
	Chef d'équipe d'intervention evaluation situation	Directeur des secours come in control room and CPI brief him	Guard call 1er ESI and Responsible PCO	Supervisor check situation onsite	Processman call 112	Guard call Responsible d'intervention (or self mobilized by horn)	Responsible d'intervention check on site	Chef ESI call 112
	On demande of Chef d'équipe d'intervention, Opérateur call 112	CPI call 112	On demand of 1er ESI or PCO, Guard trigger alarm	Supervisor call I. Guard	Process man call management	Alert system informs Oktopus which call Control to check the situation. Without answer call 112	Responsible d'intervention call 112	Chef ESI trigger alarm (evacuation) signal
	Opérateur call cadre de garde	Directeur des secours alert other compagnies of the zoning	Guard call 112	I. Guard call 112		(No direct call to 112)	Trigger Alarm and crisis system (recall)	Someone chosen by Chef ESI go at the gate
	Opérateur call Responsable de la maintenance		PCO decide to mobilize PCS	Supervisor call A. Guard				Alert to management not clear
	Opérateur trigger alarm			A. guard call Standby Manager and Area Manager				

Company	J	K	L	M	N	P	R	S	T
Warning chain	Observer /Sensor (operator in control room)	Observer /Sensor	Observer /Sensor	Observer /Sensor	Observer trigger alert	Observer /Sensor	Observer /Sensor	Observer /Sensor	Observer /Sensor
	Operator call Responsible d'intervention	Observer trigger alert system	Trigger alert signal	Guard receive information and mobil guard check onsite	Operating manager evaluate situation on screen	Check on a control panel or onsite by Responsible d'intervention	Guard send Rondier check onsite	Alert (horn)	Opérateur trigger alarm
	Responsible d'intervention call 112	or Automatic alarm trigger	Responsible d'intervention evaluate situation onsite	Guard call Responsible d'intervention	Operating manager call Fonction Conseil ou Fonction Direction	Trigger alarm and so PIU	Guard call ERC	Brigadier evaluate situation	or Automatic alarm trigger
	Responsible d'intervention call Cadre d'astreinte	Contrôleleur d'incident check the situation	Responsible d'intervention call 112 (and automatic alert)	Guard trigger call system	Operating manager call 112	or Automatic alarm triggering after delay	Guard call EHS	Brigadier trigger alarm	Opérateur call Responsible QHSE
	Responsible d'intervention meet firemen at meeting point	Contrôleleur d'incident call 112	Responsible trigger alarm	Guard call 112		Responsible d'intervention call 112	On demand of ERC, Guard call 112	or Automatic alarm trigger	Responsible QHSE call 112 (? Not clear)
		Contrôleleur d'incident call Contrôleleur principal d'incident	or Automatic alarm trigger			Responsible d'intervention call		Automatic 112 alert (?)	Responsible QHSE call Directeur Packaging or Directeur industriel
						Responsible des Accès and ask him to call Responsable Principale		Automatic responsible alert (?)	
						Responsible des accès call Responsable Principal			

Annex 2: Emergency Plan Analysis Database

Crisis Management										
Composition										
Company	A	B	C	D	E	G	H	I	Total	Comment
Executive officer	Personne de garde	Directeur des secours	PCS Responsable	Plant manager	Responsable usine	Coordinateur des secours (manager du site)	Directeur des Opérations Internes	Responsable site	17	100%
			PCO Responsable	SHE Manager					4	24%
		Resp. Exploitation		Standby and Area Manager			Fonction Exploitation	Conseiller en prévention	7	41%
	Responsable Comm. (HR manager)	Resp. Comm.	PCS Coordinateur comm. PCO Coordinateur comm.	HR Manager	Responsable comm.		Fonction Comm.	Responsable ressources humaine	10	59%
									2	12%
									1	6%
		Secretariat	PCS Rapporteur PCO Rapporteur			Resp. administratif	Fonction Secretariat		7	41%
									2	12%
	Employé du service du personnel	Resp. SIPP							6	35%
									1	6%
HR									2	12%
Technical	Responsable Maintenance (Resp. Tech.)	Resp. Maintenance				Responsable technique (resp EIA)			5	29%
									1	6%
Logistical						Responsable transmission (resp logistique)	Fonction Logistique		3	18%
Others									1	6%
						Responsable 1er soins			1	6%
							Fonction Renfort		3	18%
									5	29%
Functional ?	Yes	Yes	No	No	No	Yes	Yes	No		

Crisis Management									
Composition									
Company	J	K	L	M	N	P	R	S	T
Executive Officer	Cadre de garde	Contrôleur principale	Manager DD	Direction site	Fonction Direction	Responsable Principal	Emergency Response Coordinator	Directeur Générale	Coordinateur
			Coordinateur site					Directeur site	
First Officer		Direction			Fonction Conseil				Copilote
Communication				Comm. externe		Responsable comm.			Support Comm.
				Comm. interne					
				Centre de comm.					
Secretary				Scriptor	Fonction Secrétariat				Main courante
				Runners					
SHE			Coordinateur environnement	HSE				Responsable QSEP	HSE
			Conseiller prévention						
HR				Ressources humaine					RH
Technical								Responsable maintenance	(Optional) Maintenance (Facultatif) Production/ Technique
Logistical									(Optional) Logistique
Others				Liaison officier					
				Support Security					Support Intendance (Facultatif) Informatique
		Expert		Conseil juridique		Other available manager (Fin& HR, Logistic and Planif. HSEQ, Prod)	Other managers available in Emergency Response Team		
Functional ?	Yes	Yes	No	Yes	Yes	Yes	Yes	No	Yes

Crisis Management								
Company	A	B	C	D	E	G	H	I
Comment	Functional attribution according to availability and/or abilities. Personnel may be : Site manager, HESQ manager, Consultant in prevention, coordinator security, production managers, production coordinators	Functional attribution. 2 backups named for each function.	Not really a functional repartition. PCO (Poste de commandement Opérationnel) tactical level focused on operational problematic PCS (Poste de commandement Stratégique) strategic level focused on communication and political problematic Montée en puissance between these two levels is not clear	Board of the company. The hierarchy remains the same with SHE taking the lead.	Not a functional attribution. The crisis room is an unused unequipped room not really functional for this use	Not enough people for every role. Ambitious but without resources	Functional repartition. Attribution matrix with several backup	About crisis room: very little, at the gate of the site. Crisis team seem to not be well trained
On duty person	Personne de garde	Directeur des secours	1st ESI	Standby Manager	No	No	Directeur des Opérations Internes	No
Recall system	Yes	No	No	Yes - SIREN	No	Yes - Oktopus	Yes	No

Crisis Management									
Company	J	K	L	M	N	P	R	S	T
Comment	Automatic process so few worker onsite.Objective is mainly to ensure worker safety.	Functional repartition. Mobilization and how the crisis room work is not clear. The crisis room is an unused unequipped room not really functional for this use		Functional attribution for first row of crisis member then not a functional attribution. A lot of people but without a clear "montée en puissance" process meaning everybody is mobilized even if it is not needed	Two different site. Few people with unclear localization. For instance, Responsible Direction may be on field. There are 2 documents explaining emergency planning but they are not coherent	Only 2 static functional roles with eventually the support of other manager not in duty.	Little management team with few instructions on what they have to do.Big gap between PUI and PCA.	Very little structure. Unclear procedures.No clear instruction on who have to do what, not even authorities to call.	Functional repartition. Each function assigned to 2 person (one back up for each function (even for facultative ones))
On duty person	Cadre de garde	Contrôleleur d'incident	Yes - Management and technician	Cadre de garde	No	Responsible Principal	ERC	No	No
Recall system	Yes	Yes - Oktopus	Yes - Belgacom Alert service	Yes - FAKT24	Yes - Oktopus	Yes	No	Yes	No

Crisis Management										
Missions										
Company	A	B	C	D	E	G	H	I	Total	Comment
Calling authorities	Call authorities	Call authorities	Call authorities	Call authorities	Call authorities	Communication with authorities	Call authorities	Call authorities	12	Call authorities (generic)
	Call CGCCR	Call CGCCR	Call CGCCR	Call CGCCR	Call CGCCR	Call CGCCR	Call CGCCR	Call CGCCR	14	Call CGCCR
	Call DCRC	Call DCRC	Call DCRC	Call DCRC	Call DCRC	Call DCRC	Call DCRC	Call DCRC	14	Call DCRC
	Call SOS	Call SOS	Call SOS	Call SOS	Call SOS	Call SOS	Call SOS	Call SOS	11	Call SOS
	Pollution	Pollution	Pollution	Pollution	Pollution	Pollution	Pollution	Pollution	7	Call RAM
Alerting neighboring companies	Call RAM	Call RAM	Call Commune	Call Commune	Call Commune	Call Commune	Call Commune	Call Commune	9	Call Communal representant
	Call Province	Call Province	Call Province	Call Province	Call Province	Call Province	Call Province	Call Province	7	Call Provincial representant
	Call Essencia	Call Essencia	Call Essencia	Call Essencia	Call Essencia	Call Essencia	Call Essencia	Call Essencia	7	Call Essencia
	Trigger the call system	Trigger the call system	Trigger the call system	Trigger the call system	Trigger the call system	Trigger the call system	Trigger the call system	Trigger the call system	8	Specific action / commentaries
Alerting neighboring companies	Communicate with neighboring companies	Stay in contact with zoning companies	Ensure coordination with zoning (neighboring) companies	Ensure coordination with zoning (neighboring) companies	Ensure coordination with zoning (neighboring) companies	Ensure (passively) comm. with neighboring companies	Call neighboring companies	Call neighboring companies	11	Communicate to neighboring companies
	Communicate to other services of the company	Communicate to other services of the company	Communicate to other services of the company	Communicate to other services of the company	Communicate to other services of the company	Communicate to other services of the company	Communicate to other services of the company	Communicate to other services of the company	7	Communicate to civil neighbors
Alert other manager and corporate level	Communicate to other services of the company	Communicate to other services of the company	Communicate to other services of the company	Communicate to other services of the company	Communicate to other services of the company	Communicate to other services of the company	Communicate to other services of the company	Communicate to other services of the company	14	Alert internal stakeholder (managers,...)
	Communication with corporate crisis center and public affairs	Communication with corporate crisis center and public affairs	Communication with corporate crisis center and public affairs	Communication with corporate crisis center and public affairs	Communication with corporate crisis center and public affairs	Communication with corporate crisis center and public affairs	Communication with corporate crisis center and public affairs	Communication with corporate crisis center and public affairs	14	Alert corporate level
First aid, counting casualties and contact with families	Get information about casualties and accident	Get information about casualties and inform their families	Identify casualties and count them	Identify casualties and count them	Identify casualties and count them	Identify casualties and count them	Identify casualties and count them	Identify casualties and count them	14	Get information on casualties
	Coordination of the first aid and evacuation of casualties.	Coordination of the first aid and evacuation of casualties.	Coordination of the first aid and evacuation of casualties.	Coordination of the first aid and evacuation of casualties.	Coordination of the first aid and evacuation of casualties.	Coordination of the first aid and evacuation of casualties.	Coordination of the first aid and evacuation of casualties.	Coordination of the first aid and evacuation of casualties.	14	Give or coordinate first aid
	Ensure relation with D2 and D3	Ensure relation with D2 and D3	Ensure relation with D2 and D3	Ensure relation with D2 and D3	Ensure relation with D2 and D3	Ensure relation with D2 and D3	Ensure relation with D2 and D3	Ensure relation with D2 and D3	14	Give or coordinate first aid
	Inform casualties' family	Inform casualties' family	Contact and relation with casualties' family	Contact casualties' family and give information and offer resources	Contact casualties' family and give information and offer resources	Contact casualties' family and give information and offer resources	Contact casualties' family and give information and offer resources	Contact casualties' family and give information and offer resources	14	Contact casualties families

Crisis Management											
Missions											
Company	J	K	L	M	N	P	R	S	T	Comment	
Calling authorities	Call authorities	Communication (passive) with authorities	Call authorities	Call authorities	Call authorities	Call authorities	Call authorities	Call authorities (without details)	Call authorities (generic)		
	Call CGCCR		Call CGCCR	Call CGCCR	Call CGCCR	Call CGCCR	Call CGCCR		Call CGCCR		
	Call DCR		Call DCR	Call DCR	Call CBE	Call DCR	Call DCR		Call DCR		
			Call SOS	Call SOS	Call SOS	Call SOS	Call SOS		Call SOS		
			Pollution	Pollution	Pollution	Pollution	Pollution		Pollution		
Alerting neighbor companies and/or corporate			Call Commune	Call Commune		Call	Call RAM		Call RAM		
						Bourgmestre and/or PlanU			Call Communal representative		
				Call Provincial					Call Provincial representative		
				Call Essencia					Call Essencia		
Alert other and manager corporate				Liaison officer with authorities			Contact list with no explanations		Identify stakeholders	Specific action / commentaries	
	Call neighboring companies	Ensure (passively) comm. with neighboring companies	Alert neighboring companies	Alert neighboring companies						Communicate to neighboring companies	
			Ring horn to alert neighbor							Communicate to civil neighbors	
First aid, counting casualties and contact with families	Call hierarchical line	Call direction	Call member of emergency planning services and market director	Evaluate situation and clarify roles	Role attribution and goals definition	Alert Site manager, Resp. Comm. and +				Alert internal stakeholder (managers,...)	
					Contact Corporate level	Contact Corporate level			Contact Corporate level	Alert corporate level	
		Collect information on casualties and missing person		Establish casualties' list		Collect information on casualties and missing person				Get information on casualties	
First aid, counting casualties and contact with families						Assess situation and contact psycho-social prevention cell				Give or coordinate first aid	
				Contact with casualties' families (if authorities agreed)		If fatal casualties, decision of external comm. by Site manager					
			Contact and relation with casualty's family							Contact casualties' families	

Crisis Management										
Missions										
Company	A	B	C	D	E	G	H	I	Total	Comment
Media communication and internal communication	Write message for media, make it signed by firemen officer and validated by provincial crisis center	Write message for media diffusion and make it validated by Public Affairs		Write a press document and make it validate by the plant manager	Write a press document and give it to firemen officer		Prepare internal and external comm.		11	Prepare first press statement
		Contact media	Ensure communication with media	Prepare communication and question		Ensure contact with medias	Communicate with media		10	Ensure communication with medias
					Organize press meeting				9	Organize press point/meeting
			Ensure intra-crisis cell comm.	HR manager write an internal comm.			Ensure internal comm.		7	Ensure internal communication
Interaction with firemen, Assistance to EP/ESI, Providing resources	Take contact with operating room and brief about the situation	Communication with Chef de Première Intervention. Assess situation and hazards. Intervention decisions.	Ensure communication with 1st ESI		Check action of Processman, brief about evacuation and evaluate the situation				10	Briefing with operational
			Assist 1st ESI in intervention choice		Assist Processman in intervention choice	Choose intervention strategy, decide evacuation			7	Choose intervention strategy or help EPI/ESI
	Maintenance realize needed electrical or technical intervention	Resp.			Coordinate intervention with firemen and evaluate evolution of the situation		Welcome and lead firemen onsite		8	Welcome, lead and assist firemen onsite
	Provided supply, operators and devices for intervention.	Provide information (plans, ...) and utilities	Provide men and engines			Ensure electricity supply	Provide information and resources		8	Provide information or resources
	Take shut down decision and check if 112 have been called	DirSec check if 112 and zoning companies have been alerted	Take shut down decision. Decide crisis room mobilization and to call 112			Check if loading and unloading are stopped			8	Safing of installation and 112 verification

Crisis Management										
Company	J	K	L	M	N	P	R	S	T	Comment
Media communication and internal communication		Ensure (passively) communication with medias	Write a first press statement	Welcome journalist and restrain them at a specific area. Answer their question	Contact with press partner whose should write a press statement	Write a pre-report then a press paper and submit it to firemen			Prepare communication	Prepare first press statement
			Ensure press contact and communication may		Answer journalist questions (Guideline for press comm.)				Inform media and ensure external communication	Ensure communication with medias
			Organize a press point	Organized press point with authorities		Organize press point				Organize press point/meeting
				Inform worker of the situation regularly and ensure they re ok					Ensure internal communication	Ensure internal communication
Missions		Meet Coordinateur d'incident and have a briefing of the situation. Assist Coordinateur d'incident in intervention choice especially by anticipating (in)direct effect		Communicate with operational level and give feedback to the scripter		Check action of Responsible of intervention			Held an initial point and gather information	Briefing with operational
										Choose intervention strategy or help EPI/ESI
			Welcome and lead firemen onsite		Coordinate intervention with emergency services					Welcome, lead and assist firemen onsite
			Provide all needed information	Provide technical information						Provide information or resources
Interaction with firemen, Assistance to EP/ESI, Providing resources			Alert ELIA	Stop or postpone delivery						Safing of installation and 112 verification

Crisis Management										
Missions										
Company	A	B	C	D	E	G	H	I	Total	Comment
Secretariat	Take incoming call, filter and transmit them						Take meeting demand and inform DOI		16	Take and filter phone call
			Take note and report event			Report evolution of accidental phases	Report data chronologically and support other function in information management		13	Gather and report information on a shared support
			Decide to trigger alarm phases (evacuation)		Print worker and truck driver list	Take worker and visitor list at the meeting point			15	Print list and/or trigger alarm
			Check everyone has evacuate and coordinate workers movement		Ensure evacuation	Ensure evacuation			15	Ensure evacuation
					Ensure everybody evacuate correctly				13	Ensure everyone have evacuate and/or count worker
Anticipation and strategic decision making	Choose crisis room depending the accident								13	Anticipate evolution and/or impacts
									15	Take strategic decision and facilitate crisis cell
Insurance				HSE Manager contact insurance	Resp.Com Write a report for insurance				13	Deals with insurance
Control at gates					Resp. Evac manage entrance of the site before D3 arrived	Resp. Log control access of site			13	Control acces (if not at operational level)
Comment									13	Other
	Main actions made by Personnel de garde but possibilities of delegation	Clear, except for redundant authority's alert. Not proactive but provide all correct info.	Not sure PCO level and PCS level are functional together and won't merge in one crisis unit	Few documentations and formalization of emergency planning for managers	There are a lot of mission held by Processman who risk to be overflowed.	Few actions because main part of strategic crisis cell is also interventionist which may be a problem	Secretariat and Communication are the same. Exploitation have his phone number display outside the site	Very redundant procedure. Operational missions are written in crisis cell's procedures		

Crisis Management											
Company		J	K	L	M	N	P	R	S	T	Comment
Missions		Secretariat			Report and centralize event or information on flipchart	Gather all information about accident				Take and filter phone call	Take and filter phone call Gather & report information on a shared support
		Evacuation		Ensure evacuation of administrative worker							Print list and/or trigger alarm
				Count worker present and report it to firemen							Ensure evacuation
		Anticipation and strategic decision making	Anticipate end of crisis and cleaning phases	Evaluate production impact					Anticipate long term management (standby of business, logistical matters,...)	Anticipate evolution and/or impacts	
			Direction : validate decision		Make regular point					Decide global strategy and take relative decision	Take strategic decision and facilitate crisis cell
		Insurance									
		Control at gates									
Other		Set up crisis room and crisis call center								Ensure confidentiality	
		Very little crisis team at this level. Afraid the main crisis job was in upper hierarchical level who wouldn't have necessary information	Little crisis management (but not a SEVESO companies). Seem to be efficient enough considering the size and the hazard level of the company	Interaction with upper crisis level seem weird. Interaction probably not as good as intended	Very big team but big site. Maybe too much person or at least too much in the same moment. Little doubt on interaction with firemen services.	Instruction messy, in different document, not very clear what everyone have to do.	Some doubt on interaction between operational team and management team	Not even mention of a PIU-BCP transition.	No specific instruction. Even for authorities call...	It seems crisis management process is a copy past of the french process without adaptation to the new context	
Comment											

Annex 3 : Crisis missions (Lapierre, 2016)

		N°	Pedagogical target	Task
Crisis strategic response	Hazard assessment	11	Determine dangerous phenomenon	I Assess kinetic of the dangerous phenomenon and its spatial range
				N Identify initial/root phenomenon
		12	Knowing the consequences	I Assess consequences severity of the dangerous phenomenon
				N Identify dangerous phenomenon's effects
		13	Anticipate situation evolution	I Assess worsening or reduction of the phenomenon
				N Identify worsening or improving elements
		14	Use model tools	I Asking for phenomenon modelling to an expert and considering results with one's expertise
				I Based on transmitted modelling, request and expert to interpret results
		15	Choose effect's threshold	I Consider threshold of effect for ongoing phenomenon
				N Request different threshold of effect to an expert
		16	Determinate effect's distance	N Consider present and future meteorological situation on the emergency
				N Request an expert to identify worst case scenario
	Determination of impacted issues	21	Characterize impacted issues	N Quantify impacted issues
				N Identify different categories of impacted issues
		22	Manage protective actions on impacted issues	N Implement action protecting impacted issues
				N Identify actions protecting impacted issues
	Anticipation of threatened issues	31	Determine exclusion area and closure obstacles	I Justify safety perimeter choices as well as check points
				N Request setting of a safety perimeter to competent authorities
		32	Gather data on issues	N Request a cartographic support
				N Searching issues categories in legal document
		33	Characterize threatened issues	N Quantified threatened issues
				N Identify different categories of threatened issues
		34	Manage preventive action on threatened issues	N Identify actions protecting threatening issues
				N Implement action protecting threatened issues
	Response's resources and backup management	41	Identify available resources and backup	N Discriminate available and potential (back-up) emergency response resources
				N Searching available emergency response on legal document or by directly contacting external or internal stakeholders
		42	Study actions' feasibility	I Assess adequacy of engage resources with dangerous phenomenon
				N Asking to involved stakeholders if request action is possible
		43	Monitor ongoing actions	I Organize ongoing actions monitoring with a progress chart
				N Contact engaged stakeholders to get information on ongoing actions
	Post-Crisis management anticipation	51	Identify legal and administrative matters	I Select administrative procedures in legal document when specific demand occurs
				N Check if crisis cell monitoring process is operational
		52	Implement legal procedure	I Identify and justify legal actions to ask or to apply according to the situation
				N Ask to a team member to deal with juridical and legal aspect relate to the organization

		N°	Pedagogical target	Task		
Crisis cell management	Crisis cell activation	61	Mobilize crisis unit team	I	Encourage sub-cell manager to contact their operators	
				N	Contact crisis cells member and summon them in crisis room	
		62	Go to the crisis room	N	Looking for emergency reflex sheet in emergency files and read it	
		63	Equip the crisis room	I	Check if crisis cell monitoring process work and alert authorities	
				N	Come at one's emergency workstation and check that everything works correctly	
		64	Manage the crisis unit	I	Formulate instruction to reach targets	
				N	Keep the crisis unit calm	
		65	Organize information transmission	I	Encourage the crisis unit to report action on the monitoring system	
				N	Remind that reading the crisis shared support is very important	
		Team's resources identification	71	Identify lacking competencies	I	Adapt crisis sub-cell processing to match situation requirements
					N	Ensure that each required crisis sub-cell is present
			72	Request lacking competencies	I	Present the situation to an expert
					N	Request help from an expert in the crisis room or support the unit from distance
			73	Anticipate the take over	I	Summon backup team 30-45 before they have to work to prepare them
	I				Inform members of the part of the crisis system not involved in the crisis management that back up may be required	
	74		Identify resources and equipment	I	Rely on devices supporting analysis	
				N	Identify available ressources in the crisis unit	
	Information transmission management		81	Manage information transmission	I	Write gathered data on shared supports
					N	Communicate/Transmit information to crisis unit monitoring process and answer to question person in charge ask
		82	Gather information	I	Classify information received according to their relevance	
				N	Identify what to looking for and from who to collect information	
		83	Share information	I	Use a common language during interaction	
	N			Requestion adapted internal stakeholders		
	84	Archive and monitor ongoing actions	I	Make summary and take notes in each sub-cell		
	Leadership in crisis cell	91	Lead the crisis cell	I	Collectively prioritize objectives	
				N	Present objectives tio reach to all teammates	
		92	Delegate and divide taskwork in the group	I	Delegate some missions to crisis unit members	
				N	Distribute task for each sub-cell	
		93	Show authority	I	Discuss problems meet with crisis unit team members	
				I	Encourage initiative in the crisis unit and highlight it when it appears	
		94	Keep mutual confidence	I	Make suggestion and listen those of other team members	
				I	Encourage problem-solving and identify root cause	
		95	Mediate disputes	N	Identify conflict through crisis team members	
				N	Encourage team members to report the situation	
	Keeping a shared mental picture of the situation	101	Make regular status report	I	Start an status report of the situation	
				I	Update shared support during the exercise	
		102	User shared medium	N	Take note of information on shared support from the beginning of the crisis management	
				N		
	Teamwork coordination	111	Coordinate sub-cells	I	Refer to other team members of the crisis room to procced actions	
				N	Keep other team members informed of action realized	
		112	Make team decision	I	Determine several possible solutions for problems met.	
				N	Identify problem and discuss them in group	
		113	Monitor team performance	I	Identify and take into account mistake done or almost done by other team members	
				N	Check that every sub-cell fulfills its own mission and not other sub-cell's ones	
		114	Support sub-cell	I	Help other crisis team members without they request it	
				N	Help other crisis team members on request	
	Feeling management	121	Manage stress in crisis unit	I	Move to a calm part of the crisis room	
				N	Tell other teammates one's own difficulties	
		122	Manage tiredness in crisis unit	I	Formulate a supply or catering request	
N				Tell other team members one's own difficulties related to tiredness		

		N°	Pedagogical target	Task	
Crisis cell management	Media monitoring	131	Gather information on the event	I	Gather and organize information broadcast by medias
				N	Identify medias broadcasting about the ongoing crisis
		132	Check information	I	Analyze information broadcast by medias and contradict it if required
				N	Listen medias feed broadcast in crisis room
		133	Answer to media questions	I	Agreed with medias on press point and scheduled them
				N	Answer to medias requests
	Media information leadership	141	Define a communication strategy	I	Designate a spokesman for company internal communication
				N	Anticipated the press statement writing
		142	Make a press statement	I	Structure content of the press statement in a groupwork
				N	Get validation from the executive officer before broadcasting press statement outside the crisis unit
		143	Follow strategic decision taken	I	Assign one single contact point for each media
				N	List summary element before external communication
		144	Show persuasion	I	Show confidence during external communication
				N	Inform and be transparent in statements
		145	Deal with media	I	Deal specifically with national and local medias
				N	Take contact with medias
		146	Contact media	I	Request to have access on pictures taken by medias
				N	Request that specialist media cover the situation
	Communication with population	151	Transmit instructions	I	Adapt instructions transmitted according to the nature of the situation
				N	Communicate safety instruction to population and workers
		152	Write a consistent message	I	rephrase to ensure that message is understood
				N	Say short, simple and precise sentences
		153	Choose a relevant communication medium	I	Update the different communication channel choosen and used
				N	Identify existing communication channel
		154	Communication on social media	I	Update message with new element on ongoing situation
				N	Double instruction broadcasting on social media
		155	Deal with social media	I	Answer to requests when asked
				N	Gather information broadcasted on social network
	Communication with authorities	161	Choose the relevant recipient	I	Communicate with dedicated contact person for each department
				N	Contact adapted department for corresponding request
		162	Write a message	I	Use a common language
				N	Adapt one's voice according to the environment
		163	Make regular status report	I	Demand to do actions and justify why
				N	Make summary of the situation to stakeholders
	Communication with emergency response team	171	Choose the relevant recipient	I	Communicate to a dedicated contact person for each stakeholder
				N	Contact adapted stakeholder for corresponding request
		172	Write a message	I	Repeat critical information to interlocutor
				N	Be concise
		173	Coordinate with emergency response team	I	Request feedback or confirmation for ongoing action and/or their outputs
				N	Request to do an action
		174	Identify available resources	I	Request that engaged devices get set up
				N	Ask the quantity of resources involved onsite

Annex 4: Generic situation task

N°	Stakeholders involved	Description of the situation
1	Authorities/ Media/ Emergency services/ Neighbors/ Others	Request information on the situation (the accidental sequence, consequences, evolutions...) and/or about actions taken by crisis unit
2	Emergency services/ Internal firemen or operators/ Experts/ Neighbors (industries and inhabitants)	Provide information on the situation but according to different point of view depending on the source or the recipient of the message and possibly being inconsistent ones with others.
3	Emergency services (firemen)/ Internal firemen or operators	Provide information on the present situation onsite
4	Authorities/ Emergency services (firemen)/ internal firemen/ Neighbors	Provide information and/or question the crisis unit about the situation on topic such as involved hazards, their position, or the odds of such event
5	Authorities/ Medias/ Internal firemen	Question the crisis unit about regulations, legal and juridical aspect of crisis management and crisis group's competencies on such topic and/or propose a support.
6	Auditive or visual inputs injected in a diegetic way by the facilitation and reflecting an evolution of the situation such as explosion, a warning signal...	
7	Authorities/ Medias/ Emergency services/ Internal firemen	Question the crisis unit about its emergency planning, ask for precisions on some points, and possibly request it
8	Call/ Face to face interaction/ Auditive or visual inputs: Evolution of the situation with or without following characterization: fast, complex, with numerous inputs, worsening or improvement the the situation	
9	Authorities/ Emergency services/ Internal firemen or operator/ Other	Provide information and/or question the crisis unit about issues possibly impacted or threatened by the situation, their position and how to protect them
10	Authorities/ Internal firemen, technicians or operator	Propose, suggest or provide support or help either for operational task or on communication problems
11	(Public) authorities/ Media/ Emergency services/ NGO/ Expert/ Neighbor	Input, call mail or face to face integration that challenge or contradict information provided by the company or its representation of the situation.
12	Authorities/ Internal firemen or operators	Request decision-making /taking or a support (either fast or not)
13	Authorities/Medias	Call, mail or face to face interactions requesting information, press statement or a contact point/person
14	(Public) authorities/ Internal firemen /Neighbors (industries and inhabitants)	Variation in the workload – increase or decrease – for all the crisis unit or for some sub-cells. Tasks related to this workload may belongs to another specialty that the sub-cell one's, or not being adapted
15	(Public) authorities/ Internal firemen /Neighbors (industries and inhabitants)	Question the crisis unit about actions they can do in order to, for instance, protect material and/or human issues
16	Authorities/ Media/ Emergency services/ Insurance/ Internal firemen or operators	Call or other inputs referring to a specific piece of information either previously stated by the crisis or discuss with a team member. This information may relate to the crisis, its management or its chronology, and possibly based on monitoring system of the crisis unit.
17	Technical or communication problems for the crisis unit, sub-cells or simulated stakeholders (onsite operators for instance that cannot provide feedback anymore)	
18	Authorities/ Hospital/Emergency services/ Other:	Inputs – such as auditive or visual inputs as explosion sound or ambulance horn sound/light – related to casualties either wounded or dead, and possibly asking or providing information on this topic.

N°	Stakeholders involved	Description of the situation
19	Inputs or situation related to the length or the time of the exercises: long simulation, at night, at lunch time, during a change in shift...	
20	Direct non diegetic inputs from facilitators to redirect trainees on an obvious or a (supposedly) reflex action	
21	All stakeholders	
22	Authorities/ Medias/ Emergency services/ Internal firemen or operators	Call or other reaction in case of lack of communication from the crisis unit. Inability, refusal or no answer/help from stakeholders if the crisis unit does not ask the proper interlocutor (organization or contact person) for a task. Several stakeholders may contact several sub-cells to simultaneous deal with their specific problems.
23	Emergency services (firemen)/ Internal firemen	Propose or required operational or strategic targets
24	Complex situation or problems requiring to be managed by all the crisis unit or a large part of it in order to propose a common scheduled solution, innovative or not.	Introduce or deal with pieces of information relate to event, intervention or other element(s) that may worsen or improve the situation and/or propose several actions based on this information
25	Media, including social medias	
26	Authorities	inputs (call, direct interactions or other, depending on the setting) related to crisis information such as its current situation. Information may be true, partial, or false.
27	Presence of curious onlookers and/or medias possibly malicious. Their presence may or may not be directly introduced to the crisis unit through inputs.	Ask if the crisis unit have already communicated or written a press statement and/or demand to do it
28	Authorities/ Medias/ Emergency services/ Neighbors (industries)	
29	Authorities/ Media /Emergency services/ Internal firemen/Other	Use of a specific language during interactions in order to make the crisis managers ask for reformulate and/or to induce a bad understanding to force crisis unit to ask for precisions
30	Authorities / Emergency services/ Internal firemen	Provide or required confirmation on a blurred, uncertain, partial or wrong information coming from outside the crisis unit
31	Medias/Authorities/Emergency services/Internal firemen or operators/ Others	Require forecast or anticipation related to incoming events or possible evolutions
32	Emergency services (Police)/NGO/ Others	Important number of inputs focused in a short time, possibly on one single sub-cell
33	All stakeholders	State views opposed to crisis unit one's showing lack of transparency in crisis unit communication
34	Authorities/Media/ Emergency services/ Internal firemen	Inputs of several pieces of a shattered information to different team members of the crisis unit, with lacking piece of information, contradictions (or not) and, possibly, questions from sub-cells to help the team making sense with them

Annex 5: Crisis mission and Generic situation relation table

N°	Generic situation	Missions possibly aimed by such situations									
1	Authorities/ Media/ Emergency services/ Neighbors/ Others: Request information on the situation (the accidental sequence, consequences, evolutions...) and/or about actions taken by crisis unit	11I	12N&I	14I	22N	31N&I	34N	41N&N	43N	51N	65N&I
		71N	101N&I	102N	111I	151N&I	154I	162I	163N	173I	174N
2	Emergency services/ Internal firemen or operators/ Experts/ Neighbors (industries and inhabitants): Provide information on the situation but according to different point of view depending on the source or the recipient of the message and possibly being inconsistent ones with others.	11N	12N	13I	21N	64N	82I	83I	84I	95I	
		102N&I	113I	143I							
3	Emergency services (firemen)/ Internal firemen or operators: Provide information on the present situation onsite	12N&I	42I	111N							
4	Authorities/ Emergency services(firemen)/ internal firemen/ Neighbors: Provide information and/or question the crisis unit about the situation on topic such as involved hazards, their position, or the odds of such event	13N	16N	32N	64I						
5	Authorities/ Medias/ Internal firemen: Question the crisis unit about regulations, legal and juridical aspect of crisis management and crisis group's competencies on such topic and/or propose a support.	13I	52N&I	72N&I	82N	14I&I	15N&I				
6	Auditive or visual inputs injected in a diegetic way by the facilitation and reflecting an evolution of the situation such as explosion, a warning signal...	11N	12N	16N	121I	162N					
7	Authorities/ Medias /Emergency services/ Internal firemen: Question the crisis unit about its emergency planning, ask for precisions on some point, and possibly request it	16N	51I	62N	74N						
8	Call/ Face to face interaction/ Auditive or visual inputs: Evolution of the situation with or without following characterization: fast, complex, with numerous inputs, worsening or improvement the the situation	13I	21N	22N	33N	34N	43I	51N	64N	65I	72N&I
		74I	81N&I	84I	91I	101N&I	102I	142I	151I	174I	
9	Authorities/ Emergency services Internal firemen or operator/ Other: Provide information and/or question the crisis unit about issues possibly impacted or threatened by the situation, their position and how to protect them	21N	22N	32N&N	33N&N	34N	64I				
10	Authorities/ Technicians or operator/Internal firemen: Propose, suggest or provide support or help either for operational task or on communication problems	13I	41N	121N	122I	153N	154N				

N°	Generic situation	Missions possibly aimed by such situations									
11	(Public) authorities/ Media/ Emergency services/ NGO/ Expert/Neighbor: Input, call mail or face to face integration that challenge or contradict information provided by the company or its representation of the situation.	12I	31I	42N	144N&I	163I					
12	Authorities/ Internal firemen or operators: Request decision-making /taking or a support (either fast or not)	14I	41N	51I	64N	73I	74N&I				
		111I	112N&I	155I	163I	173N					
13	Authorities/Medias: Call, mail or face to face interactions requesting information, press statement or a contact point/person	12I	43I	52N	81N	131N&I	133N&I				
		141N&I	142N&I	143N	144N	145I	151N&I				
14	Variation in the workload – increase or decrease – for all the crisis unit or for some sub-cells. Tasks related to this workload may belongs to another specialty that the sub-cell one's, or not being adapted	61I	64N	71I	83N	92I	113I	114N&I	121N		
15	(Public) authorities/ Internal firemen /Neighbors (industries and inhabitants): Question the crisis unit about actions they can do in order to, for instance, protect material and/or human issues	22N	34N	61N	111I	151N&I	155I	163I	172I	173N	
16	Authorities/ Media/ Emergency services/ Insurance/ Internal firemen or operators: Call or other inputs referring to a specific piece of information either previously stated by the crisis or discuss with a team member. This information may relate to the crisis, its management or its chronology, and possibly based on monitoring system of the crisis unit.	51N	63I	65N&I	81N&I	84I	102N&I				
17	Technical or communication problems for the crisis unit, sub-cells or simulated stakeholders (onsite operators for instance that cannot provide feedback anymore)	63N	71I	81I	93I	94I	121I	153I	162N		
18	Authorities/ Hospital/Emergency services/ Other: Inputs – such as auditive or visual inputs as explosion sound or ambulance horn sound/light – related to casualties either wounded or dead, and possibly asking or providing information on this topic.	64N	155I								
19	Inputs or situation related to the length or the time of the exercises: long simulation, at night, at lunch time, during a change in shift...	64N	73I&I	95N	121N	122N&I					
20	Direct non diegetic inputs from facilitators to redirect trainees on an obvious or a (supposedly) reflex action	61N	74N	113N	121N	122N	146N	155N			
21	Stakeholders: Call or other reaction in case of lack of communication from the crisis unit. Inability, refusal or no answer/help from stakeholders if the crisis unit do not ask the proper interlocutor (organization or contact person) for a task. Several stakeholders may contact several sub-cells to simultaneous deal with their specific problems.	71N	83N	161N&I	171N&I						
22	Authorities/ Medias/ Emergency services/ Internal firemen or operators: Propose or required operational or strategic objectives	71I	73I	81I	91N&I	92N	133N	141N	146I	173N	

N°	Generic situation	Missions possibly aimed by such situations									
23	Emergency services (firemen)/ Internal firemen: Introduce or deal with pieces of information relate to event, intervention or other element(s) that may worsen or improve the situation and/or propose several actions based on this information	13N&I	42I	111I	112I						
24	Complex situation or problems requiring to be managed by all the crisis unit or a large part of it in order to propose a common scheduled solution, innovative or not.	94I	112N								
25	Media, including social medias: inputs (call, direct interactions or other, depending on the setting) related to crisis information such as its current situation. Information may be true, partial, or false.	131N&I	132N&I	133N	144N	146N&I	154N&I	155N&I			
26	Authorities: Ask if the crisis unit have already communicated or written a press statement and/or demand to do it	133N	141N&I	142N	143N&I	144N	145N				
27	Presence of curious onlookers and/or medias possibly malicious. Their presence may or may not be directly introduced to the crisis unit through inputs.	31N	133I	145N	146I						
28	Authorities/ Medias/ Emergency services/ Neighbors (industries): Use of a specific language during interactions in order to make the crisis managers ask for reformulate and/or to induce a bad understanding to force crisis unit to ask for precisions	152N&I	162I	172N&I							
29	Authorities/ Media /Emergency services/ Internal firemen/Other: Provide or required confirmation on a blurred, uncertain, partial or wrong information coming from outside the crisis unit	11N	12N&I	82I	102N	131I	132N&I	143I	146I	155N	
30	Authorities / Emergency services/ Internal firemen: Require forecast or anticipation related to incoming events or possible evolutions	16N&I	51I	112I							
31	Medias/Authorities/Emergency services/Internal firemen or operators/ Others: Important number of inputs focused in a short time, possibly on one single sub-cell	61N	64N	162N							
32	Emergency services (Police)/NGO/ Others stakeholders: State views opposed to crisis unit one's showing lack of transparency in crisis unit communication	95I	144N								
33	Inputs of several pieces of a shattered information to different team members of the crisis unit, with lacking piece of information, contradictions (or not) and, possibly, questions from sub-cells to help the team making sense with them	64N	94I	95N	112N	114N&I	141I				
34	Authorities/Media/ Emergency services/ Internal firemen/: Time limits imposed requiring to organize the crisis management according to this constraint	65I	141N								

Annex 6: Example for the design in a generic company

In order to illustrate the crisis and emergency exercises design process, a company was used as an example in the previous chapter. It allowed to fully illustrate the complete process including steps related to the particular organization of a company. However, using such example do not value elements discussed in Chapter 6 and it seems relevant to describe, in the end of this document, the very same design process but applied to a generic theoretical company, and show that the methodology can be led until an advanced stage without having to state particular elements. Then, such canvas can be used as a generic framework for designing crisis and emergency exercises for most companies after having proceed to some modifications and adaptations in order to fit the specific context of the aimed company.

A6.1 Generic needs and diegesis

Because we already assessed generic needs of Walloon Seveso companies as well as how their emergency system work in Chapter 6, the design process may start with the definition of the scope of this generic exercise. As discussed, Seveso companies often consider emergency planning from an operational point of view then it is difficult to not include intervention operations in the exercise or, at least, involve the leader of operation in the peripheral audience. In addition, because companies are already used to do evacuation exercise, leader of evacuation will not be integrated in the target audience, but in the peripheral audience instead. In the end, the crisis cells constitute the core of the target audience including the 5 functions identified in Chapter 6: Executive Officer, First Officer, Communication manager, SHE Manager and Secretariat.

On the other hand, interfaces of these trainees will be most the generic ones: face to face, phone call, e-mail and, possibly, walkie-talkie. Interfaces with the target audience are reported below with communication medium related:

- **Peripheral audience:**
 - The leader of operation, *face to face interaction, phone call or walkie-talkie*
 - The leader of evacuation, *face to face interaction, phone call or walkie-talkie*
 - Operators, guardsmen and technicians – or their supervisors according to the size of the organization – as temporary audience for warning phase, *phone call or walkie-talkie*
- **Emergency services:**
 - 112 call center, *phone call*
 - Local hospital, *phone call*
 - Emergency services Onsite, *face to face interaction, phone call or through peripheral audience*
- **Authorities' center and officials:**
 - Federal crisis center (CGCCR), *phone call and/or e-mail*
 - Federal Occupational health agency (DCRC), *phone call and/or e-mail*

- Regional environment agency (SOS Pollution), *phone call and/or e-mail*
- Local and provincial administration services and politic official, *phone call and/or e-mail*
- Neighboring companies, *phone call*
- Press and media, *phone call and/or e-mail*

These interfaces and stakeholders aimed to allow trainees to achieve missions usually found in Seveso companies' emergency plans and resumed in Figure 40. This representation figures out main possible interactions between trainees and stakeholders and allows to anticipate what trainees could want to do during the exercise and let them the ability to do it.

On the other hand, most part of the exercise occurs, for the target audience, in the crisis room defined in emergency plan while the peripheral audience may be grouped in one room with facilitators or separated from them in a different room depending on available rooms. Therefore, at least two rooms, including the crisis room is required but more rooms may be more comfortable – if enough facilitators and observers are available to managed them – to ensure interactions in a realistic environment. Moreover, note that, movement may be expected between the crisis room and the place where the disaster is simulated, especially at the beginning of the exercise. Those travels must be anticipated in order to ensure a proper immersion – with the adapted interface – to trainees going from a place to another or to intercept them before they arrive onsite and explain what they can see or feel at the place they want to reach. These travels from an area to another last a certain amount time and occur in a temporal scope it matters to define. Usually, exercises set – due to trainees' availability, organizational constraints and training effectiveness – last for between two and three hours, and up to four hours. Beyond four hours, exercises may be both difficult to implement and not be pedagogically effective even if they are more realistic and integrate more crisis elements. Therefore, for the exercise global framework proposed in this chapter, we consider a three-hours exercise allowing to implement enough elements to be relevant for most companies, including those having lacks in their emergency planning.

Once this generic framework set, let consider generic needs assess in Chapter 6 – see Table 22 – and make them match with Lapierre mission in Table 34 in order to define situation-task that will be staged in this exercise. However, 21 KSA targets were previously identified and, because it is too much for an exercise, only half of them were retained on secondary axes while all targets on main axes “Crisis Unit Management” were retained.

Table 34: Transposition of generic KSA competences needed into crisis unit missions
Tena Cholet KSA targets

	Operational Response Management
S	Adequacy of resources
S	Determining operational response
A	Prioritization of goals

>

Lapierre crisis unit mission

Axe	Mission	Goals
Crisis strategic response	Anticipation of threatened issues	Determine exclusion area and closure obstacles
		Monitor ongoing actions

	Crisis Unit Management
S	Clear Representation and Summary
S	Giving order and instructions
S	Definition of the roles and missions
S	Available data collection
A	Ability to share information
A	Cooperation
A	Fast decision-making

>

Axe	Mission	Goals
Crisis cell management	Keeping a shared mental picture of the situation	
	Leadership in crisis cell	Delegate and divide taskwork in the group
	Crisis cell activation	Manage the crisis unit
	Information transmission management	Gather information
		Share information
	Teamwork coordination	

	Crisis Communication
S	Message construction
S	Choice of addresses
S	Reporting
A	Ability to make spontaneous and on requesting transmission

Axe	Mission	Goals
Crisis cell management	Communication with #	Write a consistent message
		Choose the relevant recipient
	Communication with authorities	Make regular status report

It appears that attitude identified by Tena-Cholet are hardly transposable into Lapierre crisis unit mission then must, during the exercise, highlight such mission in order to implement them. They must modify missions to involve such attitude in a realistic and relevant way. Note that needs assessment proceed with the company may be done directly through Lapierre crisis unit mission which is both more explicit for industrial and avoid to do such transposition steps. However, industrial companies' needs assessment was done during Expert'Crise project according to Tena-Cholet repository and it is required to proceed to this transposition step.

Then, based on specific missions the crisis unit must do that stimulate cognitive process leading to pedagogical targets, the next step consists in choosing generic situations that stage such missions in the exercise following the Annex 5 relating mission with situations. Note that having too much situations to implement in the script is as bad as having too little of them because over saturating the script with events makes the scripting process too complex and the final script ends to be too dense in order to reach pedagogical targets.

Then, on the 34 generic situations, 11 relate to only **one** mission while 11 other ones relate to several missions then, because 22 generic situations are not relevant to script efficiently a scenario, only those relating to more than one mission are selected and represented here with the same identification numbers as in Table 29:

- **1** – Authorities/ Media/ Emergency services/ Neighbors/ Others: Request information on the situation (the accidental sequence, consequences, evolutions...) and/or on actions taken by crisis unit.
- **2** – Emergency services/ Internal firemen or operators/ Experts/ Neighbors (industries and inhabitants): Provide information on the situation but according to different point of view depending on the source or the recipient of the message and possibly being inconsistent ones with others.
- **8** – Call/ Face to face interaction/ Auditive or visual inputs: Evolution of the situation with or without following characterization: fast, complex, with numerous inputs, worsening or improvement the situation
- **11** – (Public) authorities/ Media/ Emergency services/ NGO/ Expert/Neighbor: Input, call, mail or face to face integration that challenge or contradict information provided by the company or its representation of the situation.
- **12** – Authorities/ Internal firemen or operators request decision-making /taking or a support (either fast or not)
- **14** – Variation in the workload – increase or decrease – for all the crisis unit or for some sub-cells. Tasks related to this workload may belongs to another specialty that the sub-cell one's, or not being adapted
- **15** – (Public) authorities/ Internal firemen /Neighbors (industries and inhabitants): Question the crisis unit about actions they can do in order to, for instance, protect material and/or human issues
- **21** – Stakeholders: Call or other reaction in case of lack of communication from the crisis unit. Inability, refusal or no answer/help from stakeholders if the crisis unit do not ask the proper interlocutor (organization or contact person) for a task. Several stakeholders may contact several sub-cells to simultaneous deal with their specific problems.
- **29** – Authorities/ Media /Emergency services/ Internal firemen/Other: Provide or required confirmation on a blurred, uncertain, partial or wrong information coming from outside the crisis unit
- **31** – Medias/Authorities/Emergency services/Internal firemen or operators/ Others: Important number of inputs focused in a short time, possibly on one single sub-cell
- **33** – Inputs of several pieces of a shattered information to different team members of the crisis unit, with lacking piece of information, contradictions (or not) and, possibly, questions from sub-cells to help the team making sense with them

Then, based on these generic situation-task constituting scripting ideas, proto-situation-tasks must be proposed. In the example used in Chapter 8, generic situation-task was directly implemented in the script. Although as eleven situation tasks are a lot for an exercise, it is required to resume them in a little number of situations merging close situations.

Five pedagogical blocks may then be suggested:

- **ST1 – Warning chain pedagogical block** staging numerous alerts from operators – and possibly industrial neighbors – to different crisis managers, related to a situation occurring onsite but with little and shattered information about it. These alerts are given from different point of view and depict the situation in different way, possibly inconsistent ones with others. This pedagogical bloc groups generic situations 2, 31 and 33 that target following missions:
 - 64 – **Crisis cell management** – Crisis cell activation – Manage the crisis unit
 - 82 & 83 – **Crisis cell management** – Information transmission management
 - 101 & 102 – **Crisis cell management** – Keeping a shared mental picture of the situation
 - 111 to 114 – **Crisis cell management** – Teamwork coordination
- **ST2 – Setting of the crisis unit and pooling of information pedagogical block** staging different stakeholders – especially internal firemen, authorities, emergency services and neighbors – requesting information and/or instruction on the situation in order to operate correctly either for the intervention, the public communication and the safing. This part of the exercise aims two things: first, crisis managers must pool their shattered and blurred information and, second, they must carefully transmit them in adapted stakeholders according to their legal requirements and procedures, possibly after taking a decision. This pedagogical bloc groups generic situations 1, 15 and 29, and target following missions:
 - 31 – **Crisis strategic response** – Anticipation of threatened issues – Determine exclusion area and closure obstacles
 - 43 – **Crisis strategic response** – Anticipation of threatened issues – Monitor ongoing actions
 - 82 – **Crisis cell management** – Information transmission management – Gather information
 - 101 & 102 – **Crisis cell management** – Keeping a shared mental picture of the situation
 - 111 to 114 – **Crisis cell management** – Teamwork coordination
 - 163 – **Crisis cell management** – Communication with authorities – Make regular status report
- **ST3 – Evolution of the situation pedagogical block** staging a major evolution of the situation and building up the climax of the exercise that must occurs at the end of this block. An evolution of the situation is injected in the diegesis from different simulated stakeholders – the peripheral audience or facilitators – describing the situation to different crisis managers from different point of view and providing unprecise and partial information of the situation. Some inputs may come from the outside of the organization and challenging or contradicting the representation of the situation by the crisis unit. These inputs come in an important numbers and overflow – by requesting information, confirmation, orders, or giving new elements – some part of the crisis unit that have, meanwhile, to decide what to do considering the brutal evolution of the situation.

This pedagogical bloc groups generic situations 2, 8, 11, 14, 31 and 33, and target following missions:

- 64 – **Crisis cell management** – Crisis cell activation – Manage the crisis unit
- 82 & 83 – **Crisis cell management** – Information transmission management
- 92 – **Crisis cell management** – Leadership in crisis cell – Delegate and divide taskwork in the group
- 101 & 102 – **Crisis cell management** – Keeping a shared mental picture of the situation
- 111 to 114 – **Crisis cell management** – Teamwork coordination
- **ST4 – Mediatic, administrative and politic response pedagogical block** implemented some instant after the previous pedagogical block and partially overlaying it and staging question from both media, local and provincial administration and politician. As this bloc occurs right after the previous one, it stages a workload transfer from intervention to communication sub-cell to inform wanted stakeholder under adapted timing and with proper information transmitted. Some stakeholders – especially political and administrative ones – may have specific reaction if they are not informed on time. This pedagogical bloc groups generic situations 1, 2, 11, 14, 29, 31 and 21, target following missions:
 - 82 & 83 – **Crisis cell management** – Information transmission management
 - 92 – **Crisis cell management** – Leadership in crisis cell – Delegate and divide taskwork in the group
 - 101 & 102 – **Crisis cell management** – Keeping a shared mental picture of the situation
 - 111 to 114 – **Crisis cell management** – Teamwork coordination
 - 152, 161, 162, 171, 172 – **Crisis cell management** – Communication with authorities and population
 - 163 – **Crisis cell management** – Communication with authorities – Make regular status report
- **ST5 – Closing the crisis unit pedagogical block** staging the conclusion of the climax including the end of operational, mediatic and political communication in a formal way, possibly with a press point or a common press statement. It also stages a global point on the situation that must induce the check of each mission the crisis unit had to do and a reflexive thinking on what had been done during the sequence. Then, it starts – during the exercise – a part of the exercise debriefing that occurs right after it. This pedagogical bloc groups generic situations 1, 15, 21 and 29.
 - 43 – **Crisis strategical response** – Anticipation of threatened issues – Monitor ongoing actions
 - 111 to 114 – **Crisis cell management** – Teamwork coordination
 - 152, 161, 162, 171, 172 – **Crisis cell management** – Communication with authorities and population
 - 163 – **Crisis cell management** – Communication with authorities – Make regular status report

It appears, in this example for a theoretical generic company, that generic situations are powerful tools that may considerably help scriptwriter for designing specific situation that

may be implemented at several moment of the script. The main difficulty lies in the simplification process from needs statement which may cover a very large scope of themes to proto-situation-tasks that focus on more specific actions and are more useful in scriptwriting. However, our three steps refining methods appears to be simple and progressive enough to let even novice scriptwriters do it.

Once proto-situation tasks that will be implemented in the script are defined, it matters to make them fit in the Hero's journey adapted for crisis management in order to figure out the global structure of the script, how each situation will order in this global framework as shown in Figure 51. Even if it is not required to graphically represent the script in a figure, it allows to explain and describe the process to involved company's person and make them understand the main phases of the exercise.

1st Situation-task: Warning chain pedagogical block staging numerous alerts from operators to different crisis managers, related to a situation, occurring, on-site with little and shattered information given from different point of view. <ul style="list-style-type: none">• 64 Crisis cell management• 82 & 83 Crisis cell management• 101 Keeping a shared mental picture of the situation• 111 to 114 Crisis cell management
2nd Situation-task: Setting of the crisis unit and pooling of information pedagogical block staging different stakeholders requesting information on the situation in order to operate correctly. <ul style="list-style-type: none">• 31 Determine exclusion area and closure obstacles• 43 Monitor ongoing actions• 82 Gather information• 101 & 102 Keeping a shared mental picture of the situation• 111 to 114 Teamwork coordination• 163 Make regular status report
3rd Situation-task: Evolution of the situation pedagogical block staging a major evolution of the situation and building up the climax. <ul style="list-style-type: none">• 64 Manage the crisis unit• 82 & 83 Information transmission management• 92 Delegate and divide taskwork in the group• 101 & 102 Keeping a shared mental picture• 111 to 114 Teamwork coordination
4th Situation-task: Mediate, administrative and politic response pedagogical block staging question from both media, local and provincial administration and politician. <ul style="list-style-type: none">• 82 & 83 Information transmission management• 92 Delegate and divide taskwork in the group• 101 & 102 Keeping a shared mental picture of the situation• 111 to 114 Teamwork coordination• 152, 161, 162, 171, 172 Communication with authorities and population• 163 Make regular status report
5th Situation-task: Closing the crisis unit pedagogical block staging the conclusion of the climax including the end of operational, mediate and political communication in a formal way, possibly with a press point or a common press statement. <ul style="list-style-type: none">• 43 Monitor ongoing actions• 111 to 114 Teamwork coordination• 152, 161, 162, 171, 172 Communication with authorities and population• 163 Make regular status report

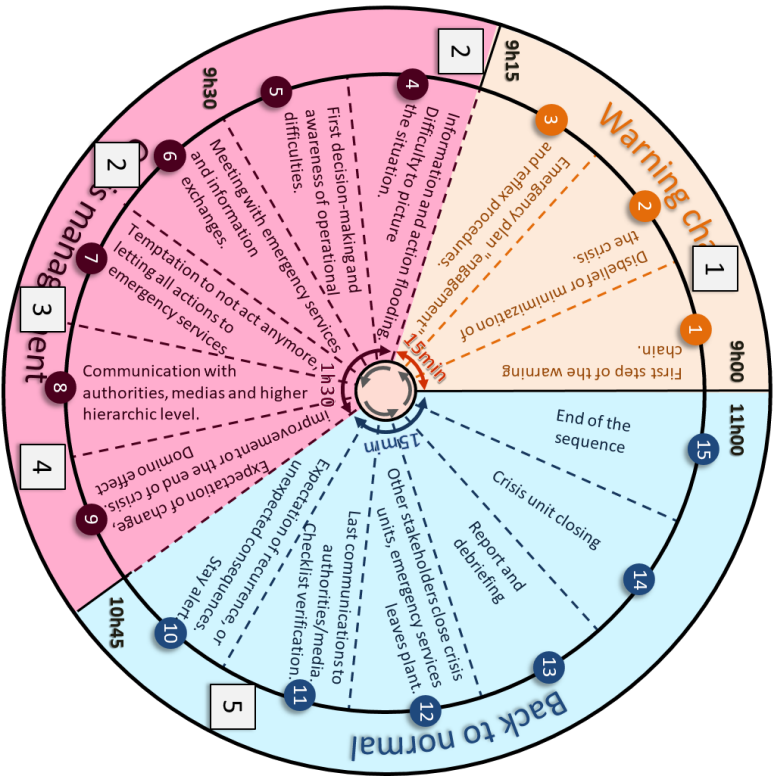


Figure 51: Generic pedagogical blocs in the Hero's journey

A6.2 Generic scenario framework and its refining

Based on the previous scheme, the 15-minutes meshing scripting table may be complete with pedagogical blocs, pedagogical targets aimed through crisis unit missions that must be done, and first incentives and perturbations ideas for the following scripting steps. This first exercise chronology for a generic SEVESO company is represented in Table 35. Note that blanks in this timeline represent the continuation of previous pedagogical block that pursue for more than 15 minutes. Moreover, it allows the script to not be oversaturated and let trainees focus on specific topics.

Table 35: Block chronology of a generic exercise

Time block	Pedagogical bloc	Pedagogical target	Incentive / Perturbation
09h00	Numerous alerts from operators and, possibly, industrial neighbors are given to different crisis managers describing a situation occurring onsite. These alerts have little and shattered information and come from different sources, depicting differently the situation, possibly inconsistent ones with others.	Crisis cell management axe: <ul style="list-style-type: none"> Information transmission management Keeping a shared mental picture of the situation Teamwork coordination Crisis cell activation: Manage the crisis unit 	Onsite operators from different areas of the plant, neighbors and guard call their direct managers (or contact point) to report the situation from their point of view. Important differences between description stated implying to clarify the situation. Situation depicted seems critical.
09h15	Different stakeholders including internal firemen, authorities, emergency services and neighbors request information on the situation in order to operate correctly either the intervention, the public communication or the safing.	Crisis strategic response: <ul style="list-style-type: none"> Information transmission management: Gather information Anticipation of threatened issues: Determine exclusion area and closure obstacles & Monitor ongoing actions Crisis cell management <ul style="list-style-type: none"> Keeping a shared mental picture of the situation Teamwork coordination Communication with authorities: Make regular status report 	Several incoming calls from different stakeholders. First, onsite operators requiring information on what happen and what to do, then neighboring companies worrying of the situation. If trainees do not call emergency services, they may call themselves the company after 20 minutes in order to force this interaction. After been called emergency services arrived onsite and request information on the nature of the situation and involved substances or equipment.
09h30			
09h45	An evolution of the situation occurs and is reported in crisis unit by different stakeholders. These inputs request information, orders, or, on the other hand, give new elements and arrived in an important number, overflowing some part of the crisis unit Meanwhile, the crisis unit have to decide what to do considering the brutal evolution of the situation.	Crisis cell management <ul style="list-style-type: none"> Crisis cell activation: Manage the crisis unit Information transmission management Keeping a shared mental picture of the situation Teamwork coordination Leadership in crisis cell: Delegate and divide taskwork in the group 	Inputs describing the situation are sent to different crisis managers from different points of view and provide unprecise and partial information of the situation. These inputs may come from outside the company and challenge how trainees picture the situation. Emergency services may be more or less commanding both according the complexity of the situation and how the crisis unit deal with the situation.

Time block	Pedagogical bloc	Pedagogical target	Incentive / Perturbation
10h00			
10h15	Media as well as local and provincial administration and politician start to question crisis managers about the situation. First, the crisis unit is solicited from only some stakeholders becoming more and more numerous and covering larger scope of involved organizations.	Crisis cell management <ul style="list-style-type: none"> • Information transmission management • Keeping a shared mental picture of the situation • Teamwork coordination • Communication with authorities and population • Leadership in crisis cell: Delegate and divide taskwork in the group • Communication with authorities: Make regular status report 	<p>First inputs of this block may be sent at the same time as previous block 's last inputs in order to stages a workload transfer from intervention to communication sub-cell.</p> <p>Stakeholder can pressure the crisis unit – especially authorities –to have formal answers. Some stakeholders may have specific reaction if they are not informed on time.</p> <p>Media can contradict the crisis unit based on information they gather themselves and ask for answer.</p>
10h30			
10h45	<p>Conclusion of the climax situation built through the two last pedagogical block and including the end of operational, mediatic and political communication in a formal way, possibly with a press point or a common press statement.</p> <p>Global point on the situation inducing the check of each missions done by the crisis unit and preparing the reflexive thinking on what had been done during the sequence for the following debriefing.</p>	Crisis strategical response <ul style="list-style-type: none"> • Anticipation of threatened issues: Monitor ongoing actions Crisis cell management <ul style="list-style-type: none"> • Teamwork coordination • Communication with authorities and population • Communication with authorities: Make regular status report 	<p>Inputs from authorities requiring a support official communication are sent to crisis unit. It may be a formal press statement or that a company's representant come to the press point</p> <p>Media or NGO may ask last few questions before press point if scheduled; If it is not, they continue to harass the crisis unit with question.</p> <p>Waste and other post-crisis management problems such as insurance and possibility work continuation on some part of the plant may be raised by Chief of operation or evacuation manager.</p>
11h00	End of the sequence		

This global chronology set the main lines of the script to be written and requires now to be extended and refined in order to have a complete scenario. However, the plot of the script – the accidental sequence – cannot be defined for the generic case. Indeed, the staged disaster varies considerably from a company to another and from an exercise to another depending on what the organization want and/or need, and what is interesting to stage. Nevertheless, the nature of the accidental sequence – even if it naturally impacts the exercise – may be overlooked for the generic case and be added later as an overlay of the generic exercise in order to adapted it to a particular company, its organization and its needs. Therefore, the accidental sequence may be seen as a sub-theme refining the main theme – the crisis or emergency management in Expert'Crise serious games – and, as developed in Chapter 5 with games design, it may be independent of (serious)-game mechanics, especially pedagogical ones. Then, despite not having an accidental sequence defined for the scenario, the next steps consist in refining the scenario in a 5-minutes meshing and

attributing inputs to facilitators. Similarly, to accidental sequence varying from an exercise to another, facilitators available may vary according to the date chosen. Considering the number of stakeholders simulated, peripheral audience to be mentored and exercises' feedback from Expert'Crise, 3 facilitators may be enough to manage an exercise with a crisis unit composed of the 5 functions previously identified. Facilitators' missions – simulating stakeholders and peripheral audience mentoring – are distributed as following, with verb underlined, simulated stakeholder in **red**, peripheral audience in **bold**, and means of communication in *italic*:

- **Onsite facilitator:**
 - Simulate **Emergency services** Onsite *through face to face interactions with peripheral audience and possibly phone calls with the crisis unit*
 - Mentor **The leader of operation** *through face to face interactions*
 - Mentor **The leader of evacuation** *through face to face interactions*
 - Simulate **112 call center** *through phone calls*
- **Authorities facilitator**
 - Simulate **112 call center** *through phone calls*
 - Simulate **Local hospital** *through phone calls*
 - Simulate **Federal crisis center (CGCCR)** *through phone call and/or e-mail*
 - Simulate **Federal Occupational health agency (DCRC)** *through phone call and/or e-mail*
 - Simulate **Regional environment agency (SOS Pollution)** *through phone call and/or e-mail*
 - Simulate **Local and provincial administration services and politic official** *through phone call and/or e-mail*
- **Media facilitator**
 - Simulate **Neighboring companies** *through phone call*
 - Simulate **Press and media** *through phone call and/or e-mail*

Based on this distribution and the previous table resuming pedagogical blocks and first scripting ideas – especially incentives and perturbations – in 15-minutes meshing, a more detailed script table may be written, expending these ideas and assigning inputs to facilitators. This table have a 5-minutes meshing and, in order to remain readable, both situation-task description and scripting ideas are simplified, or even delete if they appear in the description of related inputs.

Table 36: Precise chronology and input timeline for a generic exercise

Time block	Situation-task	Incentive / Perturbation	Facilitator sheet	Precise timing
09h00 - 09h15	Numerous alerts from operators, describing a situation occurring onsite, are given to different crisis managers in order to trigger the warning chain.	Numerous alerts describing the situation from different point of view. Differences between descriptions stated implying to clarify the situation. Situation depicted seems critical.	Onsite facilitator + <i>Support from others facilitators</i>	09h00: One first operator, witness of the situation (<i>temporary peripheral audience</i>) call one's direct manager and describe a malfunction on a device or equipment. 09h05/10: After a possible sound effect, several onsite operators and guardsmen (<i>temporary peripheral audience</i>) from different areas of the site start to call both their manager and the emergency line or contact point to report the situation from their point of view but with little information on what happen. 09h10: <u>If the crisis unit check information</u> by asking to dedicated workers close to the situation or having a special role in emergency planning (<i>temporary peripheral audience</i>), feedbacks they will get are more complete. In any case, at this time, descriptions received depict a critical situation.
09h15 - 09h30	Different stakeholders request information to the crisis unit on the situation in order to take their own decisions.	More or less comprehensive and/or precise description of the situation. If the crisis unit do not call 112, emergency services may call themselves	Onsite facilitator Media facilitator	09h15: Several onsite operators or supervisors (<i>temporary peripheral audience</i>) call crisis managers in order to have information about installations safing and, more globally, to receive instructions. 09h20/25: Industrials neighboring companies – if any or, otherwise, individual neighbor – call the crisis unit to receive information on the situation and, possibly, decide their own evacuation and safing. Meanwhile, <u>if internal firemen had been sent onsite</u> , the leader of operation call the crisis unit and describe more or less precisely and comprehensively the situation. 09h25: <u>If the crisis unit have called emergency services during the first situation-task</u> , they arrive onsite with a sound effect and ask, though the leader of operation, the nature of the equipment or chemical substances involved as well as dedicated emergency resources available onsite. <u>If the crisis unit had not called emergency services</u> , they may call themselves the company and tell they receive numerous calls from neighbors and want to know if they have to come.

Time block	Situation-task	Incentive / Perturbation	Facilitator sheet	Precise timing
09h30 - 09h45		<p>Administrative and political authorities with more or less involvement, self-control and readiness depending on pedagogical targets set and how prepare the company is on this topic</p> <p>Wounded and/or dead person may be implemented to adapt severity of the situation to trainees.</p> <p>During evacuation, a missing person may be reported as companies' evacuation counting processes are usually not efficient.</p>	<p>Onsite facilitator</p> <p>Authorities facilitator</p>	<p>09h30: <u>If they have not been contacted by the company</u>, local administration services, warned by neighbors, call the crisis unit to know what happen and if they have to trigger their own local emergency plan and/or evacuate population surrounding.</p> <p>09h35: The leader of operation calls the crisis unit and either provide a feedback on emergency services' operations or, <u>if emergency services are still not arrived</u>, describe internal firemen actions, precisising they require new instructions or information.</p> <p>Extracted wounded workers or dead casualties may be implemented at this moment according to how the crisis unit deals with the situation and targeted pedagogical goals.</p> <p>09h40: Provincial administration services, warned by the local administration services, call the crisis unit in order to know what happen and if they have to trigger the provincial emergency plan and communicate about the situation to population.</p> <p><u>If an evacuation had been decided</u>, the leader of evacuation call crisis unit and report the situation. According to how trainees deal with the crisis management <u>a missing person may be reported</u>.</p> <p><u>If the crisis unit had not called emergency services and they had to call themselves</u>, they arrive onsite with a sound effect and ask, though the leader of operation, the nature of the equipment or chemicals substances involved as well as dedicated emergency resources available onsite.</p>
09h45 - 10h00	<p>An evolution of the situation occurs and is reported in crisis unit by different stakeholders while others require information on what happen. Crisis unit must then adapt actions previously taken.</p>	<p>Inputs describing the situation to different crisis managers come from different point of view and providing unprecise and partial information of the situation.</p>	<p>Onsite facilitator</p> <p>Authorities facilitator</p>	<p>09h45: A sound effect implying a worsening of the situation is sent in crisis unit. No internal communication to onsite operators is possible for a little moment, simulating the confusion at such moment.</p> <p>09h50: The leader of evacuation calls the crisis unit to describe from one's point of view – away from the operation area – what happen and ask the crisis unit if they have more information and what evacuated worker must do.</p> <p>09h55: The leader of operation calls the crisis unit and describe briefly the situation in two or three minutes then have to shut abruptly the communication.</p>

Time block	Situation-task	Incentive / Perturbation	Facilitator sheet	Precise timing
10h00 - 10h15		Emergency services may be more or less helpful according to the complexity of the situation, how the crisis unit deals with the situation and targets set. If crisis unit manage correctly the situation, wounded or dead worker may be added to adapt severity of the situation to trainees.	Onsite facilitator Authorities facilitator	<p>10h00: Local administration services or political representative, alerted of the worsening of the situation by neighbors, call the crisis unit to have complementary information and be able to take one's own emergency decisions.</p> <p>10h05: The leader of operation calls back the crisis unit and describe more extensively the situation as well as actions taken by emergency services. According to the nature of company and the accidental sequence chosen, complementary questions on the plant – position of hazardous substances, utilities, etc – may be added to involve the crisis unit in operational intervention decision.</p> <p><u>If casualties had been implemented in the script</u>, a reminder – hospital calling or the leader of intervention precisising the hospital where casualties are sent for instance – may be implemented with information related to it.</p> <p>Meanwhile, <u>if no instructions were given before</u> – especially related to possible missing persons – the leader of evacuation calls the crisis unit in order to receive instruction related to the new situation.</p> <p>10h10/15: Federal and regional authorities – informed of the initial situation by 112 centers but not aware of the recent evolution of the situation – call the crisis unit to have information about the disaster and its possible environmental impact (regional competency) or worker casualties (federal competency).</p>
10h15 - 10h30	Media, local and provincial administrative services and politician start to intensively question crisis managers about the situation.	Stakeholders (especially authorities) may pressure the crisis unit with an ultimatum to have formal answers. Some stakeholders may have specific reactions if they are not informed on time.	Onsite facilitator Authorities facilitator Medias facilitator	<p>10h15/25: <u>Between two and four local medias</u> call – and <u>may even come at the entrance</u> of the plant depending on exercise organization – the crisis unit and start asking theme-oriented questions according to the media, depending on its editorial policy.</p> <p>10h20: Local administration services or political representative call the crisis unit after being solicited by local medias that want to know what happen and actions taken both by industrial and administration to protect population an environment. Questions asked relate to nature of event, actions taken, and future common official communication to be prepared. Then a press statement and a press point are implied by the stakeholder.</p> <p>10h25: The leader of operation calls the crisis unit and describe how intervention progress and, possibly, request new information, confirmations or instructions based on firemen officer demands. Actions taken against the disaster start to have some visible effects.</p> <p>Meanwhile, the leader of evacuation calls the crisis unit and indicate that a journalist was seen questioning evacuated workers or neighbors, outside the plant.</p>

Time block	Situation-task	Incentive / Perturbation	Facilitator sheet	Precise timing
10h30 - 10h45	End of operational, mediatic and political communication in a formal way, possibly with a press point or a common press statement.	Media or NGO may ask last few questions before press point (if scheduled). Waste and post-crisis management problems such as insurance and possibilities to continue to work on some parts of the plant may be raised		<p>10h30: <u>If casualties were implemented in the script</u>, families worrying of their states call the crisis unit.</p> <p>10h35: <i>No specific inputs</i></p> <p>10h40: Previous local medias as well as more renowned medias (national or provincial) call the crisis unit and ask details on the situation with more or less persistence depending if it is the first time they call or if they previously requested information without results. Moreover, questions related to a possible press point or, at least, an official statement, are asked.</p>
10h45 - 11h00				<p>10h45: The leader of operation calls the crisis unit and describes the last evolutions of the intervention and the situation that starts to be under control but still required to work on it.</p> <p><u>Meanwhile, the leader of evacuation may call the crisis unit</u> and ask what evacuated workers have to do, if they can go back home or if work can continue on some parts of the company.</p> <p>10h50: Local administration services or political representatives call the crisis unit and conclude details related to common official communication, clarifying details on press point/press statement and, possibly, requiring support, such as a company's representant during the press. <u>If no elements are communicated to authorities</u>, a press statement is requested under 10-15 minute.</p>
11h00				<p>10h55: <i>No specific inputs</i></p> <p>Back to normal / End of the sequence</p>

This table provides a detailed view of how exercises' inputs will be carried into the crisis unit and the nature of messages transmitted by each facilitator's actions. First conditional inputs are implemented in this script version, being underlined as italic was already used to identified peripheral audience. Note that, at this stage, steps of the process begin to be difficult to accomplish for a theoretical generic company because the more the script is detail, the more it depends on the company. However, the script produced here remains a proper canvas for an exercise in almost for most Seveso companies.

The most difficult part of this step consists in designing a consistent storyline that actually triggers crisis missions identified before that should involve cognitive processes leading to pedagogical targets. Moreover, because the proposed methodology is a deductive process – the company has particular needs so particular crisis missions are aimed so particular input are set and so on – some elements may be forgotten in the process and a checkup step may be required in order to assess that every pedagogic goals are properly targeted by one or several inputs.

Despite difficulties to fit with the generic case, it is possible to go a step further by identifying outputs that may be expected from a generic crisis unit after receiving inputs previously identified as represented in Table 37. Although these reactions, similarly to

messages sent as inputs, cannot be extended too much as their content depend of the nature of the company as well as the exercise setting and goals.

Table 37: Developed meshing scenario for a generic scenario with inputs and expected outputs

Time block	Situation-task	Input	Facilitators	Expected Output
09h00 - 09h15	Numerous alerts from operators, describing a situation occurring onsite, are given to different crisis managers in order to trigger the warning chain.	<p>09h00: One first operator witness calls one's direct manager and describe a malfunction on a device or equipment.</p> <p>09h05/10: After a sound effect, several onsite operators call their managers and the emergency line or their contact point to report the situation</p> <p>09h10: <u>If the crisis unit check information</u> by asking dedicated workers close to the situation or having a special role in emergency planning, feedbacks they will get are more complete.</p> <p>In any case, at this time, descriptions received depict a critical situation.</p>	<p>Onsite facilitator</p> <p>Onsite facilitator + <i>Support from others facilitators</i></p> <p>Onsite facilitator</p>	<p>Either the manager directly triggers the warning chain and mobilize the crisis unit or stay alert to next evolutions of the situation.</p> <p>Discussion between managers who trigger the warning system – if not automatic – to mobilize all the crisis unit.</p> <p>Mobilization of the crisis unit and pooling of information received.</p> <p>Calling of the 112 and start of emergency actions.</p> <p>Asking to dedicated person – internal firemen – to evaluate the situation onsite or at distance.</p> <p>Gathering information on the situation from several sources.</p>
09h15 - 09h30	Different stakeholders request information to the crisis unit on the situation in order to take their own decisions.	<p>09h15: Several onsite operators or supervisors call crisis managers in order to have information about installations safing and, more globally, to receive instructions.</p> <p>09h20/25: Industrials neighboring companies call the crisis unit to receive information on the situation and, possibly, decide their own evacuation and safing.</p> <p>Meanwhile, <u>if internal firemen had been sent onsite</u>, the leader of operation call the crisis unit and describe more or less precisely and comprehensively the situation.</p>	<p>Onsite facilitator</p> <p>Media facilitator Onsite facilitator</p>	<p>Providing information about the situation and giving instructions based on what the crisis unit know of the situation and the emergency plan, especially their reflex sheets.</p> <p>Gathering information on the situation and providing relevant information to adapted stakeholders.</p> <p>Calling 112 if not already done</p> <p>Giving adapted intervention instructions to internal firemen as well as relevant information.</p> <p>Crisis unit continues its emergency reflex actions, including those related to alerting authorities.</p>

Time block	Situation-task	Input	Facilitators	Expected Output
09h30 - 09h45	Different stakeholders request information to the crisis unit on the situation in order to take their own decisions.	09h30: <u>If they have not been contacted by the company</u> , local administration services, warned by neighbors call the crisis unit to know what happen and if they have to trigger their own local emergency plan and/or evacuate population surrounding.	Authorities facilitator	Providing relevant information to the proper stakeholders in an adapted timing. Communicating more or less transparently to authorities according to the background of the company.
		09h35: The leader of operation calls the crisis unit and either provide a feedback on emergency services' operations or, <u>if emergency services are still not arrived</u> , describe internal firemen actions, precising they require new instructions or information. Extracted wounded workers or dead casualties <u>may be implemented at this moment</u>	Onsite facilitator	Pooling information and transmitting updates to involved stakeholders. Giving instructions to operators onsite, especially if emergency services had not arrived yet. <u>If casualties are implemented in the script</u> , starting HR process related to wounded workers and/or gathering information on how to react.
		09h40: Provincial administration services call the crisis unit in order to know what happen and if they have to trigger the provincial emergency plan and communicate about the situation to population. <u>If an evacuation had been decided</u> , the leader of evacuation call crisis unit and report the situation. According to how trainees deal with the crisis management <u>a missing person may be reported</u> . <u>If the crisis unit had not called emergency services and they had to call themselves</u> , they arrive onsite with a sound effect and ask, though the leader of operation, the nature of the equipment or chemicals substances involved as well as dedicated emergency resources available onsite.	Authorities facilitator Onsite facilitator	Providing relevant information to political stakeholders and ensuring that communication run properly with them for next steps of crisis management. Give instructions and information to evacuate workers and possibly transmit their information. <u>If the crisis unit had not called emergency services and they had to call themselves</u> , provide relevant answers to emergency services in an adapted timing. Know how to answer to technical questions related to the situation and equipment involved
09h45 - 10h00	An evolution of the situation occurs and is reported in crisis unit by different stakeholders while others require	09h45: A sound effect implying a worsening of the situation is sent in crisis unit. No internal communication to onsite operators is possible for a little moment, simulating the confusion at such moment.	Onsite facilitator	Gathering and polling information on the situation then sorting them by relevancy and reliability. Anticipating and forecasting the possible consequences and get ready to take decisions.

	information on what happen. Crisis unit must then adapt actions previously taken.	09h50: The leader of evacuation calls the crisis unit to describe from one's point of view – away from the operation area – what happen and ask the crisis unit if they have more information and what evacuated worker must do.	Onsite facilitator	Asking for detail of what can be seen and trying to imagine what arrived. Picturing the situation based on little information.
		09h55: The leader of operation calls the crisis unit and describe briefly the situation in two or three minutes then have to shut abruptly the communication.	Onsite facilitator	Trying to maximize information gathering from this short interaction and start decision-making process based on it.

Time block	Situation-task	Input	Facilitators	Expected Output
10h00 - 10h15		<p>10h00: Local administration services or political representatives, alerted of the worsening of the situation by neighbors, call the crisis unit to have complementary information and be able take one's own emergency decisions.</p> <p>10h05: The leader of operation calls back the crisis unit and describe more extensively the situation as well as actions taken by emergency services. According to the company, complementary question on the plant – position of hazardous substances, utilities, etc – may be added to involve the crisis unit in operational intervention decisions.</p> <p><u>If casualties were implemented in the script</u>, a reminder input – hospital calling or the leader of intervention precisig the hospital where casualties are sent for instance – may be implemented during this input with information related to it.</p> <p>Meanwhile, if no instructions were given before – especially related to possible missing persons – the leader of evacuation calls the crisis unit in order to receive instructions related to the new situation.</p> <p>10h10/15: Federal and regional authorities informed of the initial situation – by 112 centers but not aware of the evolution of the situation – call the crisis unit in order to have information about the disaster and possible environmental impact or worker casualties.</p>	<p>Authorities facilitator</p> <p>Onsite facilitator</p> <p>Authorities facilitator</p>	<p>Providing first information to stakeholders and admitting the crisis unit have yet not extensive information on what happen</p> <p>Postponing by telling them they will be informed when more information will be available.</p> <p>Gather all required information on the situation and identifying operational decision to be taken.</p> <p>Deciding and/or providing information for emergency services decisions.</p> <p><u>If casualties were implemented in the script</u>, dealing with them according to internal HR process.</p> <p>Providing information and instruction to evacuated workers.</p> <p>Providing available information and stay open to future investigation – especially for DCRC – after intervention.</p> <p>Postponing complex questions for after the emergency management phase.</p>

Time block	Situation-task	Input	Facilitators	Expected Output
10h15 - 10h30	Media, local and provincial administrative services and politician start to intensively question crisis managers about the situation.	10h15/25: <u>Between two and four local medias call – and may even come at the entrance</u> of the plant depending on exercise organization – the crisis unit and start asking theme-oriented questions according to the media, depending on its editorial policy.	Medias facilitator	Providing a first corpus of information to medias stating there is a problem without detailing and precisising a press point will be scheduled at a safe place with extended information on the situation.
		10h20: Local administration services or political representative call the crisis unit after being solicited by local medias that want to know what happen and actions taken both by industrials and by administration to protect population. Questions asked relate to nature of event, actions taken, and future common official communication to be prepared. Then a press statement and a press point are implied by the stakeholder.	Authorities facilitator	Sharing available information and indicate how the company want to communicate according to its agenda and its procedures. Deciding the way of a common communication will be done including if a press point needs to be done, its time, and the nature of the information transmitted.
		10h25: The leader of operation calls the crisis unit and describe how intervention progress and, <u>possibly</u> , request new information, confirmation or instructions based on firemen officer demands. The action taken against the disaster start to have some visible effect. Meanwhile, the leader of evacuation calls the crisis unit and indicate that a journalist was seen questioning evacuated workers or neighbors, outside the plant	Onsite facilitator	Gathering and confirming information required by the leader of operation. If required, transmit new instruction and decision from the crisis unit. Dealing with journalists by providing information and setting an official and formal communication medium.
10h30 - 10h45		10h30: <u>If casualties were implemented in the script</u> , families worrying of their states call the crisis unit.	Authorities facilitator	Deal with families in a professional and empathic way.
		10h35: <i>No specific inputs</i> 10h40: Previous local medias as well as more renowned medias (national or provincial) call the crisis unit and ask details on the situation with more or less persistence depending on if it is the first time they call or if they previously requested information. Moreover, questions related to a possible press point or, at least, an official statement, are asked.	Media facilitator	Communicating and providing adapted, validated and clear information. Answering question with available and verified information. Postponing all question either too complex or too sensitive.

Time block	Situation-task	Input	Facilitators	Expected Output
10h45 - 11h00	End of operational, mediatic and political communication in a formal way, possibly with a press point or a common press statement.	10h45: The leader of operation calls the crisis unit and describes the last evolutions of the intervention and the situation that starts to be under control but still required to work on it. <u>Meanwhile, the leader of evacuation calls the crisis unit</u> and ask what evacuated workers have to do, if they can go back home or if work can continue on some part of the company.	Onsite facilitator	Gathering last pieces of information and instructing workers to go home or not. Decision-making related to post-crisis management.
		10h50: Local administration services or political representatives call the crisis unit and conclude common official communication modalities, clarifying details on press point/press statement and, possibly, requiring support, such as a company's representant during the press. <u>If no elements are communicated to authorities</u> , a press statement is requested under 10-15 minute.	Authorities facilitator	Formal communication and last decisions related to common communication Sending or preparing the press statement or the press point
		10h55: <i>No specific inputs</i>		Checking if every action has been taken and that nothing has been forgotten.
11h00	Back to normal / End of the sequence			

Based on this refined scenario, a complete script including all inputs can be written. However, during this writing step, it may appear, as explained in the methodology description, that complementary information is required in order to proceed correctly the exercise and must be implemented in the script. It may be organizational element or action facilitators must do – for instance, to transmit information – as well as information that must absolutely be correctly transmitted during the briefing.

Briefing is, as discussed, essential as it clarifies how trainees can interact with the diegesis and describe exercises limits. This last element is critical for an exercise in order to avoid trainees go to place where no facilitator is present and no interaction is possible, placing them “under the radar” of facilitation. Therefore, it matters to properly transmit this information and, during the exercise, take measures to ensure that even distracted managers remain in the diegesis.

A6.3 Generic scenario for a generic Belgian Seveso company

The following script is the conclusion of the design process applied to a generic Belgian Seveso company with a generic emergency plan and generic needs as defined in Chapter 6. Such script cannot be fully functional both because no accidental sequence was defined and because it does not rely on any actual emergency plan or company organization. Nevertheless, it may be a useful base for designing an emergency or crisis exercise in a company in condition to adapt it to the organization of the company. Moreover, it does not require a lot of specialized skills in crisis management to proceed to such modifications. However, the exercise management may be difficult to ensure for non-specialist which is a clear limitation of this method.

Legend:

- Timestamps have the **XXhXX** format and are stated at the beginning of paragraphs,
- Actions verbs related to facilitator's activity are written in **bold**,
- Conditions on facilitator's actions are written in **red**,
- Elements highlighted are underlined and elements stated for informative purpose only are *italicized*
- Different colors are assigned to each facilitator as well as peripheral audience in order to spot each facilitator's action – and possible interactions between facilitators – in the sheet.
 - **Media facilitator**
 - **Authorities facilitator**
 - **Onsite Facilitator**
 - **the leader of operation**
 - **the leader of evacuation**
- Texts that must be read by facilitator are written in *red italicized*.
- Element that cannot be detailed in the script are shaded

Before exercise

“Right before the exercise, **number of operator available** operators from different part of the plant will be gathered as well as **number of supervisor available** supervisors in facilitation room, and **Media facilitator** and **Authorities facilitator** will describe what they will do during the exercise. Their mission will last only for the very beginning of the accidental sequence and aim to simulate the warning phase of the exercise.

Exercise beginning at 09h00

At **08h55**, **Onsite Facilitator** will go to **area of the simulated accident** with **the leader of operation** and will describe first accidental disfunction to onsite operator by reading the following text:

*“*Description of the situation 1*”*.

Then, **Onsite Facilitator** will ask this operator what actions must be done in such situation, precisising they must not be actually done, except the one related to the call to one's

direct manager. **If operator do not mention such call, Onsite Facilitator will demand** to proceed to it and to describe the situation to one's manager.

According to how the called manager react, it is possible that the warning alert get trigger right after operator's call.

At **09h05, Media facilitator will play** the file **name of the disaster sound effect** on Bluetooth speakers located in areas where managers are expected to be and, meanwhile, with **Authorities facilitator, will give** facilitation sheets to operators in facilitation room. These sheets describe the situation they can see from their particular point of view. After that, a discussion between facilitators and operators should occurs and facilitators will ask what operators must do during an emergency. Eventually, facilitators will lead operators to call their direct managers and the emergency line.

Once alert given, managers should discuss of the situation and, eventually, trigger the warning system in order to mobilize all the crisis unit. It is possible that, during the warning phase, people actually come onsite to see what happen. In such situation, **Onsite Facilitator will describe** the situation to witnesses and remind them that all onsite interactions should occurs in facilitation room. At **09h10, Onsite Facilitator will tell** onsite operator that this one can continue one's work as usual, possibly evacuating if the alarm is triggered, as normal. Although **Media facilitator** and **Authorities facilitator will precise** that, either if one's manager or the crisis unit call, the witness operator must tell them the situation was too dangerous and evacuation required so no more details about the situation can be transmitted. After that, **Onsite Facilitator will go** to facilitation room and continue facilitation with **the leader of operation** that may had been called in between by the crisis unit to go onsite.

Around **09h10**, it is possible that crisis unit call particular operator(s), close to the situation, identified before and integrated in the operator group in facilitation room. This one will have a *particular facilitation sheet* stating information on one's sheet that must be provided *reactively* to the crisis unit and not *proactively* like for other operators. **Media facilitator will mentor** this particular operator in order to properly provide information – or not – to crisis unit.

Meanwhile, it is possible that **Authorities facilitator** receive a call at **phone number of 112** from the crisis unit as 112 centers requiring an intervention from emergency services. In that case, **Authorities facilitator will follow** 112 questions framework sheet, in annex, to ask all required questions for firemen operations.

If it appears that crisis unit is still not mobilize or that nothing seems to happen, Authorities facilitator will ask operators to re-call their manager in order to depict a critical situation requiring a proper intervention to save the plant.

At **09h15, Media facilitator** and **Authorities facilitator will describe** to supervisors what each ones saw and heard during the disaster based on facilitation sheets they distribute to them then will ask them to call the crisis unit in order to request information about the situation as well as instructions from their manager related to installation safing and, possibly, evacuation.

Around **09h20, Media facilitator will call** the **public phone number of the company** and **ask** for a manager, introducing oneself as a manager from **name of a neighboring*

company*, a neighboring company. **Media facilitator** will question the crisis unit on the situation, requesting information on the severity of the situation and hazards one's own workers face if they stay onsite. Based on information given by the crisis unit, this industrial company will decide to safe its own equipment and evacuate or not. In order to support this explanation, **Media facilitator** will read the following text.

*“*Script and questions from another company worrying about the situation*”.*

According the industrial zoning where the company is implemented, this input may be implemented several times in order to be realistic enough.

Meanwhile, if **the leader of operation** was sent onsite by crisis managers, **Onsite Facilitator** will describe the situation as this one is able to perceive it without getting oneself in danger. In order to support this explanation, **Onsite Facilitator** will read the following text.

*“*Description of the situation_2*”*

Then, if it is not done spontaneously, **Onsite Facilitator** will ask **the leader of operation** to call the crisis unit to transmit this description.

As at this moment, evacuation should have been triggered and operators from different part of the plant are not required anymore for the exercise then **Media facilitator** will tell them they can either evacuate as everybody, or go back to work if evacuation is not part of the exercise.

At **09h25**, if the crisis unit had called the 112 previously, **Onsite Facilitator** will play the file **sound of a firemen horn** on Bluetooth speakers and tell **the leader of operation** that firemen just arrived and **start to question** this one about the plant: hazardous substances onsite, process, available resources and so on. In order to support the firemen officer interaction with **the leader of operation**, **Onsite Facilitator** will read the following text.

*“*Incoming firemen officer interaction script*”*

Then, if it is not done spontaneously, **Onsite Facilitator** will ask **the leader of operation** to call the crisis unit to transmit information and requests of the firemen officer, even if some questions may be answered directly by the leader. Some very specific and technical question that only may be answered by managers after dedicated research on maps or schemes may be emphasized in order to stimulate an answer.

On the other hand, if emergency services have not been contacted yet by the crisis unit, **Authorities facilitator** will call the ** phone number of the company in emergency plan** in order to tell the company that the 112 centers received numerous calls from its neighborhood, ask what happen and if it required an emergency services intervention. In order to support this interaction, **Authorities facilitator** will read the following text then **will follow** 112 questions framework sheet, in annex, to ask all required questions for firemen operations.

*“*Neighbors worried feedback and 112 centers questions *”*

Around **09h30**, if local administration services have not been proactively contacted by the crisis unit, they are warned by neighbors and **Authorities facilitator** will call the ** phone number of the company in emergency plan** playing their role to know what happen and to assess if the situation require to trigger the local emergency plan, possibly implying

to evacuate neighboring population. In order to play such role, **Authorities facilitator** will read the following text then **will follow** the authorities question canvas in annex.

*“*Interaction with local authorities 1*”*

Around 09h35, if the crisis unit had called the 112 previously, **Onsite Facilitator** will describe how emergency services' operations progress to **the leader of operation** then will ask this one to call the crisis unit in order to report the situation and transmit supplementary question from firemen's officer. In order to support both description and firemen officer question, **Onsite Facilitator** will read the following text:

*“*Description of the situation 3*”*

*“*Firemen's questions 1*”*

On the other hand, if emergency services are still not arrived, **Onsite Facilitator** will describe how internal firemen 's operation progress with material limitations they encounter and refusal (or reluctance) to proceed some operation because they are not trained enough to do them. **Onsite Facilitator** will conclude by saying internal firemen ended all reflex actions they can do with available equipment then require new instructions from the crisis unit. In order to support this description and interaction, **Onsite Facilitator** will read the following text:

*“*Description of the situation 3bis*”*

*“*Internal firemen's questions*”*

Perturbation 1: According to how the crisis unit deals with the situation, casualties may be added in the script at this moment. In such case, during the description **Onsite Facilitator** make, this one may mention that one or several workers were extracted from the surrounding of the disaster and move at a safe distance of the situation. The gravity of each worker may be modulated according to the purpose aimed.

Around 09h40, **Authorities facilitator** will call the * phone number of the company in emergency plan* as Provincial administration services in order to know what happen and to assess if the situation requires to trigger the provincial emergency plan, similarly to local administration services. In order to support this interaction, **Authorities facilitator** will read the following text then use the authorities question canvas in annex.

*“*Interaction with provincial authorities 1*”*

Meanwhile, if an internal evacuation has been decided, **Onsite Facilitator** will tell **the leader of evacuation** how evacuation proceed then will ask this one to contact the crisis unit in order to report the situation from one's point of view, precising were they evacuated and how many people are in the evacuated group. In order to support this interaction, **Onsite Facilitator** will read the following text:

*“*Evacuation description 1*”*

Perturbation 2: According to how the crisis unit deals with the situation, missing persons may be added in the script at this moment. In such case, during the description **Onsite Facilitator** make, this one may mention that one or several workers are not in the evacuated group and either may be wounded (*see previous perturbation*), belong to internal firemen group or have just evacuate at another place.

If the crisis unit had not called emergency services and they had to call themselves, **Onsite Facilitator** will play the file *sound of a firemen horn* on Bluetooth speakers and

will tell **the leader of operation** that firemen just arrived and start to question this one about the plant: hazardous substances onsite, process, available resources and so on. In order to support the firemen officer interaction with **the leader of operation**, **Onsite Facilitator** will read the following text.

*“*Incoming firemen officer interaction script*”*

At **09h45**, **Onsite Facilitator** will play the file ** Worsening of the situation sound** on Bluetooth speakers and will tell **the leader of operation** as well as **the leader of evacuation** they must not answer to calls from crisis unit in order to simulate the confusion in such situation. Then, **Onsite Facilitator** will explain the situation to the two leaders, reading the following text and precisising what each leader saw from one’s particular point of view and what remains unknown:

*“*Description of the situation_4_Leader of operation*”*

*“*Description of the situation_4_Leader of evacuation*”*

At this point, as they cannot get information on what happen onsite, the crisis unit could send someone to see what happen. Therefore, it matters that the facilitation room was clearly identified during the briefing as the location where onsite interactions occurs. **If someone is sent onsite**, **Onsite Facilitator** will summarize the situation but without telling too much information, justifying the witness cannot go further because of hazards of the situation.

Around **09h50**, **Onsite Facilitator** will ask **the leader of evacuation** to call the crisis unit to describe the situation from one’s point of view – without “over”-describing it – then ask them if they have more information on the situation and what evacuated workers must do, questioning the safeness of their actual position.

At **09h55**, **Onsite Facilitator** will ask **the leader of operation** to call the crisis unit and describe the situation in less than 1 minute (with a chrono set up) and, at the end of the minute, to stop the communication even if the description (or the last sentence) is not completed. Note that **Onsite Facilitator** may have to induce such stop by speaking to the leader, asking something or playing an audio file on local Bluetooth speakers.

Around **10h00**, **Authorities facilitator** call the ** phone number of the company in emergency plan** as local administration services, alerted of the worsening of the situation by neighbors, and will ask the crisis unit for complementary information about the new situation in order to take their own emergency decisions such as enlarging the range of evacuation or ensuring a safety perimeter. In order to support this interaction by providing enough issues a public authority may have, **Authorities facilitator** will read the following text then use the authorities question canvas in annex.

*“*Interaction with local authorities_2*”*

However, at this point, the crisis unit should not have enough information to provide a consistent answer to public administration so it is interesting to assess answers provided here: do the crisis unit choose to postpone a little the answers, minimize the situation, lie or other.

At **10h05**, **Onsite Facilitator** will ask **the leader of operation** to call back the crisis unit to complete one’s unfinished description of the situation. Before that, the **Onsite Facilitator** will tell **the leader of operation** actions taken by emergency services in order to react to the worsening of the situation as well as questions they may have on various

topics related to next operations such as position of hazardous substance, utilities or others relevant information. Note that the worsening of the situation may have been anticipated by the crisis unit and transmitted to emergency services at their arrival. In such case, they are not surprised and can overcome this disaster more easily. In order to support this interaction through both description of firemen's actions and their questions, **Onsite Facilitator** will read the following text:

“*Description of the situation_5*”

“*Firemen's questions_2*”

If casualties were implemented before in the script, **Onsite Facilitator** will ask **the leader of operation** to mention them in the previous message by precisising where wounded workers are sent or by identifying them for instance.

Meanwhile, if no complementary information was given to evacuate workers before, **Onsite Facilitator** will ask **the leader of evacuation** to call the crisis unit to receive instructions on what to do and what to tell to evacuated workers. Moreover, if missing persons were implemented in the script, **Onsite Facilitator** will demand to **the leader of evacuation** to ask if the crisis unit found where they were.

Around 10h10, **Authorities facilitator** will call the *phone number of the company in emergency plan* first as federal authority then as regional authority, both warned by 112 centers but not aware of evolutions that occurred since the first call to 112. Both authorities will ask for information about the situation but from different points of view according to their missions: federal authorities will then focus on possible casualties amongst workers while regional authorities will focus on environmental repercussion of the situation. Both authorities will ask – if the company mention an impact of the disaster on their topic of interest – to come investigate themselves and the company will only be able to postpone such investigations after the operational crisis management. In order to support this interaction, **Authorities facilitator** will read the following text then use the authorities question canvas in annex.

“*Interaction with regional and federal authorities*”

Between 10h15 and 10h30, **Media facilitator** will call the *public phone number of the company* and introduce oneself as a local journalist then will start to question the crisis unit – or whoever answer the phone call – about the crisis situation. Depending on how crisis unit deals with the management of the situation, **Media facilitator** will proceed to such call between two and four times, introducing oneself each time as a journalist from a different media and asking questions from different points of view, according to the editorial policy of the represented media and its preferred topics. Possibly, depending on facilitators availability and crisis unit reactions, one facilitator may be sent at the entrance of the plant, near evacuated workers in order to play the role of a journalist coming in person. In order to support this interaction and, especially, not being too redundant in question asked, **Media facilitator** will use the media questions canvas in annex.

Around 10h20, **Authorities facilitator** will call the *phone number of the company in emergency plan* as local administration services or political representative and will say they were recently solicited by local media which want to know what happened onsite and what actions had been taken both by industrials and administration in order to protect

population and environment. Then, **Authorities facilitator** will ask questions related to the nature of event, actions taken, and **will introduce** that a common official communication need to be prepared in order to respond to all mediatic stakeholders in a formal way. Then, **Authorities facilitator** will imply a press statement and, possibly, a press point and ask the crisis unit to start preparing it. In order to support this interaction, **Authorities facilitator** will read the following text:

“**Interaction with local authorities 3**”

Around 10h25, **Onsite Facilitator** will tell **the leader of operation** how intervention progresses, its visible effect on the disaster and, **depending on how technical the intervention** is, ask new question or confirmation from firemen. Then, **Onsite Facilitator** will ask the leader to call the crisis unit to report the situation, transmit firemen officer's question and receive possible instructions from the crisis unit. In order to support this interaction and, especially, describe the situation, **Onsite Facilitator** will read the following text:

“**Description of the situation 6**”

“**Firemen's questions 3**”

Right after **the leader of operation** briefing, **Onsite Facilitator** will tell **the leader of evacuation** that a journalist was seen questioning evacuated workers or neighbors, outside the plant. Then, **Onsite Facilitator** will ask the leader to call the crisis unit in order to report this information.

At 10h30, **if casualties were implemented in the script**, **Authorities facilitator** will call the **public phone number of the company**, **introduce** oneself as casualties' family – warned by colleagues or unable to contact their family members – and **will ask** where wounded workers had been sent and how severe their situation are. In order to support this interaction and, make it more realistic, **Authorities facilitator** will read the following text:

“**Casualties' family interaction**”

Around 10h40, **Media facilitator** will call the **public phone number of the company** and **introduce** oneself as one of the previous journalists that called before then start again to ask question about the situation. **Media facilitator** will proceed to such call several times, simulating both journalists who already called and journalists from more renowned media such as provincial or even national ones. Journalists will be more or less persistent depending on if it is the first time they call or the second one. Moreover, similarly to previous mediatic questions, they will focus on different topics according to the editorial line of each media. **If the crisis unit mention an incoming press point**, precisising its time and place, facilitator will stop questioning the crisis unit, and, **if no mention of a press point is made**, some journalists will ask if such event is planned. In order to support these interactions and try to make them the less redundant possible, **Media facilitator** will use the media questions canvas in annex.

Around 10h45, **Onsite Facilitator** will describe to **the leader of operation** the last evolution of the situation, precisising that, thanks to emergency services' intervention, the situation starts to be under control but still require to work on it. Then, the facilitators will ask the leader to call the crisis unit to report the situation. In order to describe the situation, **Onsite Facilitator** will read the following text:

““**Description of the situation 7**”

“**Firemen’s questions 4**”

Right after **the leader of operation** briefing, **if no medium/long-terms instructions were given to evacuated workers**, **Onsite Facilitator** will tell **the leader of evacuation** that evacuated workers start to ask what is next: if they will work in the afternoon or not. **In the situation where the weather is bad**, evacuated workers may ask such question before – around **10h00** – possibly requiring a shelter. Then, **Onsite Facilitator** will ask **the leader of evacuation** to call the crisis unit in order to report this request.

At **10h50**, **Authorities facilitator** will call the * phone number of the company in emergency plan* as local administration services or political representative, and **will conclude** common official communication modalities, clarifying details on press point or press statement and, possibly, requiring the support of a company representant. **If no element has been communicated to authorities**, a company representant is called under 10 or 15 minutes for a press statement.

Around **11h00**, **according to how the crisis unit deals with the last inputs**, **facilitators will come** in the crisis cell to tell trainees that the exercise is finished and, after a 15-minutes break, the briefing will start.

Exercise end at 11h00

Besides all text written in *red italic* in the scenario and facilitation sheets required for each ones of the three facilitators and consisting in the previous script adapted for each one of them, several annexes must be prepared in order to provide required information both to facilitators and peripheral audience. These annexes strongly depend on the context of the exercise and cannot be developed in this generic framework. However, it is possible to clearly identified them:

- Facilitation sheets for operators and supervisors explaining the disaster from their point of view and information they must provide to the crisis unit reactively and proactively.
- 112 questions framework sheet consisting in the question-template used by emergency call center (Service public fédéral - Intérieur, 2015) simplified for the accidental sequence chosen only because the complete questioner’s purpose is to answer to every possible disaster which is not useful for exercise purpose.
- Authorities question canvas consisting in questions authorities may ask to industrials during a disastrous situation, depending on both relations they have and severity of the situation. Because different kinds of authorities may be involved, this annex may be divided in several sub-parts:
 - Local authorities
 - Provincial authorities
 - Regional authorities
 - Federal authorities

- Media questions canvas consisting in, first, names of several local medias that could question the crisis unit, and various questions on the nature of the situation, its impact, and others questions on the disaster.

These annexes, besides facilitation sheets and possible complementary files, are the last pieces of facilitation documents required in order to proceed to a crisis or emergency exercise. Therefore, it is possible, once every facilitator learned of actions they will have to do during the exercise and how this one will proceed, to held the simulation. Moreover, as said in introduction, the previous script can be a useful tool to develop adapted exercise for most Seveso companies without involving too much human resources in such endeavor and then contribute in simplifying the organization of this kind of trainings, that appears to be critical for a proper crisis management.

A6.4 Annex 6 Resume

The scripting method for designing an emergency exercise described in Chapter 7 and Chapter 8 is applied in this chapter to a generic theoretical company. This theoretical company has a generic emergency system including most common emergency planning features as identified in Chapter 7, and has generic needs for an emergency training, also identified in the same chapter. Analysis that led to propose such generic needs and emergency planning are based on Expert'Crise 3-years' experience with 14 companies. Defining such generic company, supposedly close to most Belgian Seveso companies, allows to propose a training framework for emergency and crisis management that can be used the most broadly possible. Naturally, each company is different in their needs and organization so adaption is required in order to customize this framework for a specific pedagogical situation. Nevertheless, designing a generic exercise framework based on most common needs and organization is the most finished steps for a methodology aiming to make more affordable emergency and crisis exercise design. Moreover, in the case of such framework does not match with specific needs and organization of a company that want to go further and test others emergency function, this one may process the design methodology and conceive its own scenario, fitting with its needs.

Based on generic needs and global emergency organization set up, the context – depending both on the emergency planning and emergency function that must be tested – can be defined. It consists in trainees involved in the exercise and interfaces they will be able to interact with such as peripheral audience, stakeholders simulated by facilitators or other inputs. These first elements allow to picture the global setup of the exercise – despite it does rely on any actual organization – and base the next steps of the design methodology. Then, needs targeted by the exercise lead to identify cognitive processes then emergency missions that must be performed by the crisis unit in order to reach these pedagogical targets. Based on these missions, adapted proto-situation-task are identified that will structure the

exercises once implemented in the Campbell hero's journey framework. However, while in the method presented in previous chapters the next step of the design process consists in choosing an accidental sequence, for the generic case developed here, it is not possible to choose such a generic disaster fitting with every company needs. Therefore, this step is delayed for the end of the process, as a feature that must be adapted to each company, in order to develop the script as much as possible but without considering this important information. Then, the next step consists in identifying inputs ideas for each proto-situation-task and, after that, drafting a first 15-minutes meshing chronology ordinating situation-tasks. This chronology is then refined into a 5-minutes meshed script where each input is assigned to a facilitator. A last processing steps aiming to ensure that most of trainees' reaction are considered and actually conducted to pedagogical targets is done and consist in assessing output expected for each input sent. In the end, the detailed chronology is transposed into a final written script including every action each facilitator must do or say to carry out the exercise. Such script calls several annexes that must be developed – besides choosing an accidental sequence and converting the script into facilitators 'sheet – in order to adapt this generic script for an actual company.

Contribution To A Design Methodology For Crisis And Emergency Training On Hazardous Industrial Sites



As shown by annual industrial major accidents statistics in Europe, despite progress of risk prevention in hazardous companies, disaster still appears and these organizations cannot overlook the need to organize to manage such situation. Yet, crisis and emergency management in hazardous industries rely on a particular organization which modifies the companies' normal operating mode. This kind of organization requires, both from operatives and decision-makers, specific knowledge that cannot be acquired through theoretical course or real-life practice only. Simulation exercises can be a training solution to allow the practice of crisis management. However, developing and implementing adapted exercises for agents and their needs is time and resource-consuming, especially when the system where they operate is complex. Therefore, in order to make these trainings more affordable for companies, their development and exploitation must be simplified.

Between the ends of 2015 and 2018, the Expert'Crise project, funded by the European Social Fund, provided emergency and crisis trainings to 19 hazardous companies or critical infrastructure, including 14 immersive simulation exercises on industrial sites. Based on this recurrent exercise development process, a scriptwriting methodology was developed, integrating Expert'Crise project's experience as well as existing methodologies and literature.

During such kind of simulation, trainees play their own role in their usual working place. Hence, only some emergency functions are simulated and, for instance, physical intervention with firefighter's tool are rarely set up.

Then, because some parts of the emergency organization are not tested, arrangements must be made to isolate trainees from real environment and establish the framework in which participants can interact with each other and with the facilitation interface. Because such organization strongly relates to Live-Action Role Playing Games, with a special focus on interaction between participants, improvements coming from the LARP literature were integrated in the methodology and contribute in making it more interactive, making such trainings close to serious games.

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