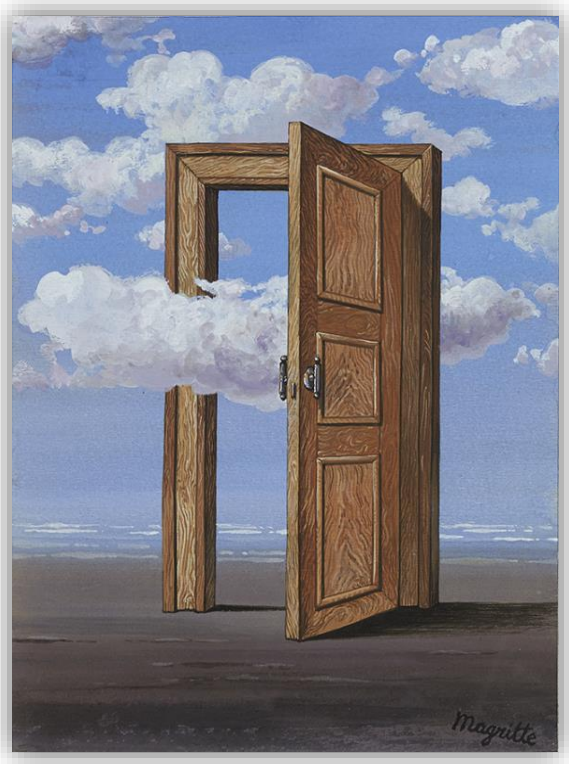
SAFETY AND SECURITY IN AND THROUGH PRACTICE: TENSIONS AT THE INTERFACE



Colin Glesner

Dissertation submitted to the faculty of Law, Political sciences and Criminology of the *Université de Liège* in partial fulfillment of the requirements for the degree of Doctor in Political Science

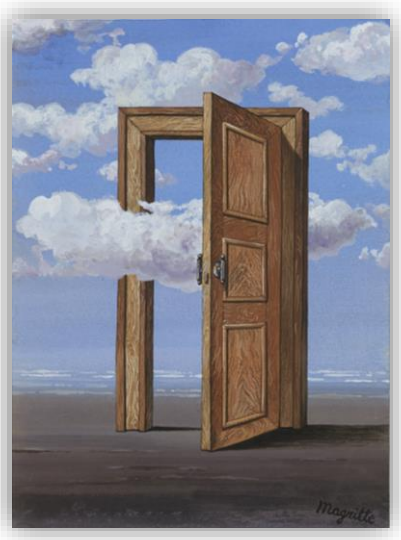
Promoter: Catherine Fallon
Mentor: Robbe Geysmans
Co-mentor: Catrinel Turcanu
Academic year: 2021-2022

LIÈGE université

Spiral

sck cen

SAFETY AND SECURITY IN AND THROUGH PRACTICE: TENSIONS AT THE INTERFACE



Thèse de doctorat présentée par Colin Glesner
en vue de l'obtention du titre de Docteur en Sciences Politiques et Sociales

Membres du Jury:
Prof. Sissel Jore, Stavanger University
Dr. Frank Hardeman, Directeur de l'Agence Fédérale de Contrôle du Nucléaire
Dr. Michiel Van Oudheusden, Katholiek Universiteit van Leuven
Prof. Sébastien Brunet, Université de Liège
Prof. Catherine Fallon, Spiral, Université de Liège, Promotrice
Dr. Robbe Geysmans, SCK CEN, Mentor
Dr. Catrinel Turcanu, SCK CEN, Co-mentor

Faculté de Droit, Science Politique et Criminologie
2021-2022

LIÈGE université Spiral sck cen

Table of contents

List of tables

List of figures

List of abbreviations

ANT	Actor-Network Theory
DBT	Design Basis Threat
D1	Discipline 1
D2	Discipline 2
D3	Discipline 3
D4	Discipline 4
D5	Discipline 5
EM	Emergency Management
EOC	Emergency Operation Center
Hazmats	Hazardous Materials
ICMS	Incident and Crisis Management System
IAEA	International Atomic Energy Agency
INSAG	International Nuclear Safety Group
IPCC	International Panel on Climate Change
NRC	Nuclear Research Center
NNR	National Nuclear Regulator
OCAM	Organe de Coordination pour l'Analyse de la Menace
OECD	Organization for Economic Co-operation and Development
RD	Royal Decree
SSMU	Service of Safety and Security Management
STS	Science and Technology Studies
TFEU	Treaty on the Functioning of the European Union
WB	World Bank
WENRA	West European Nuclear Regulators' Association

Foreword

In January 2017, I responded to the annual call for PhD proposals launched by a Belgian nuclear research center (NRC) and submitted a project entitled "Safety, security and innovation in High-Risk sociotechnical systems - Tensions and Tradeoffs". Although this proposal clearly stated that the project's objective was to explore the dynamic interactions between safety, security and innovation, we quickly realized that addressing these three concepts and their relationships would prevent us from contributing the necessary scientific and empirical depth to our study. We therefore decided to leave the concept of innovation aside and focus on the relationships between safety and security.

Apart from this modification, this doctoral thesis has strictly respected the elements mentioned in the proposal. Using an interpretivist approach that draws on the heuristics of Science & Technology Studies, this thesis investigates the ways in which safety and security are enacted and enter a relationship. The questions of tensions and their management are at the center of our reflection. The issues surrounding safety and security cultures within safety and security studies are also addressed. Two case studies were used, one focused on high-risk organizations and the other on emergency management in Belgium. This research cross-fertilizes previous observations and gives them greater empirical depth.

The choice of the two case studies was carefully considered and discussed with the members of my thesis committee. Although I did the fieldwork alone, my thesis supervisors helped me to define and carry out the fieldwork in accordance with the scientific frameworks. In the end, the distinctiveness of the two case studies represents a deliberate choice made to identify elements common to the diverse approaches.

To prepare my PhD thesis, I was lucky enough to not only have an office at the University of Liège but also at the NRC, which enabled me to become a full member of the NRC's

"Programme for the Integration of Social Aspects in Nuclear Research" as well as of the Spiral research center of the University of Liège. This twofold affiliation meant I benefited from the opinions, expertise and experience of these two groups which pushed me to constantly question my reflections in the framework of this thesis.

Furthermore, given the theme of my thesis and as I was able to accomplish my ethnography at the nuclear research center in optimal conditions, I was given specific access to various protected areas of the site that allowed me to observe the precise places where safety and security emerge and meet first hand.

This thesis is the compilation of four scientific papers linked by a general introduction, a methodological chapter, a general discussion, and a final conclusion. The first paper (chapter 1 of this manuscript) has already been published in *Safety Science*. The third paper (chapter 3) has been accepted for publication in the *Journal of Safety Research* with minor revisions. The second (chapter 2) has been submitted the *Journal of Emergency Management* and the fourth paper (chapter 4) is under review for publication in *Safety Science*. Each of the 4 articles is distinct and reconstructs the puzzle of the relationships between safety and security each through its unique perspective.

I am the first author of the four papers and the sole author of paper 4. My co-authors significantly helped me to make sense of what I was observing, refine my reflections, and transcribe those reflections. Beyond the papers presented in this compilation, the doctoral thesis journey enabled me to work and write on other related topics and thereby increase my expertise in domains including emergency management, emergency response and lessons learned from emergency management.

Before beginning, I need to warn the reader that as this thesis deals with sensitive issues, we signed a confidentiality agreement for our two case studies, which deal with protective measures against the threat of terrorism. This agreement implies that no visual information, no interview or workshop transcripts (except for the extracted citations), and no names of participants are

disclosed. Furthermore, as you may have already noticed, the names of the organizations are also anonymized.

But enough said about the context and framework of this research. Let's now begin this adventure into the world of safety and security management.

Executive summary

The notions of safety and security have long been treated in distinct literatures. The latter emerged in the context of international relations and in connection with the notion of war, while the former emerged in response to the advent of the concept of risk and developed in parallel with the industrial accidents that occurred in the second half of the 20th century. The 9/11 terrorist attacks made people realize that malicious attacks on high-risk organizations could have the same effects as industrial accidents. Based on this observation, a whole literature started to integrate the concept of security in reflections around safety. At first thought to be mostly synergistic, the recent growth of security issues (through the wave of terrorist attacks that took place in Western Europe between 2015 and 2018, among others,) challenged this dominant synergistic vision of safety and security relations. Indeed, several researchers recently highlighted potential tensions between safety and security and the lack of empirical studies around the relationship between the two.

Like recent studies, this thesis investigates and questions the relationships between safety and security in and through practice. To this end, this thesis is built around one case study composed of an ethnographic study in a nuclear research center (NRC) and fieldwork on emergency management (EM) in Belgium. Opting for heuristics from Science and Technology Studies (STS), the Actor-Network Theory (ANT) provided me with the methodological and conceptual tools necessary for the collection and analysis of field data. However, far from limiting ourselves to an orthodox ANT approach, we enriched our analytical framework by using the instrumentation approach and the co-production idiom. The former allowed us to account for the autonomous agency of regulatory instruments and their influence on emergency management regimes in Belgium. The latter served as a sensitizing concept to stimulate our reflections, throughout our study, on the mutual influences between safety and security and on the power relations around their implementation.

This fieldwork resulted in the 4 above-mentioned papers for publication in scientific journals, which also form the backbone and the different pieces of the puzzle that compose this thesis. Rather than report on the successive studies, each article aims to shed a specific light on the topic. It is through their cross-fertilization that they led to a more global understanding of the relationships between safety and security.

Chapter 1 analyses of the scholarly, regulatory and policy literatures on safety and security cultures. It firstly identifies two important recurring gaps in the literatures, namely the subordination of security culture to safety culture and the anthropocentric focus of research on both notions. To address these two gaps, it discusses the potential benefits of cross-fertilizing the idiom of co-production and ANT to report and make sense of the mutual shaping of safety and security cultures as well as the active roles played by non-humans. Through two concrete illustrations, the labelling of hazardous material and the "four eyes" principle, chapter 1 highlights how combining the two approaches opens the way for a more symmetrical analysis of safety and security cultures in high-risk contexts, such as the nuclear arena.

Chapter 2 analyzes the changes in emergency management (EM) in Belgium that have accompanied growing security concerns in Western countries since the 9/11 terrorist attacks. By analyzing the changes in regulatory instruments, it first demonstrates how EM changed in response to industrial accidents, thereby constructing an "EM safety regime". By tracking the influence of EM regulatory instruments, it unveils how a royal decree published in 2006 unintentionally participated in giving a more prominent role to judicial actors in emergency response and in the overall reshuffle of the constellation of actors involved in responses to crises. It analyzes how these changes helped bring about new security-oriented practices eventually leading to the emergence of a "EM security regime".

Chapter 3 extends the reflections begun in chapter 1 and applies them specifically to the interactions between safety and security. Based on fieldwork in a nuclear research center, it analyzes how safety and security relations are experienced by field actors. It reveals that while they share the

same goal of protecting people and the environment and have similar management frameworks (e.g. defense-in-depth) and practical means (e.g. emergency exercises), safety and security relations are also characterized by tensions. These tensions may be rooted either in organizational and interpersonal relations or in antagonistic values and requirements, termed paradoxes. Specifically, we counted three paradoxes between safety and security: movement enablement vs. movement restriction; transparency vs. confidentiality, trust vs. distrust. Based on these paradoxes and mobilizing the paradox theory, we argue that a coherent approach to safety and security should not sideline tensions but place them at the center of attention as, if tackled properly, they have a generative potential. Building on the "dynamic equilibrium model", we recommend approaches that recognize the existence of tensions and their underlying paradoxes by creating "tension venues", i.e., physical or virtual spaces dedicated to putting tensions under the spotlight and reflecting on their roots, thereby enabling the identification of innovative measures to articulate them.

Applying the results of chapter 3, using an embedded ethnographic case study in a nuclear research center, chapter 4 examines how safety and security practically interact. Leaning on an ANT approach and by focusing on the role of non-humans, it emphasizes the materiality of safety and security enactments. Using the case of the entrance gate to the nuclear research center, chapter 4 traces how two overlapping actor-networks enact antagonistic programs of action, i.e., site access control and site evacuation, the former belonging more to the realm of security, and the latter to that of safety. This examples illustrates the complex agency of non-humans and the role they play in enacting and articulating safety and security. In contradiction with the common ANT approach, it also shows that in order to be aligned, safety and security networks articulating around the gate require interoperability.

Based on the reflections developed through these papers, in the general discussion we cross-fertilize our findings in order to highlight their scientific and practical implications. We end the final chapter by presenting several limitations and avenues for future research.

I. Introductory chapters

1. Introducing safety and security concepts

> *The interfaces [between safety and security] consist of aspects that are in common or need to be managed in an integrated way in order to achieve the common aim of nuclear safety and nuclear security. (WENRA, 2019, p. 15)*

> *It will not be easy to bring both safety and security missions under a larger framework. (Schulman, 2020, p. 94)*

Despite many years of reflection and practice, questions surrounding the coexistence of safety and security persist, tugging at the heartstrings of scientists and practitioners alike. How can safety and security actually co-exist? How should they be managed? What would an integrated approach entail and to what extent is this achievable or desirable? Although safety and security have the same objective, *i.e.* the protection of organizations and society from the dangers (e.g industrial, natural or malevolent) to which they are exposed, it is clear that there are still considerable differences in the way these two concepts are conceived and coordinated.

These are precisely the questions this thesis explores. Understanding how these two concepts are related and how their interactions are reflected in policies and shaped into practices at the organizational level but also at the societal level is the central issue but also the main contribution of this thesis.

In order to answer these questions, it was first important to understand the context in which the two concepts emerged and how they are defined. Starting from their common source, i.e., the concept of danger, it is possible to understand why the implementation of these two concepts still gives rise to differences of opinion today. The following sections attempt to trace the evolution of our societies from the point of view of the dangers they face.

1.1. The common roots of safety and security: dangers

As reflected in the prominent work of Ulrich Beck, societies have evolved in the light of the dangers they are confronted with. Reflecting back on Beck's development is necessary to understand how the concepts of safety and security emerged and have developed over time. Beck's historiographic studies of Western societies from the perspective of the concept of risk[1] led him to distinguish three types of societies: pre-industrial, industrial and reflexive (risk) society (U. Beck, 1992). Although the temporal distinction between the different societies he depicts has faced multiple criticisms (M. Beck & Kewell, 2013; Brunet, 2007; Callens, 2015; Fressoz, 2012; Mythen, 2006), his work still has a major influence on the ways dangers are perceived and managed. These reflections provide a solid conceptual base to introduce the concepts of safety and security, which take a central position in this doctoral thesis.

Beck explains that after a long period (he names pre-industrial society) in which the dangers societies faced were overwhelmingly apprehended as inevitable, untamable and unpredictable and were interpreted as consequences of divine action, the Renaissance marked a change in the apprehension of dangers through the emergence of the concept of risk (U. Beck, 1996). The development of probability analysis accompanied the rise of commercial activities. It allowed the use of the concept of "risk" that enabled European societies to partially extricate themselves from this untamable vision of dangers and the associated predictive ignorance (Bernstein, 1996; Claisse et al., 2002). In contrast to the concept of danger that refers to a catastrophe or a peril that one (an individual or a society) faces without being able to assess its likelihood, the concept of risk is associated with the likelihood that harm will be caused. A risk is therefore a mathematical exposure

[1] Beck's conception of risk is broader than the understanding of the topic in the current literature (see. (Aven, 2017) and rather corresponds to the concept of danger. Incidentally, Beck has been criticized for the lack of conceptual clarification concerning the concept of risk (Bonneuil et al., 2002).

to hazards[2], a danger rationally approached through probabilities. In other words, a risk is an "*expression for the combination of likelihood and consequences of an unwanted event.*" (Aven, 2017). This conception of risk allowed the emergence of a society that rationalizes dangers and brings a certain predictability and order to human activities, leading to the exponential growth of the economy. As Bernstein summarizes, :

> *'by defining a rational process of risk-taking these innovators [Cardano among others] provided the missing ingredient that has propelled science and enterprise into the world of speed, power, instant communication, and sophisticated finance that marks our own age. […] Risk management guides us over a vast range of decision-making, from allocating wealth to safeguarding public health, from waging war to planning a family, from paying insurance premiums to wearing a seatbelt, from planting corn to marketing cornflakes.' (Bernstein, 1996, p. 2).*

This society (Beck called the industrial society), characterized by the advent of scientific rationality, is also marked by the growing power that humans have over nature and the division between humans and nature. The undesirable and harmful effects, intrinsic to the development of technology and industrial activities were somehow grasped and rationalized through a regulatory system: the concept of risk was promoted and became, at the same time, an indicator of the development of Western societies (Brunet, 2007).

> *'The incalculable threats of pre-industrial society plague, famine, natural catastrophes, wars but also magic, gods, demons are transformed into calculable risks in the course of the development of instrumental rational control, which the process of modernisation promotes in all spheres of life.' (U. Beck, 1992, p. 30).*

In the 19th century, industrial society in Europe took on another dimension due to the convergence of two closely intertwined phenomena. On the one hand the availability of natural resources and on the other, that of human resources, both intellectual and manpower (Brunet,

[2] A hazard corresponds to the condition that presents a danger to the environment as well as endangering an individual's life. A hazard can be a material or an artefact (radioactive waste or a bomb), a process or an activity (working in dangerous circumstances).

2018). The coupling of fossil energies, technological innovations, and the mathematical risk concept significantly increased human power. New risks emerged from this convergences, which, by exacerbating such developments, led to the advent of what Beck called the "risk society" characterized by a significant increase in anthropic risks of unprecedented magnitude. It is precisely the victories of industrial societies and modernization processes that unintentionally led to the emergence of "reflexive risks" capable of shaking the foundations of our societies (Brunet, 2007). These risks are characterized by an extended temporal and spatial dimension, irreversibility and multidimensionality (economic, public health, environmental, political, ethical at the same time) (Brunet, 2007). Industrial disasters, such as the Bohpal catastrophe (1984), the Chernobyl catastrophe (1986), the Seveso disaster (1976) or the Fukushima nuclear disaster (2011), are illustrations that led Beck to affirm that '*it is now possible for humans to destroy all that we have created, with what we have created*' (retrieved from Lupton, 1999, p. 4). If industrial societies are marked by an opposition between nature and society, "reflexive societies" correspond: '*to the end of [this] opposition*' (U. Beck, 1992, p. 146). Technological development, once considered as a pure source of progress is presented as a new source of insecurity. Reconsidering the notion of progress, the advent of reflexive society is characterized by an extension of insecurity in all individuals (Callens, 2015).

Although Beck's reflections were triggered by the phenomenon of acid rain in Germany and by major industrial accidents, after the turn of the 21st century and the 9/11 terrorist attacks, they increasingly include another type of risk: the threat of terrorism (U. Beck, 2002). In Beck's opinion, these terrorist threats fit the perspective of reflexive societies very well. Indeed, they have the same disruptive power as the major industrial accidents highlighted by this literature. In the same way as ecological disasters and global financial crises, Beck suggests conceptualizing terrorist threats under the aegis of reflexive risks (U. Beck, 2002).

> *'At the same time, progress itself leads to an exponential multiplication of terrorist risks. Through the technologies of the future - genetics, technology and robotics - we are opening a "new Pandora's box". Thus, the legitimization of future technologies will depend decisively on*

> *when and to what degree we are able to see these risks no longer as chance effects, but as intentional acts, no longer as side effects, but as the results of terrorist acts' (U. Beck, 2003, p. 33).*

Terrorism opens a new arena of reflexive modernization. Risk models need to take the possibility of malicious application into account (U. Beck, 2003). Consequently, the organizations, I refer to throughout this thesis as "high-risk organizations" (meaning organizations in the nuclear, chemistry, aviation or telecommunication sectors that are both potential targets for malevolent attacks and represent a high potential hazard for societies), simultaneously become the cause of major industrial disasters (see above) but are also the target of malicious intent[3] e.g. threats of terrorist attack. The concept of threat is used throughout this thesis to refer to the risk of malevolent activity. Following Jore's definition of threat, this concept is apprehended in this thesis '*as a perceived possibility of harm or a possible perpetrator's intention to cause harm'* (2019, p. 162). In general, such organizations are consequently real crossroads of risk societies and therefore require particular attention.

1.2 The evolution of safety and security studies

It is in the context of increasing reflexive dangers (or risks in Beck's understanding of the term), both accidental and malevolent, that the central concepts of this doctoral thesis are discussed. They indeed make me wonder: how does a reflexive modernity address accidental risks and malevolent threats?

The concepts of safety and security emerged to protect society from an increase in respectively, non-malevolent risks and malevolent threats, and are taking an increasingly prominent place in reflexive society (Bieder & Pettersen Gould, 2020; Cambacédès & Bouissou, 2013).

[3] For instance, the terrorist attack on the In Amenas refinery (2013), the terrorist attacks on the Madrid, London and Brussels subways (2004-2005-2016), the terrorist attack on Brussels airport (2016), the terrorist attack on the "Renaissance Dam" in Ethiopia (2017), and the attempted terrorist attacks on a nuclear power plant in Sydney (2013).

Generally speaking, the concepts of safety and security are ubiquitous. Whether talking about accidents or disease prevention and protection[4] but also the fight against terrorism or inter-state wars etc., these concepts appear to be central to our societies. They are mobilized to organize our work, our movements, and our social relations in the light of any danger. However, safety and security are not new concepts. They have their roots in and have evolved in various contexts.

1.2.1 Scientific development of safety and security concepts

1.2.1.1 The concept of safety as a response to industrial risks

The concept of safety emerged in industrial society around the issue of accident prevention and insurance. As Leveson shows, '*safety has been a part of engineering for at least 100 years and has been a concern to societies for much longer than that*' (1993, p. 17).

The engineering approach combined with the science of safety has led to the emergence of risk control techniques that have spread, in particular, with the increasing use of probabilities (U. Beck, 1992; Bernstein, 1996). Beck demonstrates how the approach developed through scientific techniques (such as risk analysis techniques or, in the nuclear world, the development of the "As Low As Reasonably Achievable" (ALARA) principle) giving the illusion that risks are under control. The perception of safety changed after the Second World War and the occurrence of major industrial accidents. These accidents led to a growing general awareness that industrial risks could extend beyond the place where they occur and impact the whole society. In response, emergency

[4] Through for instance, road safety, industrial accident prevention, worker protection or protection against Covid-19 (eg. the "Covid Safe ticket").

planning and crisis management were developed in the 1960s (Alexander, 2002; U. Beck, 1992; Haddow et al., 2017).

The evolution of these risk management techniques, as well as the occurrence of major disasters, were the source of significant academic developments in the concept of safety. Indeed, throughout its development, the concept of safety has been perceived in a distinct manner and divergent approaches and key concepts guided its development. Overall, most of the literature on safety and the issues addressed within it have been developed in an organizational context. Safety studies are therefore widely connected to organizational literature. Notably, the concept of safety developed along the distinction between the "passive" and "active" definitions which still articulates its developments. Studying the use of the concepts of safety (but also the one of security) in vernacular language, Boholm and colleagues as well as Hollnagel note that the most common view of the concept corresponds to the condition or quality of being free of danger (Boholm, 2012; Hollnagel, 2014). This approach which predominates in the literature, perceives safety as the absence of risk (Amundrud et al., 2017; Atkins, 1991; Aven et al., 2015; Hessami, 2004; Leveson, 1993; OECD/NEA/FSC, 2013; Schnieder et al., 2009). According to this view, safety is therefore a state rather than a process. This view of safety has been categorized as a "passive vision". Criticizing this vision, several authors claim that absolute safety is inherently unachievable (Boholm et al., 2016; Le Coze, 2019; Rollenhagen, 2010). According to these authors, reaching "zero risk" is totally illusory. According to this hypothesis, the use of the concept is therefore dangerous in that it gives a false impression of absence of risk (Rollenhagen, 2010).

Continuing these reflections, Rollenhagen defines safety as '*the presence of material, symbolic and immaterial arrangements and conditions (technological, norms, administrative, social, etc.) which have the function to dynamically cope with direct and indirect real or potential hazards which may result in negative consequences.*' (2010, p. 270). This active vision of safety tends to interpret it as a set of measures and elements whose objective is to prevent the occurrence of risks. Several other definitions of the concept have been formulated according to this vision. For example, in the context of radioactive

waste management, the European Nuclear Safety Regulators Group defines safety as '*the achievement of proper operating conditions, prevention of accidents, or mitigation of accident consequences*' (ENSREG, 2013). For their part, Olsen and colleagues define societal safety as the '*ability to maintain critical social functions, to protect the life and health of citizens and to meet the citizens' basic requirements in a variety of stress situations'* (Olsen et al., 2007, p. 71). This vision incidentally concurs with Beck' arguments on how societies deal with risks. First, the three societies (pre-industrial, industrial and risk societies) he depicts are rooted in the presence of dangers and, in results, in the impossibility of achieving a state of "being safe". Beck then shows how, in the face of such dangers, societies actively build protection frameworks through lay or scientific measures in order to prevent and mitigate dangers.

Another essential discussion around the concept of safety concerns the one of safety culture. This concept, which emerged at the end of the 1950s through the concept of safety climate in the organizational context, changed following the Chernobyl catastrophe and the first IAEA report (INSAG-1), which used the concept of safety culture for the first time (IAEA, 1986). Although facing a lot of confusion and including distinct perspectives, broadly speaking it is characterized as the set of values and principles shared by human actors intended to prevent and mitigate the occurrence of safety risks (see for instance, Choudhry et al., 2007; Cooper, 2008; Guldenmund, 2007; Mbaye et al., 2009). The discussions around this concept helped highlight and conceptualize the organizational issues and the impacts values and principles have on protection against accidental risks. The concept of safety evolved to tackle human impacts on safety. The safety culture concept became increasingly prominent and, until the 2010s, was the subject of major scientific advances, mainly in safety studies (M. D. Cooper, 2000; Guldenmund, 2000). Research around safety cultures was also one of the vectors of the amalgamation of safety and security literatures through the emergence of the concept of security culture (IAEA, 2017; Jore, 2017a; Reniers et al., 2011).

1.2.1.2From war to terrorist attacks: the concept of security

For its part, the contemporary meaning of security originates in the context of international relations. More specifically, the first political and scientific development of the concept emerged in Germany (under the term *sicherheit*) within the framework of the Treaty of Westphalia (1648) to designate the "security of nations" that the treaty intended to organize. The concept then spread to France and England in the context of the revolution at the very end of the 18th century. The concept thus became predominant in parallel with the formation of nation-states.

In this context, the Hobbesian academic literature strongly influenced the conceptualization of the term security. As Spieker states, the '*project of security is [...] not temporary but perpetual, for it constitutes the very principle of stability, which sustains the body politic.'* (2011, p. 193). For states, security is a fundamental concept in that it is linked to their main objective, namely, their survival. Indeed, it is only once the state is stabilized that it can seek to achieve goals of tranquility, profit, and power (Waltz, 2010). It is therefore in parallel to the threat of war that the concept of security develops.

According to Spieker, the concept of security was initially substantiated through normalization, discursive regulation and the state of exception (2011). Subsequently, in line with Grotius's reflections, the concept developed more and more at the international level and influenced the creation of international institutions (Haftendorn, 1991). As a result, a differentiation appeared between external security, referring to protection against threats from other states, and internal security, referring to protection against threats within the country (Bigo, 2006). After the Second World War, it integrated the bipolar logic of the Cold War, while remaining focused on inter-state relations (Jore, 2019; Pettersen Gould & Bieder, 2020).

At the turn of the 21st century, the concept of security evolved around the '*increased consciousness about societies' own vulnerabilities to malicious acts such as sabotage and terrorism*.' (Pettersen Gould & Bieder, 2020, p. 2). As contended by Jore, these latest developments are

> *'in stark contrast to a few decades ago, when security was predominantly perceived as the responsibility of the police and army. Along with the broadening of the meaning of security, in addition to more focus on society itself as an object of security, security is no longer exclusively connected to the nation state. Given the diverse meanings of security, it is not obvious to whom and to what the concept of security refers.' (2019, p. 159).*

1.2.2 The challenges of defining safety and security

Although today ubiquitous, the concepts of safety and security are still used, described and defined rather vaguely and defining safety and security remains a challenge. As Pettersen and Bieder put it: '*a single word for safety and security [is used] in many languages (unlike in English)'* (2020, p. 4). Languages such as Swedish (säkerhet) or German (Siecherheit) have only one term for the two concepts. Beyond the linguistic issues, these concepts of safety and security are still used interchangeably in some cases, thereby accentuating this confusion. As Boholm and colleagues state, '*safety (safe) and security (secure) have similar meanings, and are therefore often treated as synonyms*.' (2016, p. 329). For example, studying the relationship between the concepts of risk and safety, Blokland and Reniers incorporate the concept of security within safety science when they state: '*risk and safety -where safety needs to be understood in a broad perspective including security- are tightly related and the understanding of these two concepts have evolved in similar ways.*' (2020, p. 11).

Moreover, the very conception of these respective concepts also remains divergent depending on the perspectives and domains in which they are employed. As Cambacédès and Bouissou state,

> *'the terms "safety" and "security" have varying meanings depending on the context and the technical communities. They differ for instance substantially between an electrical engineer, a computer scientist or a nuclear expert; they can even swap in some cases (e.g. nuclear security vs. electrical security). In fact, there are no absolute definitions for such concepts.' (2013, p. 111).*

Specifically concerning the concept of safety, it seems that despite a profusion of works dealing with or mobilizing the concept, there is still no consensus on its definition. As stated by Blokland and Reniers: '*after reviewing the safety science literature, it is clear that the question "what is safety*" *can be answered in many ways and that it is very hard to find a clear definition of its opposite*' (2020, p. 10). This aspect, coupled with the use of the term in common language under multiple meanings makes its meaning all the more ambiguous (Pettersen Gould & Bieder, 2020).

The problem seems to be different for the concept of security. Despite almost equally frequent use in common language, the concept of security has not been the subject of scientific scrutiny (Jore, 2019). Indeed, dealing with the concept of security in a context of international relations, continuing the reflections developed by Buzan (1991), Baldwin states that '*it would be an exaggeration to say that conceptual analysis of security began and ended with Wolfers' article in 1952 [Wolfers, 1952]-but not much of one. The neglect of security as a concept is reflected in various surveys of security affairs as an academic field.*' (1997, p. 8). This lack of research and academic debate coupled with the fragmentation and segmentation of the concept was already underlined by several authors in the 1990's and the 2000's including Baldwin (1997), Buzan (1991), Malcolmson (2009), Manunta (2007). It has been more recently re-emphasized and has led some, like Brooks and Coole, to argue that it '*lacks the characteristics of a defined body of knowledge'* (2020, p. 65).

1.2.3 The malevolent/non-malevolent axis: distinguishing safety and security

The widespread confusion about the meaning, relationship and distinction between the concepts of safety and security makes it more difficult to understand how they are characterized, and subsequently, what connects and differentiates them in theory and in practice. To understand

what characterizes the concepts and how they are interconnected, it is necessary to understand what distinguishes them.

For the past two decades, academic literature has been reinvestigating the two concepts and their relations and has sought to determine what distinguishes them (Amundrud et al., 2017; Aven, 2007a; Bieder & Pettersen Gould, 2020; Boholm et al., 2016; Cambacédès & Bouissou, 2013; Cusimano & Byers, 2010; Gandhi & Kang, 2013; Hessami, 2004; IAEA, 2010; Jore, 2019; Kim & Kang, 2012; Malcolmson, 2009; Schnieder et al., 2009). Until a few years ago, the concepts of safety and security were often distinguished along two axes. The first axis distinguished between safety and security according to the origin of the danger against which they are developed. According to this division, safety focused on the risks internal to an entity, more specifically those of high-risk organizations, whereas security focused on dangers external to this entity (Boholm et al., 2016; Cambacédès & Bouissou, 2013). As Cambacédès and Bouissou summarize, '*this distinction separates risks*[5] *originating from the environment (i.e. assets, goods and people as well as the surrounding natural world) and impacting the system, from those coming from the system and impacting the environment'* (2013, p. 111).

A second distinction developed concomitantly and gradually absorbed the first. This demarcation is based not on the origin of the dangers, but rather on their nature. According to this perspective, many authors distinguish safety and security based on their respective apprehension of unintentional or undeliberate dangers on the one hand and intentional/deliberate ones on the other (Hessami, 2004; Holtrop & Kretz, 2008; Kriaa et al., 2015; Pièrre-Cambacédès, 2010). More recently, Jore stabilized the distinction by demarcating safety and security concepts along the malevolent/non-malevolent axis (2019). Today this distinction harmonizes the vernacular and dominant academic use of the terms (see Boholm et al., 2016). Throughout the thesis, I therefore refer to the second distinction when referring to safety and security concepts.

[5] Once again, in their conception, risks are understood in a broad sense and encompasses all types of dangers.

1.2.4 Integrating safety and security: the dominant perspective

As shown above, these two concepts and fields of study were treated in very distinct literatures. Consequently, few interpenetrations were made, few cross-fertilizations took place or parallels were drawn between the two concepts until the turn of the 21st century. The 9/11 terrorist attacks in 2001 profoundly modified the understanding of the two concepts and forced the organizational safety literature to open up to security considerations. Several authors considered critical infrastructures, such as nuclear power plants, as potential targets of terrorist attack, that could have consequences comparable to the those of the biggest nuclear accidents in history (NTI, 2011).

As Allison summarizes:

> *'the United Airlines flight that crashed in Pennsylvania on its way to the Capitol might instead have targeted Three Mile Island. The airplane that attacked the Pentagon could have targeted the North Anna power plant near Richmond, Virginia. […] The attack could cause the reactor to melt down, releasing hundreds of millions of curies of radioactivity into the surrounding environment, hundreds of times that released by the Hiroshima and Nagasaki atomic bombs. We already know what such an incident would look like.' (2004, p. 11)*

This frightening prospect strongly influenced reflections in the literature on the concept of safety, especially in the nuclear field. Eleven years later, Kim and Kang wrote

> *'the Japanese earthquake and tsunami of 2011 rang another, implicit alarm bell: A Fukushima-like accident does not have to be caused by nature. Similar results could be wrought by a dedicated terrorist group that gained access to a nuclear power plant and disabled its safety systems' (2012, p. 86).*

Echoing this statement, Leveson argues that determining whether a crisis has its roots in malicious intent or not is not essential in the response and mitigation process: '*whether the explosion of a chemical plant, for example, is the result of an intentional act or an inadvertent one, the result is the same, i.e., harmful to both the system and the environment'* (2020, p. 20). Analyzing these events from the perspective

of the risk society, Claisse and colleagues mention that '*terrorism, threats to water supplies, as well as the Chernobyl accident, are phenomena that can be studied in terms of reflexive risks*'[6] (2002, p. 121).

These considerations highlight the fact that safety and security are interrelated around the protection of critical infrastructures. As Cambacédès and Chaudet state, '*they are in fact inseparable from CIP (Critical Infrastructure Protection)*' (2010, p. 1). This can be explained by the fact that safety and security share the same ultimate objective which is to protect '*individuals, the public and the environment'* (IAEA, 2019, p. 1), or to '*provide social wellness through risk control*' (Brooks & Coole, 2020, p. 63). In short, safety and security both aim to protect societies against dangers.

Based on this observation, the concept of security, which, at the time, still strongly focused on interstate relations, was increasingly incorporated in the literature on safety in the context of high-risk organizations. Therefore, '*the increasing emphasis on security and associated security risk reduction measures leads to an obvious intersection between safety and security management in hazardous industries.*' (Pettersen Gould & Bieder, 2020, p. 2). Safety and security were increasingly considered using an integrated approach. And as Cambacédès and Bouissou write, '*all the tools extended from one domain to another mentioned in this paper become logically good candidates to provide integrative frameworks to deal with both safety and security'* (2013, p. 122).

Even if these evolutions infiltrated all organizational literatures, it should be noted that the nuclear domain was a pioneer and is still at the forefront of reflections on the integration of safety and security (Gandhi & Kang, 2013; IAEA, 2001, 2004, 2010; Kim & Kang, 2012).

These integrated approaches generally focused on finding similarities and synergies. As Gandhi and Kang noted, an '*exhaustive literature survey had been carried out to identify the areas in which synergy between safety and security could be maximized*' (2013, p. 358). Although many authors recognize that safety and security have different needs and requirements (such as delay barriers, access control or transport of nuclear material), they strive to highlight the areas where safety and security improve mutually (Kim & Kang, 2012). Again, in the nuclear sector,

[6] Translation from the French made by the author

> *'the notions of risk and graded approach […] play a central role during the design phase, both in safety and security. In particular, the defense-in-depth approach, initially deployed in military circles, and then in nuclear safety, is now applied to other sectors, in computer security or physical security.' (Cambacédès & Bouissou, 2013, p. 114)*

Based on these examples, like Cusimano and Byers, many authors affirmed that '*weakness in security increases risk, decreasing safety. Safety and security are directly proportional, but are inversely proportional to risk*' (2010, p. 14). These reflections led a large number of authors to assert that the integration of safety and security would generate synergies (Batra & Nelson, 2012b; Cusimano & Byers, 2010; Gandhi & Kang, 2013; Hessami, 2004; IAEA, 2016b, 2019; Kim & Kang, 2012; Kriaa et al., 2015; Reniers et al., 2011; WENRA, 2019).

1.2.5 Contradictions and tensions in practice: recent scientific developments

More recently however, several authors questioned this dominant synergistic vision of the relationship between safety and security at the organizational level. Although they agree on the assertion that the ultimate objectives of safety and security are similar and that there may be little difference between feeling secure and feeling safe, they highlight divergent objectives between the two concepts (Jore, 2019; La Porte, 2020; Pettersen Gould & Bieder, 2020; Schulman, 2020). Going further, Brooks and Coole mention that '*safety and security only have commonalities at the overarching abstract level*' (2020, p. 63). In the opinion of these authors, such conceptual divergences lead to tensions between safety and security in the field. The transfer of the concept of security to the safety literature is not as trivial as described (Wipf, 2020).

In addition, several authors highlight the difficulty of characterizing the relationship between the two concepts, as safety and particularly security concepts require stabilization. Indeed, as Jore states

> *'the current state of organizational security research suggests there is still an extensive lack of knowledge concerning how security risk management is performed and understood from an organizational perspective. Accordingly, in view of the current state of affairs, cross-fertilization [7] between safety and security seems a more promising trajectory than an integrated approach.' (Jore, 2017a, p. 852)*

Consequently, this lack of knowledge undermines the understanding of the relationships, potential synergies or tensions that might arise from the interrelationship of the two concepts in high risk organizations. Schulman, analyzing the research on "High Reliability Organizations", states that:

> *'it has focused on a number of organizations (nuclear power plants, commercial aviation and air traffic control centers, and electrical grid management organizations, for example) with extremely well-developed reliability strategies in both technical design and management systems for protection against failures that can create catastrophic accidents. These organizations notably, as critical infrastructures, are also potentially high-value targets for terrorist assault. But it is not clear from this research that [High Reliability Organizations] are simultaneously addressing both safety and terrorist security objectives in their reliability strategies.' (2020, p. 87).*

He goes on to conclude that '*we have yet to parse out the full range of contradictory and complementary requirements of these two as managerial missions'* (Schulman, 2020, p. 87). Despite this conceptual indeterminacy, it is important to have a temporary definition of the concepts of safety and security. Corroborating Jore's works, safety can generally be characterized as a framework aimed at protecting an entity (society, organization, individual) against non-intentional risks. Security

[7] In this context, cross-fertilization refers to an approach that considers the similarities, differences and interdependencies (Jore, 2019).

corresponds to a framework aimed at protecting an entity against intentional and malevolent threats.

2. Safety and security shaped in and through practice: research focus

> *'To what degree do Safety/Security[…] re-enforce each other; conversely, impede each other sufficiently to prompt tension and conflict. […] These are demanding questions—derived from suggestive conceptual speculation, analytical hunches, and in-depth observers' experience. "Thick descriptions" in the answer are meager. Crisp analytical work has yet to be done. Considerable qualitative observational fieldwork is imperative…and extraordinarily demanding' (La Porte, 2020, p. 77).*

La Porte's plea embodies exactly the posture I defend in this thesis. As shown above, the literature on safety and security in the last two decades was mainly based on functionalist and engineering perspectives (see section 1.2.4). Grasping safety and security only as structuring concepts and as packages of technical measures that can be managed, cannot in my opinion, make sense of the complexity and the dynamic and contextual characters of their relations. The objective of this thesis is therefore to go beyond these framing approaches to safety and security relations to understand how they interplay in and through practice. By taking up and continuing these reflections, this thesis aims to answer the following research question: **how are safety and security interrelations shaped in and through practice**?

I firmly believe that answering this question will improve our understanding of the relationships between safety and security and will not only help academics but also practitioners in various sectors to better understand how to manage them. Furthermore, the issues of safety and security will become increasingly important with the growing instability and reflexive risks caused by scientific and technological progress, global warming and destruction of the environment. Understanding how these two concepts interrelate is therefore not only interesting but indeed crucial if we are to tackle the major challenges our societies are already facing and that can only

increase. As La Porte states, '*current technical and environmental changes will continually increase the relatively hazardous nature of operations such that both increased densities of Safety and Security regimes will be demanded.*' (2020, p. 77).

To answer the general research question, I chose an approach that can account for the relationality between actors participating in accomplishing safety and/or security. Practical assessment of safety and security interactions cannot be achieved by only considering them as 'states', in a passive conception of safety and security, but rather as dynamic constructs. Improving my understanding of how these two concepts interact and how to manage them also required a more contextualized perception of how they are constituted. To this end, I undertook an in-depth study of two cases in Belgium: one in a nuclear research center (NRC) and one on emergency management (EM).

3. The conceptual framework of this thesis

To make sense of how safety and security are constituted and related to each other through practice, I mobilized heuristics from Science, Technology and Society (STS) studies. More specifically, I opted for the Actor-Network Theory (ANT) to trace the concrete yet evolving associations of actors who enact safety and security using the tools developed in the scientific field of research on innovation production (Akrich et al., 2006; Callon, 1985). As I will show, ANT provides a strong epistemological approach to analyze how safety and security are put into action, overlap, and interact.

3.1 Associations and symmetry: the Actor-Network Theory

Actor-Network Theory (ANT) or *la Sociologie de la traduction* was coined by Akrich, Callon, Latour and Law in the 1980s. This approach is embedded in the broader field of *Science & Technology Studies* (STS). STS is an interdisciplinary social science field of study that investigates how social, political or cultural factors affect scientific research or technological innovations and how, in turn, these change society, politics or culture (Bonneuil & Fressoz, 2013). With its roots in the sociology and philosophy of science, STS emerged in the 1960s and 1970s with the works of authors such as Bloor (1976), Barnes and Dolby (1970), Shapin (Shapin & Barnes, 1977), Collins and Harrison (H. M. Collins, 1981; H. M. Collins & Harrison, 1975) who consider science as a social construction.

This eclectic and dynamic approach emerged as a critique of existing sociological approaches that focus on predefined entities and make a distinction between nature and culture to explain society. In agreement with Michael, Bielenia-Grajewska asserts that '*ANT is not a static edifice it has been adapted, nuanced, expanded, and problematized by numerous scholars, not least by its founders'* (2020, p. 16). Faced with a school of thought as rich and diversified as ANT, any attempt at an exhaustive synthesis seems doomed to failure. The present overview of ANT therefore only attempts to explain some of the essential elements of this approach as applied in the context of this thesis.

Although the term Actor-Network Theory indicates a scientific theory, it primarily corresponds to a methodological approach, a methodology of inquiry (Latour, 2010a). It has its origins in a conception of the term "social" that is out of step with the current dominant sociological approaches. According to that definition, the etymological derivation of the word social comes from *seq, sequi* which means "to follow". Moreover, in Latin, it refers to the term *socii* which means "to ally with". Drawing on this etymology, ANT defines social through the term "association". As Strum and Latour summarize, '*socio means to unite together, associate, to do or to hold in*

common. From the different languages, the historical genealogy of the word "social" is constructed first as following someone, then enrolling and allying and lastly having something in common.' (1987, pp. 793–794).

Consequently, his theoretical position is that the world is not composed of entities but of associations between actors. These associations of actors are necessarily local, contextual and evolving. Actors associate through the process of networking and thereby participate in the formation of society. Society is not immanent but rather emanates from associations between actors (see among others Akrich, 1987; Callon, 1985; Callon & Latour, 1981; Latour, 1984; Law, 1987; Strum & Latour, 1987). In this respect, ANT runs counter to the structuralist approach, which paradoxically suggests that '*actors, rather than appearing to create society, now appear to be inserted into a material society that overpowers them'* (Strum & Latour, 1987, p. 796).

In practice, '*the actors (no matter their size – macro or micro) define, for themselves and for others, what society is'* (Strum & Latour, 1987, p. 785). The world we live in is the contingent result of associations between actors. Through this process, actors shape and reconfigure their identities and those of others. This principle of relationality means that actors are defined and redefined through their relationships with other actors.

The study of our societies is thus undertaken by following the actors, their associations, their modifications and in this way, by noting '*the specific setups of these sophisticated constructions, [by following] the cross elaboration of a field and its object, through controversies and questioning'* (Hennion, 2013, p. 4). In this approach, any entity composing our societies becomes an actor as soon as it has the capacity to act on others. It is indeed the action that makes the actor and not the reverse. This capacity is also called agency which can be described as '*the capacity to affect something and therefore is not just attributed to human actors'* (Neisser, 2014, p. 94). It refers to the capacity to initiate desired or preferred courses of action. (Dwiartama & Rosin, 2014). Agency is therefore emergent, relational, and dynamic, not an inherent property of actors (Aanestad, 2003). As Law explains, an actor (or actant as ANT researchers sometimes call them) is defined as '*an effect generated by a network of heterogeneous, interacting, materials'* (1992, p. 383). Again, as described by Callon & Latour, it

corresponds to '*any element which bends space around itself, makes other elements dependent upon itself and translates their will into a language of its own'* (1981, p. 286). Hence ANT does not only counter the structuralist paradigm that assigns predefined power and agency to structures that set the frame of the world, but also counters the approach that emphasizes actors' internal capacities to act.

This contribution is important for several reasons. Firstly, it shows that it is the movement, the dynamism, the translation that is important in ANT rather than the actors considered as entities or actors' associations considered as a set of actors. The different elements that make up societies are not interesting per se, rather it is the connections they make with others that make them interesting. Connections transform actors. As Latour makes clear: *'action is never anything other than the contest offered by the multitude of associates: 'Socrates' associated with the low wall on which he is sitting is already no longer the same as when he was leaning, standing and walking with the help of his sandals... And the low wall is no longer quite the same either, for it is also composed of all those whose 'allies' he temporarily makes - thanks to 'Socrates'*[8] (2010a, p. 6).

Secondly, this association removes the prominence of humans over non-humans, it destroys this *a priori* ontological separation between the technical/natural and human components of our societies. Following the term used by Latour, it allows the inclusion of the "missing masses" in the framework of analysis of the social (Latour, 1992). According to this vision, the differences between entities are produced through their relations within networks but are not presupposed. This methodological precept is called "generalized symmetry" (Callon, 1985). In this sense,

> *'Actor Network Theory attempts to overcome […] the slicing of a continuous hybrid reality into separate analytical domains. Latour claims that modernity has been misinterpreted through a series of false dichotomies; the largest, nature/society, legitimizes a whole series of others: subject/object, fact/value, micro/macro, structure/agency, and so forth' (S. Cooper, 2008, p. 308).*

[8] Translation from the French by the author.

In order to study a phenomenon or an object, ANT requires the examination of all the relationships linking the actors, or in other words, it requires the study of the networks of actors. In this vision, '*networks are therefore not a set of links but rather a way of analyzing interactions. A network analysis focuses on the translations of actors that take place through their interactions. It is a tool for describing the social, not an element of the social as such*' (Latour, 2005, p. 191).

Translation, another central concept of ANT, refers to an active process through which agents create a "space", and align other actors within it. It is through this process of translation that the identity of the actors is transformed. If successful, the process of translation aggregates and mobilizes different actors, thereby creating a new actor that includes and transforms all the identities of the different actors that make it up. This new actor enacts a program of action. The "program of action" refers to the actions resulting from the associations of different actors (Latour, 1994). As an illustration, Latour gives the example, in a hotel, of the association of a key, and spoken and written instructions to: "please return the key to reception" with a weight attached to the keychain, which together, fight against an anti-program: undisciplined clients who do not hand in the key when they leave the hotel (Latour, 1993a). More than an aggregation of scripts, the program of action makes visible the negotiated mission of the actors that creates a new entity and, in this way, redefines all the actors. The "program of action" concept also avoids using deterministic ideas concerning the agencies of actor associations. To illustrate this, Latour bypasses the National Rifle Association's notorious slogan that it is people - not guns - that kill, and instead asserts that "it is neither people nor guns that kill": '*the responsibility for action must be shared among the different actors'* (1994, p. 34). As Rosenberger states, '*the program of action is in practice the answer to an antiprogram against which the mechanism braces itself*.' (2014, p. 374).

The success of the translation is determined by the "alignment" of a network of actors behind a specific program of action. In other words, network alignment is achieved when actors' interests and identities are translated into an expression that wins the consent of all actors (Aanestad, 2003; Callon, 1991; Healy, 2004; Latour, 1992; Law, 1990). Alignment can be described

as the stabilization (always contingently affected by pressure of destabilization) of actors' configurations. The stability of a network leads to more durable and less reversible interactions between actors. This stabilization of the network is termed "punctualization", creating a "black box" with the appearance of stability (Callon, 1991).

3.2 Mobilizing ANT in the fields of safety and security

ANT has developed impressively over the years and has been applied in a variety of themes and fields of study ranging from urban planning (De Munck, 2017; Wissink, 2013), trivial artifacts, (Latour, 2007; Norman, 2000), economy (Callon, 1991), geography (Graham, 1998; Murdoch, 1998) scientific discoveries and innovations (Goulet & Vinck, 2012), and risks related to technological innovations (Neisser, 2014; Pohler & Schillmeier, 2010).

In the field of risk research, ANT has already been used by Balzacq and Dunn Cavelty (2016) to study how cyber security incidents re-shape the identities of regions and states. These authors demonstrated how malware can be understood as active and fluid objects that, by challenging the sovereignty of sovereign states and the stability of their borders, triggered strong reactions aimed at reinforcing their territoriality in the virtual domain. ANT was recently used by Komasova to study airport security. She demonstrated how understanding security as a set of chains of translation that produces security and threat makes it possible to explicate the inherent challenges posed by making airports secure and their social consequences (Komasová, 2021).

In safety studies, ANT has also been used by, among others, Gherardhi and Nicolini, who studied organizational safety as a system of practice that is relational and mediated by artifacts. These authors show how safety is translated into technologies, manuals, regulations, or conferences. In their opinion '*the body of knowledge [...] does not produce safety by itself, but only when it is put to work by situated actors in situated work practices and in local interpretations of its meaning and constraints.*

In this sense, we conceive safety as a social competence enacted by an action net which recreates its context by means of institutional reflexivity' (2000, p. 344).

ANT thus appears to be as an eminently instructive approach to study the concepts of safety and security and their interactions. Indeed, ANT enabled me to examine the way in which these concepts are deployed in the field, both contextually and dynamically. It also makes it possible to empirically analyze the impact of the materiality - strongly present in this field of study - on the achievement of safety and security. Finally, it makes it possible to trace all the links between the different actors (human or non-human) and the influences they exert on each other. Thus, it provides practical tools to understand the empirical interactions between safety and security when enacted.

Although it appears particularly appropriate for the analysis of field research, some ANT precepts have and still are subject to criticism. Such reflections are interesting in the frame of this thesis because they identify potential drawbacks of using ANT and show how its limitations can be tackled and overcome with other approaches to safety and security relations.

3.2.1. The "flat ontology" or the impossibility to account for differences of scale and power relations

One major source of criticisms concerns the "flat ontology" developed and proposed in ANT. The social topography described by ANT rejects any *a priori* attribution of scale (such as macro or micro, local or global) to social actors. According to Latour, '*no place dominates enough to be global and no place is self-contained enough to be local*' (2005, p. 204).

According to its opponents, flat ontology dissolves the distinction between the local and the global, and consequently cannot distinguish the qualitative differences between the different actors who compose the world. To claim that the only dissimilarities between actor-networks stem

from their size is to say that the contrasts between several types of actors are only differences of degree and not inherent demarcations. Therefore, according to ANT, a relationship between individuals can be analyzed in the same way as a relationship between states.

Contradicting this view, authors like S. Cooper contend that qualitative differences between actors do exist (2008). In his opinion, flat ontology not only impoverishes the interpretative capacity of the different actors and their fields of power but also does violence to the observable reality of the world by reducing any type of relationship to a single level of analysis.

Beyond these criticisms, the flat ontology practiced by the proponents of ANT is also denounced for its inability to critically analyze the social relations observed: '*arguably Actor Network Theory's flat ontology, irrespective of the intentions of its practitioners, ends up in such a state of uncritical worship.*' (S. Cooper, 2008, p. 323). The descriptive and non-deterministic *a priori* nature of the analysis seems to several academics to be inappropriate for the development of a critical analysis of the networks observed and to unveil power relations (S. Cooper, 2008; Whittle & Spicer, 2008). Indeed, the descriptive nature of ANT could not reveal questions about the origins of actors' interests and the logics underlying the translation processes. In other words, ANT would not be equipped to understand why and according to what interests a network is configured in the way it is. It pays more attention to the question "how" than to the question "why".

Similarly, the descriptive nature of ANT would be unable to identify resistance within these stabilized networks. It would present an overly smoothed and deterministic view of stabilized networks notably through the concept of enrolment and "punctualization". According to its detractors, this is a totalizing, coherent and exhaustive vision of programs of action that is incapable of shedding light on the power relations and attitudes of resistance within actor-networks. Indeed, according to Whittle and Spicer, power and resistance cannot exist without each other. The sociology of translation therefore makes it difficult to take into consideration actions outside the translation process that nevertheless disrupt it (2008).

3.2.2.ANT or understanding of power as a consequence of actions

According to ANT proponents, criticisms of the concept of flat ontology and its too descriptive character which makes it unable to address power relations, stem from a misunderstanding of how ANT perceives power itself as a relational concept but also a misunderstanding of the nature of ANT itself.

On the one hand, ANT proponents assert that their inquiries are only about power relations. The issue lies in the different conception these actors have of power. Power is not held by one or several actors but shared and power is not based on intention: '*a good way of getting started here is to forget about imagined 'sources' of power, such as intentions, will or consciousness, and focus instead on effects.*' (Munro, 2009, p. 127). In the ANT perspective, power is an effect rather than an action. It is more precisely the result of actors' associations. Translation is therefore a way of achieving power. The story of European hotelkeeper keys (see section 3.1) illustrates how the actions of guests are aligned to give the key back before leaving the hotel through the "agencement" of various humans and non-humans actors into one specific program of action (Latour, 1987).

On the other hand, criticisms also stem from different interpretations of what ANT is. Replying to these criticisms Latour contends that,

> *'actor-network theory is not a theory about the nature of the social world (it is not a metaphysics of the social), but a theory about inquiry in social science. What it records is the surprise felt by the investigator - and often by the human actor that this investigation tracks - in front of the lengthening of the list of beings necessary to maintain any identity.' (2010a)*[9].

In Latour's opinion, the actor-network should not be defined by its result, as if the network corresponded to a description of the "beings of the world" but rather as a process and a method

[9] Translation from the French by the author

of investigation (2010a). Therefore, political and power considerations are not excluded by ANT, they are to be inferred as a result of the analyses carried out. In ANT, power does not precede analysis but results from it. As Alcadipani and Hassard argue, ANT '*inverts the order of scrutiny: for ANT, power is an explanandum, not the explanans, a position that is developed in the literature on ANT and After.'* (2010, p. 423). The issue of power around ANT is not that this approach is blind to power relations but that it refuses to assign statues to actors in advance. In that respect, Latour notes a radical divergence between the sociology of entities and that of associations concerning the issue of proof:

> *'both approaches are equally theoretical, but the outcomes and aesthetics of proof remain radically different in the two cases. The rupture is inevitable and it is vain to try to reconcile the two points of view, all the more so as it is a question of deontology: it is the duty of sociologists of the social to define beings in advance, and it is the duty of sociologists of association not to define them in advance. This clarifies any misunderstanding.' (2001, p. 4)*[10].

3.2.3 Cross-fertilizing ANT with co-production and the instrumentation approach

The criticisms I have just presented, especially those related to power issues and to the concept of flat ontology, although they received responses from ANT proponents, do provide food for thought. To take up these issues, I opened my analyses to other approaches that fit the field of STS, namely co-production and the instrumentation approach.

Developed by Jasanoff (2004), the co-production framework can be understood as an idiom or as a way of interpreting and accounting for complex phenomena, rather than as a fully-fledged theory. The co-production framework raises awareness of the mutual shaping of

[10] Translation from the French by the author

technology, science and society and has proved useful for the study of natural and anthropogenic disasters. In this perspective, the "technological" and "societal" orders should not be seen as two separate spheres but rather as interacting components within a global system that mutually construct each other. As Jasanoff contends,

> *'science, in the co-productionist framework, is understood as neither a simple reflection of the truth about nature nor an epiphenomenon of social and political interests. Rather, co-production is symmetrical in that it calls attention to the social dimensions of cognitive commitments and understandings, while at the same time underscoring the epistemic and material correlates of social formations. Co-production can therefore be seen as a critique of the realist ideology that persistently separates the domains of nature, facts, objectivity, reason and policy from those of culture, values, subjectivity, emotion and politics' (2004, p. 4).*

Throughout this thesis, I use this idiom as a sensitizing concept[11], bringing symmetry between safety and security by understanding them as modes of ordering organizations and societies that are produced together. These modes do not evolve in a vacuum but through their mutual shaping. This idiom sensitizes me about analyzing how safety and security shape each other as well as about the importance of developing a historical perspective as well as an abstracting and generalizing approach when analyzing the interplay between safety and security. Co-production is best suited to examining the emergence and stabilization of new phenomena as well as to the framing and resolution of controversy. Specifically, in the first chapter of the thesis, I link co-production with ANT in order to study how safety and security cultures co-produce and transform each other. This allows me to underline the extent to which the interactions between safety and security are not trivial and generate new actors.

In addition, I use the instrumentation approach developed by Lascoumes and Le Gales (2007) for the analysis of public policy, which combines a Foucauldian genealogical approach with the principle of generalized symmetry to study the evolution of public policies from the perspective

[11] The term 'sensitizing concept' was first used by Herbert Blumer in 1954. According to Blumer, it '*gives the user a general sense of reference and guidance in approaching empirical instances. Whereas definitive concepts provide prescriptions of what to see, sensitizing concepts merely suggest directions along which to look.*' (p. 7)

of their instruments. This approach considers instruments as socio-technical devices incorporating a concrete conception of political/society relations '*that organizes specific social relations between the state and those it is addressed to, according to the representations and meanings it carries'* (Lascoumes & Le Gales, 2007, p. 4). Instruments develop as an aggregation of actors, producing specific representations about the issues and the problems they address. Finally, as Kassim and Le Gales state, '*every instrument constitutes a condensed form of knowledge about social control and ways of exercising it*' (2010, p. 6). The instrumentation approach is interesting in that it allowed me to trace unexpected effects of regulatory instruments and their capacities to influence the political regime. At the intersection of the Foucauldian approach and ANT, this approach is particularly useful for tracing changes in public policies and political regimes through the evolution of safety and security instruments by monitoring the configuration of actors within the network and their specific views of the issue at stake and the rationale used to manage them. The instrumentation approach provided me with a conceptual and analytical frame that alerted me to the evolving and relational character of power. This approach is also particularly well-equipped to account for the co-shaping of material (here regulatory instruments) and for human aspects that lead to policy changes.

In general, cross-fertilization of these approaches applied to specific case studies makes it possible to analyze how safety and security are linked as consistent concepts and how they are simultaneously (or not) translated together into operational terms. This is achieved by analyzing the implementation of these two concepts in specific case studies. Cross-fertilization also allowed me to identify the actors involved in the implementation of safety and security and to trace their mutual shaping. In order to understand what safety and security are and consequently, what delineates the two concepts, I analyze the agencies and programs of action that associations of actors enact. Using a contextualized approach, I obtained the insights needed to characterize what is safety and what is security. This helped me understand how they are related and how they can be addressed. Indeed, by deepening the knowledge of their relationships, I also provide practitioners with tools to manage them.

4. Methodological chapter: a case study research approach

This chapter describes the methodological design of this thesis. The methodological design closely relates to the conceptual framework presented in the previous section. In this sense, data sampling, gathering and analysis cannot be separated from the conceptual underpinnings of this thesis.

Overall, this research approach aims to move beyond the inductive/deductive divide. Grasping phenomena did not necessarily require tackling concepts first and subsequently investigating how they could apply to a specific context or inductively exploring an actual situation with no *a priori* conception. Rather I opted for an iterative approach that entailed multiple data collection phases with simultaneous data analysis, thereby allowing me to reorient and strengthen this research (Reichertz, 2014). Ultimately, results were obtained that synthesize and provide novel insights into safety and security relations in and through practice.

The case study research approach in social sciences is widely used in STS research (Bowden, 1995; Woolgar, 1997). Following Clarke and Star, the case study research approach is understood here as a "theory/method" package (2008). It is not merely a data collection technique but a comprehensive research strategy with a research design logic, data collection techniques, and specific approaches to data analysis (Yin, 2018). It is developed around an interpretive paradigm and is readily associated with qualitative research (Latzko-Toth, 2009). This approach involves an in-depth context-rich study limited to a particular setting or issue and based on direct observations. It allows for the study of causal chains *in situ* in order to subsequently build theories (Latzko-Toth,

2009). In this sense, it represents a research design that is fully consistent with the ANT epistemological approach mobilized in this thesis.

The ANT-related case study, as I use it, is based on a "thick description" of local contexts that is symmetrically applied to both human and non-human actors. Thick description is an analytical approach first developed by Gilbert Ryle (1949) and re-popularized by the anthropologist Clifford Geertz (1973), that fosters analysis of a situation from the perspective of the persons who experience it. Denzing puts it,

> *'a thick description […] does more than record what [an actor] is doing. It goes beyond mere fact and surface appearances. It presents detail, context, emotion, and the webs of social relationships that join [actors] to one another.' (1989, p. 83)*

To conduct the case study, I undertook a "nomadic"[12] thick description in which I followed the actors and associations to describe and make sense of interactions in and through practice. Indeed, as shown in section 3.2.2, the descriptive nature of the case study research does not contradict an interpretation of how the world works, but rather proposes the means to formulate such an interpretation. It would have been impossible to draw conclusions concerning safety and security relations without first describing how safety and security actors contextually interact. This thesis therefore attempts to successfully articulate immersion in the complexity of the observed details with an explicit attempt to generalize and to make a theoretical contribution. The challenge of scientific studies based on case studies lies in linking the empirical and the theoretical. I endeavored to bring this link to light by choosing two cases that allow me to draw lessons on "how" the relationships between safety and security are characterized as well as on "why" they are characterized as such.

However, demarcating the fieldwork and selecting case studies remains arduous in ANT. Indeed, tracing and reconstructing an actor-network is a potentially indeterminate and infinite

[12] The term "nomadic" used to refer to the ANT research method which is conducted by following the actors to describe their associations (de Raymond et al., 2004).

process. The difficulty therefore lies in determining where to begin and stop the fieldwork. Summarizing this difficulty, Dubois asks *'why not talk about the printers? the paper suppliers? the variety of actors who interact with the legislator? Why add that final "etc."? Because this list is in principle endless.'* (2016, p. 129).

The inquiry's scope of analysis was thus defined based on arbitrary choices. However, this does not prevent me from delineating the case study in a reasoned manner. The selection of the case studies was partly influenced by the funding context of this thesis (funding was provided by the nuclear research center that was the subject of one of the case studies), but also because the cases approached safety and security relations in different domains and from different perspectives. These cases enabled me to identify and analyze common patterns across varied domains and cases. I will now show how and why the two case studies represent judicious choices to provide distinct but transposable and comparable insights to answer my research question.

4.1. Method of data gathering

4.1.1. The case studies

4.1.1.1. The case study in a nuclear research center

The first case study was carried out in a nuclear research center (NRC) in Belgium. The NRC was created in the 1950s with the mission to develop safe and peaceful innovative applications of nuclear technologies. To accomplish its missions, it mobilizes hazardous materials (hazmats) such as highly enriched radioactive materials and dangerous chemical substances. Moreover, the facilities on the site, including nuclear reactors, involve safety and security concerns. To tackle these concerns, the NRC has a dedicated department responsible for safety and security management

(SSMU)[13]. This department is divided into different units, one of which is focused on security, while the other units deal with different aspects of safety (e.g. nuclear safety, industrial safety).

High-risk organizations, like the NRC, were recently faced with a rise in security concerns. The 9/11 terrorist attacks and more recently the wave of terrorist attacks that occurred in Western Europe between 2015 and 2018 indeed impacted how high-risk organizations perceive their protection against danger (de Roy van Zuijdewijn, 2016; Nussio, 2020).

To study how safety and security are linked in the NRC, I did a three-year part time internship (up to 2 work days a week) from November 2017 to March 2020 and from June to October 2020[14]. My physical presence in the NRC during these three years helped me become an insider and facilitated the collection of a variety of data that would otherwise not have been accessible. During my internship, I undertook a "holistic analysis" of the NRC. To this end, I gathered a wide range of information on how the NRC is organized, how it functions, the actors that compose it and how they interact with each other (Creswell, 2006). This analysis helped me understand how safety and security are interlinked but also how the recent security concerns are impacting the functioning of the NRC. Specifically, I traced the interplay between the units in charge of, respectively, safety and security management. I also focused on non-human actors involved in applying safety and/or security measures such as surveillance cameras, doors, gates, safety and security procedures or incidents reports. I analyzed how employees perceive and enact safety and security within the NRC. This holistic analysis enabled me to reveal specific interesting aspects, such as actors or procedures that merit in-depth analysis and indeed led to my choice to analyze the entrance gate of the NRC (cf. chapter 4) in more detail through what Creswell calls "embedded analysis".

[13] Neither the name nor the acronym is real. For security reasons, no real names are used in this thesis.

[14] The interruption of my internship from March to June 2020 was due to lockdown in the context of the COVID-19 crisis. While preparing my doctoral thesis, I was unable to enter the NRC site (with very few exceptions) between March and June 2020 and between October 2020 and September 2021. During these periods I was obliged to work from home and collect the data I needed by video-conferencing.

4.1.1.2. The case study of emergency management:

The second case study examined emergency management (EM) in Belgium. EM can be defined as all '*activities that include prevention, preparedness, response, recovery, rehabilitation, advocacy, and legislation, of emergencies irrespective of their type, size, and location, and whose purpose is reduction in death, disability, damage, and destruction'* (Dykstra, 2003, p. 3). It that respect, it can be seen as an enactment of safety and/or security. Such protection is structured by the coordination of emergency actors organized in disciplines and politico-administrative actors (Alexander, 2002; Haddow et al., 2017). It is based on the recognition that crises can overflow, have impacts on the general population and lead governments to act to preserve the health of the population (Haddow et al., 2017).

The EM in Belgium emerged in the 1960s and developed over the course of the 20th century in response to major international and national industrial accidents[15]. EM is the framework through which hazards (safety-related or security-related) that occur in high-risk organizations like the NRC are tackled and mitigated. It represents an extension of the internal safety and security networks in high-risk organizations. EM is applied when for instance, internal actors cannot cope with crises that occur in high-risk organizations, and the intervention and coordination of external public rescue services are needed. The increase in the risk of terrorist threats from beginning the 21st century led to the emergence of a new type of (security-related) crisis and subsequently impacted EM. In that respect, both NRC and EM are case studies in which safety and security play an important role and that have faced increasing security concerns that called for new forms of cohabitation.

These heterogeneous case studies are interesting examples to analyze patterns that are common to safety and security. Indeed, addressing the relations between safety and security in the

[15] The consequences of many international accidents affected Belgium. Among others, the Banquio Dam failure (1975), Three Mile Island (1979), Bohpal catastrophe (1984), Chernobyl catastrophe (1986), the Exxon Valdez Oil spill (1989) or the catastrophe of the Deep Water Horizon Platform (2010). Other national disasters had major impacts in Belgium: the "Innovation" retail shop fire in Brussels (1967), the Guislenghien gas explosion (2010).

EM case study complements the relations observed in the NRC case study in that it allows me to go beyond the highly contextualized case of one organization by address a more macro-level case. Moreover, the EM case study makes it possible to take a step back, in that it analyzes the relationships between safety and security at the national level.

I use both case studies in an instrumental way to open the "black box" of the relations between safety and security but from two different angles of approach. In such cases, the researcher does not observe two case studies but, through the lens of particular case studies, observes a social phenomenon with a generalizable character. As Gomm and colleagues state, *'the production of general conclusions is not achieved through the accumulation of studies building on each other, but rather by using theoretical resources generated by previous works.'* (2000, p. 262). Indeed, my case study research enabled an analytical but not an empirical generalization; it can be generalized to theoretical propositions but not to populations or universes. Following Cronbach (1975), I argue that although generalizing data as such is impossible through case studies, it is possible to infer working hypotheses from them. The issue is therefore less on generalization than transportability (Latzko-Toth, 2009). Indeed, what I aimed to achieve through my research was not so much to reveal similarities in the two case studies, but the transportability of the underlying questions that drive the research.

4.1.2. Gathering field data

I used an immersive data gathering method (Star, 1999) to explore both case studies through detailed, in-depth data collection from multiple sources of information. The method used in each of the chapters is presented in detail in the respective chapter. To avoid redundancy, here I only refer to those that are described in detail in their respective chapter; but provide details about those that influenced the reflections of the thesis as a whole but are not directly mobilized in any chapter.

4.1.2.1. The ethnographic inquiry in the NRC

For the case study in the nuclear research center, ANT provided the methodological and conceptual guidance on where to look and how to analyze safety and security enactment (Latour, 2010b; Levi & Valverde, 2008). I opted for an ethnographic method to gather the necessary data and orient the fieldwork following ANT lens. As pointed out by multiple authors, ethnography is a dedicated approach for case study research (Creswell, 2006; Denzin & Lincoln, 1994; Gomm et al., 2000; Hess, 2002; Yin, 2018). An ethnography is an immersive method focusing on practices and on associations between actors (Baiocchi et al., 2013; Hess, 2002). It traces assemblages and interactions between heterogeneous actors (humans and non-humans) and documents the meaning they give to their world. An ethnography is necessarily spatiotemporally contextualized. It is particularly suited to capture the complexity, the context, and the contingency of situations. The questions addressed necessarily remain open and cannot be determined in advance.

The ethnographic approach fully recognizes and embraces its *'interpretive, insider, subjective and qualitative point of view'* (Atak & Kingma, 2011, p. 270). Such an approach requires a tremendous amount of time to become attached to and immersed in the fieldwork but also to detach and get the necessary distance from it to reflect on and make sense of the collected data. I was therefore lucky to be allowed to work twice a week in the NRC over the past four years excluding during the Covid 19 lock-down from March to June 2020 and from October 2020 to September 2021). This position gave me easy and rather extensive access to the research field.

Approaching safety and security interplay means I immersed myself in the daily enactment of safety and security measures in the NRC to produce detailed descriptions of the humans and materials involved and of their interactions. For this research, my approach was not to apply a set of methods, but rather to *"*move about*"* in a given environment (Rip, 2010). The methods I used in this inquiry were participatory and non-participatory observations, a documentary analysis, semi-

structured interviews, but also personal safety and security enactments. I kept a logbook throughout the period of fieldwork in which all the data were recorded.

In all, I conducted 20 semi-structured interviews. The participants were selected on the basis of their direct involvement in safety and security management and study. I contacted actors who managed safety and security in the "Safety and Security Management Units" (SSMU), as well as other employees involved in safety and/or security aspects in the framework of their job. Except two, all the interviews were recorded and transcribed. The duration of interviews varied between 50 minutes and 1 h 45 min. They were conducted in English, Dutch or French, depending on the preference of the interviewee. If possible, the interviews took place in the interviewee's office, if not, then in the meeting room in the building in which the participant worked if he/she shared an office with other colleagues (for more information, see chapter 3).

The interviews were semi-structured, meaning that they followed a thoroughly elaborated and validated question guide (see chapter 3), but the order and formulation of questions varied depending on the flow of each individual conversation. The interview guide was developed following an initial review of the literature on the concepts of safety and security and refined through participatory observations and discussions with safety and security managers.

In addition to the interviews, data were also collected in a workshop that took place in June 2019 in which safety and security relations were discussed with NRC employees. These data provide additional insights into how employees perceive safety and security and their interactions and how the interactions are articulated in the NRC.

I also used non-participatory observations at multiple meetings in which safety and security relations were discussed, through specific topics (such as the classifications of doors, the construction of new buildings or incidents that have happened onsite) discussed by actors in charge of safety and security management or with employees. In parallel, I took part in seven training courses (from December 2018 to March 2019) on security at the NRC. These training courses were organized by members of the SSMU and targeted NRC employees. During participatory

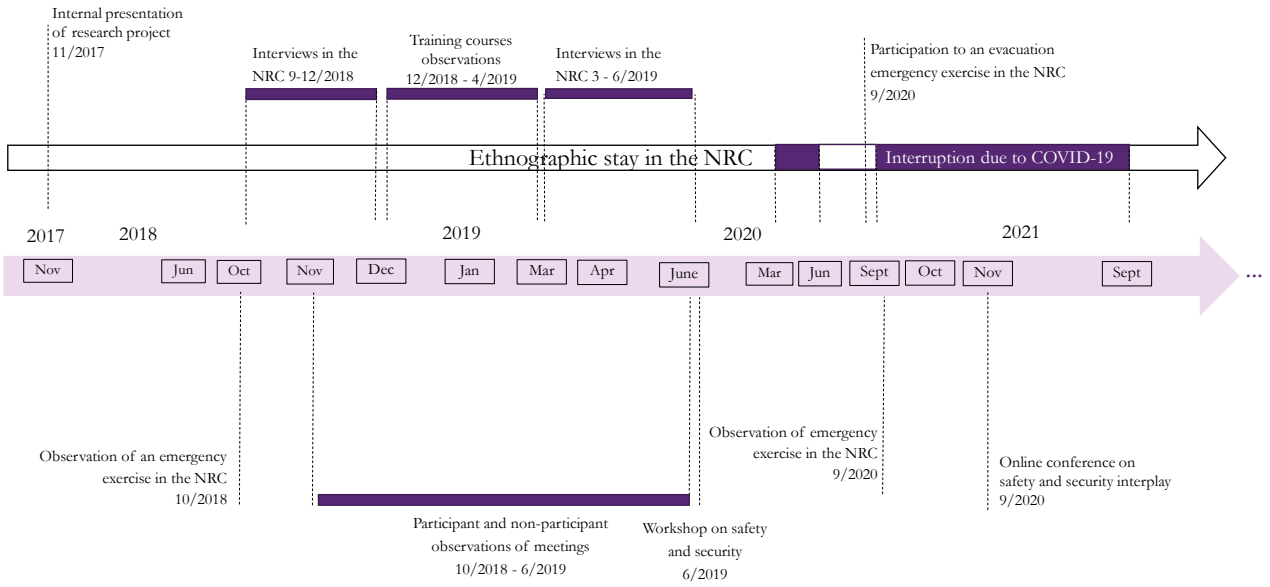
observations, I paid particular attention to how security and safety measures were presented, as well as how employees and the trainers discussed interplay between safety and security.

I also used data collected during my observation of two emergency exercises on the NRC site: one staged a safety-related accident involving an evacuation, the other concerned a security related attack. Before the exercises, I was allowed to attend the briefings that brought together the organizers of the exercise and the heads of the different departments involved in the exercise (internal fire services, internal police service, internal medical service, heads of the safety and security units of the SSMU). After the exercises, I was also allowed to attend the debriefings and take notes of the exchanges. During these debriefings, I paid particular attention to the different associations between safety and security actors (humans and non-humans). I also participated, not only as an observer, but as an active participant in an emergency evacuation exercise in September 2020. This allowed me to test existing safety measures to evacuate a NRC building, to analyze interplay with access control measures. This event fed the reflections detailed in chapter 4.

In parallel, I ran an international webinar (October 2020) entitled "Safety and security in high-risk organizations: bridging theories and practices" in which four academics (including myself), and four practitioners who study or work in safety and security presented and discussed their vision of the relation between safety and security. By bringing together academics and representatives of nuclear authorities and industries, attention was directed at how safety and security are conceptualized, how they interrelate, and the impact they have on organizations' cultures and functioning. It helped deepen my understanding of safety and security and challenged my own reflections.

Finally, I also had countless informal discussion with employees about their perceptions of how safety and security are managed. Even though these data are not included in the chapters, they nonetheless influenced my view of safety and security relations and consequently impacted the data gathering and analysis processes.

Timeline 1: Ethnographic fieldwork in the NRC



4.1.2.2. Fieldwork on EM

The case study on emergency management was built on various qualitative methods including participation in training courses, a documentary analysis, interviews and non-participatory and participatory observations. The use of an ethnographic method enabled me to get different perspectives which once cross-fertilized, led to a complex and more complete reflection on the interplay between safety and security in EM in Belgium.

Firstly, I participated in a 2-month qualifying training course on emergency management in Belgium called the "*Certificat Interuniversitaire Planicom*" one day per week from October to November 2017. This training course provided me with the theoretical and practical basis of EM in Belgium and I met many key EM actors in the different disciplines, whom I subsequently interviewed. To obtain the training course certificate, I was required to write a manuscript on a selected aspect of EM. I used this opportunity to formulate and challenge my first reflections on changes in EM in Belgium and had it corrected by academic experts in EM.

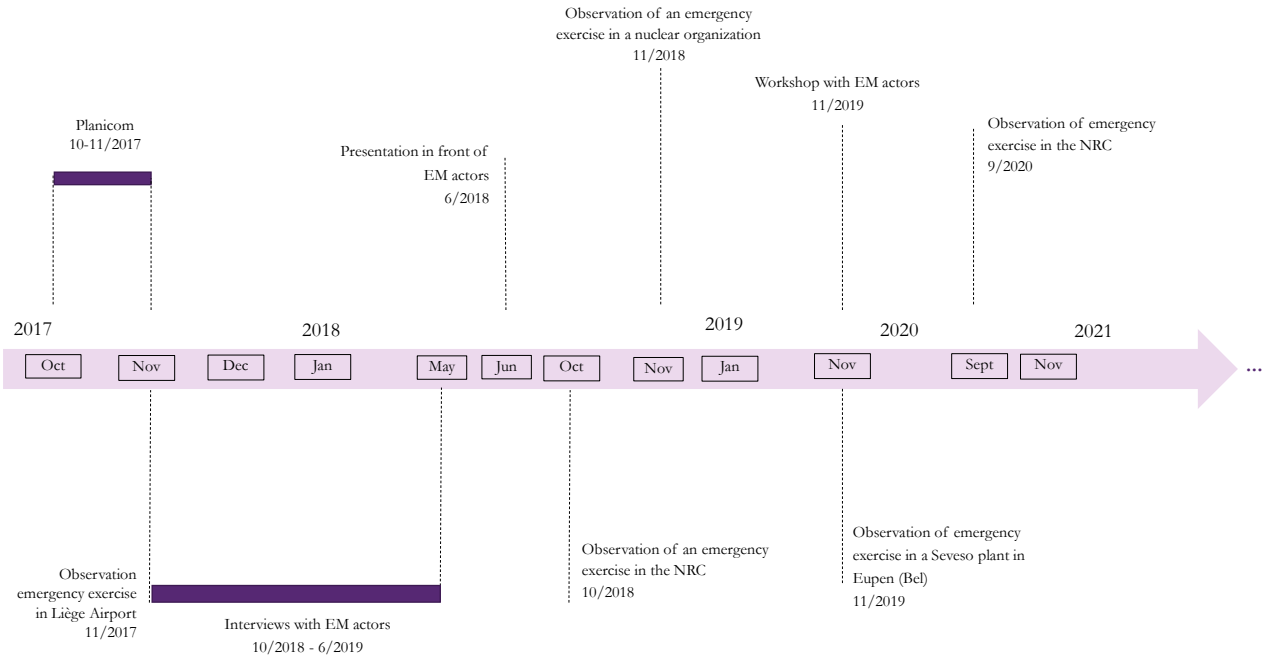
Secondly, the inquiry traced federal legislation (laws and royal decrees (RD)) but also pilot projects, parliamentary debates, RD reports and political discussions[16]. I also analyzed reports on previous emergency management, recent emergency exercises but also confidential regulations (for instance, RDs on emergency planning against terrorist attacks (Gouvernement de Belgique, 2016, 2020)), drafts of regulations and preparatory works. I also examined reports on the management of four major emergencies that had recently occurred in Belgium. All the reports provided insights as they not only summarized the lessons learned from the management of these crises but also provided hints about the current EM regime and how it evolved (For more information see chapter 2).

[16] Some of these documents are confidential, and I obtained access to them through the National Crisis Center on condition of not divulging their technical details.

Thirdly, based on a validated interview question guide, I conducted 20 semi-structured interviews, with actors involved in emergency management (planning and response) from all the main EM disciplines[17]. The interviews were conducted in French and lasted between 60 and 90 minutes. The excerpts selected for this article were translated into English by myself. The interviews were conducted in a semi-structured fashion, while the order and formulation of questions varied depending on the flow of each individual conversation (for more information see chapter 2).

Finally, I also observed five emergency exercises at operational level. The observation of the exercises and their debriefings was based on a non-participatory observation method (Cooper et al., 2004) (for more information see chapter 2).

Timeline 2: fieldwork on EM



[17] Emergency management in Belgium is organized around five disciplines that correspond to the different missions of emergency responses. The disciplines are called, respectively, Rescue services (D1), Medical services (D2), Policing (D3), Logistic support (D4), Information (D5). For further information, see chapter 2.

Table 1: Data gathered in the two case studies

Nuclear research center	Documentary analysis	
	Semi-structured interviews	SSMU
		Employees working on safety and security
	Participatory observations	Workshop on safety and security
	Non-participatory observations	Meetings on safety and security
		Training courses
		Emergency exercises
	Personal enactment	
Emergency management in Belgium	Participation to a training course	*"Certificat Interuniversitaire Planicom"*
	Documentary analysis	Legislations,
		Pilot projects,
		Parliamentary debates,
		Royal Decree reports
		Political discussions
	Semi-structured interviews	Actors involved in emergency management
	Non-participatory observations	Emergency exercises

4.2. Data analysis

Gathering data for each of these case studies provided me with interesting insights to answer the research question of this thesis: **how are the relationships between safety and security shaped in and through practice?** According to ANT, I claim that data-gathering is not a research phase that simply precedes analysis, but is rather an integrated part of data analysis, as data is gathered in accordance with the lack of insight which is itself revealed through the analysis of previously gathered data. Indeed, I argue that research equals the tracing of relations between different elements and thus I perceive data gathering and analysis as largely overlapping (see Latour, 2005). For this reason, the choice of an iterative approach in which data gathering and analysis overlap turned out to be useful, as this approach allowed me to inform the research with the initial results of the analysis and to be able to return to the field.

More specifically concerning analysis of the interviews conducted during the two case studies and during the workshop held in the NRC, I carried out a reflexive thematic analysis of each case (Braun & Clarke, 2006, 2019). Using the NVivo 12 software, I undertook 3-step coding (initial, focused and theoretical coding) which eventually enabled me to develop an integrated conceptual and theoretical framework (Thornberg & Charmaz, 2014). This coding allowed me to construct a final template comprising themes and subthemes pertaining to safety and security relations in the NRC as well as to EM regimes. In that respect, the themes were reflexively and actively developed at the intersections of my '*theoretical assumptions, [our] analytic resources and skill, and the data themselves.'* (Braun & Clarke, 2019, p. 6).

I cross-fertilized the analyzed data by confronting them with the other empirical material gathered (see section 4.1.2), discussed them with colleagues, employees of the NRC or EM actors, reviewing them, and starting all over again until a stable story was built.

For both case studies, I validated the data first through triangulation. For the fieldwork conducted in the NRC and for the EM, I crossed the different data previously analyzed from the observations, in order to highlight both redundant and marginal and/or contradictory elements. However, as I was far from satisfied with data triangulation alone, I also undertook a member-check to check back with the very same field actors who participated in my inquiry "'*Does it work that way?", "is it really so?*" (D. E. Smith, 1987, p. 160). To do so, I did not limit myself to presenting my results to outsiders in the framework of international conferences, but also discussed them with field actors in the NRC and/or in the frame of EM to get their feedback on my analysis.

For the case study in the NRC, in June 2019, I presented my intermediary results to audiences of more than 50 people composed of NRC employees and to multiple interviewees, particularly the results presented in chapter 3. I also presented the results of chapters 1 and 3 to a large audience at a conference I organized in September 2020, and to scholars and academic experts in safety and security relations. Such presentations enabled me to test my research and validate the results. In addition, chapters 1, 3 and 4 were sent to the head of the SSMU and to the head of the security unit. The former said nothing about chapter 4, but commented on chapters 1 and 3. Modifications were made to the text following these comments. The head of the security unit offered no comments. Making my results public was essential to check that what I had observed made sense to NRC employees.

Given that the EM case study is inherently more atomized and cross-cutting, I validated the results using different modes of presentation and sharing of preliminary results (see timeline 2). First, I took the "*Certificat Inter-universitaire Planicom"* end-of-course exam (and obtained the highest distinction). Second, I presented several of my preliminary results to a large number of emergency management actors who met for the day in Wallonia in June 2018. Third, during a workshop with emergency management actors held in October 2019, I had the opportunity to present and discuss my results concerning safety and security issues in the context of EM. Finally,

on multiple occasions, I shared the results of my research with emergency management specialists both at the operational level and with academic colleagues who specialize in the subject.

4.3. Ethical and data management considerations

I would like to end this methodological chapter by discussing the different ethical and data management aspects of my research and how I applied them. Specifically, I obtained the informed consent and insured the confidentiality of data gathering and analysis by complying with the principles of the Code of Ethics for Scientific Research in Belgium (2009), guidelines of the European Code of Conduct for Research Integrity (2017).

First, I obtained the informed consent of all research participants. To this end, before collecting data in interviews, during the workshop, through participatory and non-participatory observations, I introduced myself and the topic of the thesis. As all participants of the two case studies were adults, I collected their informed consent orally or in writing[18] before proceeding with data collection (See Appendix 1).

Second, by focusing on safety and security measures, this thesis deals with a highly sensitive subject. I therefore committed to treating the information I collected and analyzed with the utmost discretion. Indeed, the thesis contract stipulates that my thesis data management should respect high standards of confidentiality. The data, consisting of audio-recordings, transcripts, and documentation from participatory observations (personal notes and photographs of emergency exercises[19]), are stored on an external hardware device for analysis. Additionally, to safeguard the confidentiality and anonymity of the participants, the documents were encrypted so that access to the data is restricted to me. After the analysis is completed, the data will be deleted. In all

[18] The written consent forms were only applied from January 2019 on, due to changes in ethical consideration due to the GDPR requirements.

[19] Taking photographs of the site of the nuclear research center is forbidden. I therefore only took photographs of emergency exercises not related to the NRC.

publications and at presentations, the anonymity of the participants was guaranteed by using pseudonyms for the participants that refer to the participant's affiliation in the organization concerned. No identifying information is accessible to third parties.

Accordingly, all the participants were explicitly told that their names would not be disclosed in any documents related to the data collected in the field. Moreover, except for the citations included in the thesis, no information retrieved from the data gathered is disclosed. For example, no visual details of the data collected concerning the NRC (location of the site, graphical representations of the gate, dimensions, explicit citations and internal documents) and the emergency exercises observed in the frame of the EM case study are included in this thesis.

I also checked the validity of my research and made sure that it did not include any sensitive information by giving feedback to participants and by sending the articles to certain key actors or by presenting of the results to the field actors (during which many of the participants in the research were present) (see sections 4.1 and 4.2). During this feedback process, participants also received, orally or via email, my contact details and those of my thesis director.

5. Overview of the thesis

Before starting a detailed analysis of my research, I provide an overview of the five chapters that make up the thesis. Of the five chapters, four represent the articles submitted in a scientific journal. Each of these chapters were implicitly or explicitly inspired by ANT. I now briefly introduce the four chapters.

Chapter 1 analyzes the scholarly, regulatory and policy literatures on safety and security cultures. By analyzing two recurring gaps in the literatures, it discusses the idiom of co-production and ANT as potentially fruitful approaches to better grasp the mutual shaping of safety and security cultures as well as the active roles of non-humans. Using two concrete examples, it highlights how

these heuristics may open the way for a more symmetrical analysis of safety and security cultures in high-risk contexts.

Chapter 2 analyzes changes in emergency management in Belgium that have accompanied growing security concerns in Western countries since the 9/11 terrorist attacks in the US. Using the instrumentation approach, it shows how the adoption of a particular regulatory instrument led to the emergence of a new EM security regime that had a major impact on practices at the core of the original EM regime.

Although Chapter 3, does not explicitly mobilize ANT or other STS approaches, it furthers the reflections initiated in chapter 1 and applies them specifically to the interactions between safety and security. Based on fieldwork conducted in a NRC, it analyzes how safety and security relations are experienced by field actors. It shows how - through their interactions - safety and security shape each other. Contradicting the dominant synergetic approach, it unveils and analyzes the tensions resulting from their interplay. Analyzing the paradoxical roots of these tensions, it suggests creating tensions venues that provide field actors with tools to find innovative ways to articulate tensions.

Furthering the results of chapter 3, chapter 4 uses a specific case study in the NRC to examine how safety and security interact and where tensions emerge. Based on an ethnographic case study in a Belgian nuclear research center, it emphasizes the fact that safety and security networks overlap and clash in one particular infrastructure, the entrance gate. It shows how competing programs of action are entrenched in the materiality that articulates them.

Supported by the reflections pursued throughout these chapters, the general discussion cross-fertilizes and discusses the findings to highlight their scientific and practical implications. It also discusses several limitations and possible avenues for future research. Finally, I conclude this thesis by calling for opening up the black box of safety and security relations and for greater transdisciplinarity in dealing with safety and security tensions.

II. Empirical chapter

Chapter 1: Bringing symmetry between and within safety and security cultures in high-risk organizations[20]

Colin Glesner, Michiel Van Oudheusden, Catrinel Turcanu, Catherine Fallon

Abstract: Based on a review of scholarly, regulatory and policy literatures, this article illustrates how 'safety culture' and 'security culture' are conventionally understood within the context of high-risk organizations. It identifies two important recurring gaps in the literature: (1) the subordination of the analysis of security culture to safety culture concepts, and (2) the anthropocentricity inscribed in both notions, which sideline the dynamic interplay between social and technical elements in the constitution of 'culture'. To address these gaps, the article introduces concepts and heuristics from Science and Technology Studies, specifically co-production and Actor-Network Theory. Using the concrete examples of the labelling of hazardous materials and the "four eyes" principle, it highlights how these heuristics may open onto a more symmetrical analysis of safety and security cultures in high-risk contexts. It thereby seeks to make visible the mutual shaping of safety and security cultures and attend to the roles of non-human actors as active participants in such processes.

Keywords: Safety culture, Security culture, Co-production, Actor-Network Theory, High-risk organizations

[20] Glesner, C., Van Oudheusden, M., Fallon, C., & Turcanu, C. (2020). Bringing symmetry between and within safety and security cultures in high-risk organizations. *Safety Science*. https://doi.org/10.1016/j.ssci.2020.104950

1. Introduction

Contemporary technological societies face an increasing number of crises, such as environmental catastrophes, technological and industrial disasters, and terrorist attacks (Bijker et al., 2014). These crises may have non-malevolent human or natural causes, can be rooted in intentional and malevolent acts, or comprise a mix of motivations and behaviors (Khripunov & Kim, 2008). Particularly vulnerable to these growing threats are high-risk organizations in sectors such as the nuclear industry. In order to prevent and mitigate the risks confronting them, these organizations have developed measures to enhance first and foremost their safety, and more recently, their security. This evolution is reflected in the institutional (e.g. policy, business organizational and regulatory documentation) and academic literature, notably on organizational culture and in the concepts of *safety culture* and *security culture*, which give consideration to human and cultural impacts on safety and security (Antonsen, 2009). The two concepts have received unequal attention over time, both from policymakers and scholars (Argenti et al., 2015; Directive 2012/18/EU).

Safety culture, inspired by the concept of organizational culture, became an overriding priority in the 1980's. The Chernobyl accident (1986) and the summary report of the International Nuclear Safety Advisory Group (IAEA, 1986) that followed triggered substantial scientific research and discussion on what safety culture entails. The concept was further developed in the 1990's and early 2000's (Choudhry et al., 2007; M. D. Cooper, 2000; Guldenmund, 2000; IAEA, 1991; Pidgeon, 1991). As we illustrate below, amid the large number of works that emerged, there is considerable variation in how the term is understood and applied, which raises challenges for the use and operationalization of the concept (Antonsen, 2009; Choudhry et al., 2007; M. D. Cooper, 2000, 2016; Gilbert et al., 2018; Guldenmund, 2018, 2000; Haukelid, 2008; Henriqson et al., 2014; Hopkins, 2016; Le Coze, 2019).

The notion of security culture gained traction only in the 2000's, in the aftermath of terrorist attacks such as 9/11 (Argenti et al., 2015; Reniers et al., 2011). Debates about the concept of security culture are primarily situated in the nuclear field and were first initiated and mainly organized by the International Atomic Energy Agency (IAEA, 2001, 2016b). Studies by Jore, Malcolmson and Reniers et al. in various areas have highlighted that the IAEA's definition has remained largely unchallenged in the academic literature (Jore, 2019; Malcolmson, 2009; Reniers et al., 2011).

As security culture was not developed as a concept in its own right but mostly transposed from literatures on safety culture, there is a lack of understanding about the specific conceptual evolution of security culture and its relationship to safety. This blind spot has potentially far-reaching practical implications for high-risk organizations, raising questions such as: What are safety culture and security culture composed of? How are safety culture and security culture characterized? How do they interact? How can they be analyzed in practice? This represents the first gap this paper addresses.

A second gap revealed in the literature concerns the scope and depth of prevalent definitions of 'culture'. The research on safety culture and security culture has tended to singularly focus on anthropocentric elements in safety and security without considering, or accounting for, non-human aspects (Rollenhagen, 2010). Conceptions of both safety culture and security culture largely ignore or fail to recognize how non-human elements or actors (e.g., security cameras, fingerprints systems, evacuation doors, incident reporting system) constitute and enact individual, group, and organizational cultures. Even studies that extend the analysis of safety and security cultures to include procedures, technologies or artifacts do not consider these as active and symmetric components of the two cultures (Glendon & Stanton, 2000; Grote & Künzler, 2000; Guldenmund, 2000, 2007; Naevestad, 2008; Pidgeon, 1998; Reniers et al., 2011; Yoo & Lee, 2015). Symmetry represents here a methodological precept taken from Actor-Network Theory (ANT), and implies that no *a priori* distinction is made between human actors and non-human actors in the

construction of safety and security. Instead, it acknowledges that both humans and non-humans participate in shaping and performing both cultures; a point to which we turn below.

Taking these gaps as entry points for analysis and reflection, this article combines and discusses concepts and approaches developed in the burgeoning, interdisciplinary field of Science & Technology Studies (STS), specifically co-production and ANT (Akrich et al., 2006; Callon, 1985; Jasanoff, 2004; Joly, 2015; Latour, 2005). Co-production especially focuses on the mutual shaping and co-construction of knowledge and social orders (Jasanoff, 2004; Joly, 2015) and ANT illuminates the interactions between humans and non-humans in a symmetrical and relational manner. As we illustrate in this paper, mobilizing these approaches facilitates consideration and development of mutually informed understandings of safety culture and security culture. Moreover, they open up questions about what is at stake in safety and security, how these principles operate, and how they are enacted in practice.

By analyzing the literature and discussing what the two STS approaches could bring to safety and security cultures this article provides a theoretical and conceptual frame which can bring innovative insights regarding safety and security cultures in high-risk organizations. While an in-depth empirical analysis is beyond the scope of the current paper, we provide two examples to illustrate the potential of the newly developed frame for scholars, policymakers and various practitioners working in high-risk contexts, thus paving the way for further analyses.

In what follows, we first illustrate how safety and security cultures are understood in policy, business-organizational and academic literatures and describe in more details the two aforementioned gaps (section 2). Building on our review, the third section presents the theoretical frameworks discussed in this paper and suggests useful tools for their application to the study of safety and security cultures. The fourth section addresses the two identified gaps by applying co-production and ANT for the analysis of real-world enactments of safety and security cultures. Our article is meant as a contribution to further research on safety and security cultures, which usefully

problematizes and 'opens up' these concepts by bringing STS thinking into the safety-security equation.

2. Safety and security cultures analysis: variations and consistency

In this section, we use the technique of purposeful sampling to analyze the research on safety and security cultures in view of how these cultures have been addressed by scholars and practitioners over time. Adopting the principle of 'maximum variation', we analyzed institutional and academic manuscripts covering an extensive time range (from 1970's until present), with a focus towards including a diversity of understandings, definitions and implementations in our sample (Harsh, 2011). Our analysis highlights consistent gaps in current literatures.

2.1. Dominant notions of safety culture

The concept of safety culture was initially shaped through research on organizational culture (Antonsen, 2009). Among the seminal works in this area, Schein's book, "Organizational culture and leadership" published in 1985, especially influenced the first development of the safety culture concept (Fucks, 2004). Schein describes organizational cultures as a stable, constructed and multidimensional set of assumptions, values and behaviors shared within an organization; it protects employees against the unknown and unwanted as it creates regularities in behaviors (Schein, 1985). In its seminal INSAG-4 report published in the aftermath of the 1986 Chernobyl nuclear power plant accident, the International Atomic Energy Agency influenced by Schein's

work, characterizes the concept as: '*that assembly of characteristics and attitudes in organizations and individuals which establishes that, as an overriding priority, nuclear plant safety issues receive the attention warranted by their significance.*' (IAEA, 1991, p. 4). This definition builds on the IAEA's conception of safety:

> *'the protection of people and the environment against radiation risks, and the safety of facilities and activities that give rise to radiation risks. 'Safety' […] includes the safety of nuclear installations, radiation safety, the safety of radioactive waste management and safety in the transport of radioactive material; it does not include non-radiation-related aspects of safety.' (IAEA, 2016, p. 155; IAEA, 2007; Koenick, 2011).*

As it followed from conceptual groundwork around the concept of organizational culture, safety culture literatures strongly emphasized the "culture" component of safety and paid less attention to that of "safety" (Antonsen, 2009; Rollenhagen, 2010). Only a few definitions of "safety" were proposed, giving the impression of conceptual convergence. However, among the definitions analyzed, at least two contending visions can be portrayed (Antonsen, 2009; Edwards et al., 2013; Hessami, 2004; IAEA, 2016b; Koenick, 2011; OECD/NEA/FSC, 2013; Rochlin, 1999; Rollenhagen, 2010; Slovic, 1992). The first view, which is presently dominant in the literature, sees safety as the opposite of posing risks. It reflects a static or passive vision of safety, as *the 'freedom from harm to people caused by unintentional or random/systematic events.*' (Hessami, 2004, p. 100); or as the '*freedom from any unacceptable risk of harm'* (Schnieder et al., 2009, p. 6).

A second, more active vision of safety, argues that safety is enacted through the interaction of a multiplicity of elements:

> *'the presence of material, symbolic and immaterial arrangements and conditions (technological, norms, administrative, social, etc.) which have the function to dynamically cope with direct and indirect real or potential hazards which may result in negative consequences.' (Rollenhagen, 2010, p. 270).*

This view aligns with the high reliability organization and resilience engineering literatures, the concept of Safety-II as proposed by Hollnagel, as well as the work around complex systems carried out by Dekker (Dekker, 2011; Hollnagel, 2014).[21]

In contrast to the little attention given to the concept of safety, a multitude of scientific studies and policy documents have sought to define and further develop the concept of safety culture. Despite several decades of reviews and conceptual analyses, a large variation of understandings and a certain fuzziness still remains around the concept of safety culture (M. D. Cooper, 2016; Edwards et al., 2013; Guldenmund, 2018; Haukelid, 2008; Hopkins, 2016; Le Coze, 2019). Definitions proposed by academic and institutional literatures indeed formulate multiple terms and characterizations. For instance, Cox and Cox's (1991) definition of safety culture mobilizes concepts such as "attitudes", "beliefs", "perceptions" and "values". Richter and Koch (2004) stress "meanings", "experiences" and "interpretations". The U.S. Nuclear Regulatory Commission distinguishes "values", "behaviors" and "collective commitment" as key features (NRC, 2018). Henriqson and colleagues see safety culture as an object of knowledge which '*encapsulates consensual values, beliefs, and behaviours in relation to risk and safe behaviour.'* (2014, p. 469). Furthermore, whereas some definitions focus on safety culture as a set of actions and behaviors, others emphasize perceptions. Next to this variety of terms, little agreement exists concerning the enactment and the implementation of safety culture. While some scholars see safety culture as something shared by a group of employees inside an organization (Cox & Cox, 1991), others refer to collective elements of an organization that guide people's actions (Richter & Koch, 2004). Moreover, while some are centered on safety, others open safety culture for broader elements such as organizational aspects or objectives like quality, costs and production (Henriqson et al., 2014). In short, although the term is widely recognized and used in the literature, "safety culture" covers

[21] Hollnagel refers to the dominant vision of safety as Safety-I. This vision is accident-centered, as it concerns itself with the absence of safety and asks why things go wrong. In contrast, Safety-II centers on explaining why things go right and why accidents do not occur. This shift in focus invites us to consider how safety is enacted through the daily performance of elements that together compose a dynamic system, rather than seeing safety as a fixed state. Following this, safety is according to him summarized as a dynamic-event.

different ranges or extents (Antonsen, 2009; M. D. Cooper, 2016; Guldenmund, 2018; Hopkins, 2016; Le Coze, 2019).

This breadth of meanings, definitions and views, partly owing to its roots on organizational culture, raises challenges for the comprehension and operationalization of safety culture concepts, especially in an organizational context (Edwards et al., 2013; Gilbert et al., 2018; Guldenmund, 2018; Haukelid, 2008; Henriqson et al., 2014; Hopkins, 2016; Le Coze, 2019). Even though some scholars have recently proposed new classifications (Antonsen, 2009; Edwards et al., 2013; Henriqson et al., 2014) or criticized the very existence of the concept (Hopkins, 2016), a conceptual dichotomy opposing functionalist and interpretive approaches which developed during the period between the 1990's and 2000, analyzed as the safety culture "first wave" by Le Coze (2019) and referred to as the "safety culture peak" by Cooper (2016), still remains pivotal for understanding the roots of this variation. Without going into full details we attempt here to capture the main tenets of this still influential debate.

The functionalist perspective engenders a managerial, instrumental and top-down approach to culture. It sees "culture" as a set of behaviors, attributes, processes or policies assuring that safety remains an overriding priority. In this view, culture is something that an organization *has*. The culture's primary function is to support management ideology, goals and strategies. Assessment tools to this end typically include quantitative methods such as surveys (Huang et al., 2007; Lee & Harrison, 2000), as well as qualitative methods such as observations and interviews (IAEA, 2008b). Scholars assessing safety culture from a functionalist perspective tend to view safety as an ideal that can be managed by way of prediction and control models (Bernard, 2014; M. D. Cooper, 2000; Glendon & Stanton, 2000). In this top-down perspective, safety culture is derived from risk and safety management strategies developed by management, and focuses on macro phenomena (Naevestad, 2009). In her literature review, Fucks (2004) illustrates these functionalist characteristics by using the IAEA definition of safety culture (1991, p. 4) (quoted above) as an example. First, the IAEA definition suggests that there is no pre-existing safety culture in an

organization; rather, safety has to be instituted from above. Second, safety is formally constructed through the actions of management, without due attention to informal safety culture. Third, an organization is understood to have one culture rather than many. Overall, the functionalist perspective is dominant in organizational and safety studies; and it is mobilized by a wide range of authors working in these fields (M. D. Cooper, 2016; Cox & Flin, 1998; Furnham & Gunter, 2015; Harvey et al., 2002; Hofstede, 1994; Kono, 1990; Lee & Harrison, 2000; Lundberg, 1990; Reason, 1998).

The interpretive perspective (also called interpretative), influenced by the works of anthropologists such as Bloch (1998), Geertz (1993), Keesing (1987, 1994), views culture as something an organization *is* or *does* (Henriqson et al., 2014). Culture emerges through ongoing, complex interactions within groups '*serving as prime medium for all members of an organization to interpret their collective identity, beliefs and behaviors*' (Glendon & Stanton, 2000, p. 194). A culture is produced by all individuals within an organization through bottom-up, local and situated interactions. Safety culture is therefore seen as a consequence. The focus in this perspective is on micro phenomena within organizations. Hence, it suggests that safety culture cannot be characterized with generic features; instead, it has to be assessed through complex descriptions of work activities and contextual components. This perspective argues that any attempt to a rapid change of an organization's culture carried out by the management in a top-down fashion is unlikely to succeed as the model extoled will not readily align with the interactions at work: '*culture cannot be managed; it emerges. Leaders don't create cultures; members of the culture do. […] It is naïve and perhaps unethical to speak of managing culture'* (Haukelid, 2008, p. 417). Consequently, such a perspective more easily allows for the existence of multiple, partially overlapping sub-cultures related to specific groups and aligned on team borders in an organization, which may sometimes conflict with one another and with management strategies (Fucks, 2004; Haukelid, 2008; Krackhardt & Kilduff, 1990; Pidgeon, 1998; Tompson & Mchugh, 2002). These approaches typically mobilize triangulated and qualitative methods, such as ethnographies and participatory observation, to investigate the contextual

features of safety culture. Table 2 provides a comparative overview of these two conceptions on safety and security cultures.

Table 2: Comparative overview of the dichotomy the functionalist and interpretive perspectives of safety and security cultures

Functionalist perspective	**Interpretive perspective**
Managerial perspective (top-down)	Contextualized perspectives (bottom-up)
Culture is constituted by management	Cultures precedes attempts to produce one
Culture is a component of what an organization *has*	Cultures are an embodiment of what an organization *is/does*
Culture is a cause	Culture is a consequence
Culture is unique	Culture are multiple and potentially opposing
Safety as an ideal rationally modelled	Safety as the result of complex interactions
Assessed through quantitative and qualitative methods	Assessed through qualitative methods
Focuses on global strategies (macro-phenomena)	Focuses on local and situated interactions (micro-phenomena)
Anthropocentric perspective	*Anthropocentric perspective*

2.2. From safety culture to security culture

Despite the growing prominence of security issues, security culture has received far less scholarly attention than safety culture, and this for a number of reasons. The first is that the concept of security culture emerged fairly recently, in the aftermath of the 9/11 terrorist attacks. The second is related to the historically minor demand from high-risk organizations, which for a long time considered the intentional and malicious risk to be relatively small, if not insignificant (Reniers et al., 2011). The third is that security was first analyzed through the lens of geopolitics and defense security (Burgess et al., 2018), while organizational security has only recently come into focus (Jore, 2019). This element touches on the perceived confidential character of security, mostly dealt with by homeland and foreign security, with only a few people in charge of maintaining security in high-risk organizations (Jore, 2017a).

Taken together, these elements help explain why the literature on security remained within the defense and intelligence scope, and why academic and policy developments in the organizational field introduced the dimension of security within the already developed concept of safety culture. This subjection of security culture to safety culture represents the other literature gap this paper addresses. Such a subordination is to be observed through a number of elements we develop below and is mainly observable through the absence of further development of the concept of security culture and the emphasis on the synergies between safety and security (Flory, 2013). As Jore highlights it, this concept needs further analysis of its specificities in order to get a grasp on its interplay with safety culture (2017).

The first definition of security culture was proposed by the IAEA in 2001:

> *'security culture includes characteristics and attitudes in organizations and of individuals which establish that protection against the loss, theft, or other unlawful taking of nuclear material, on the one hand, and deliberate malicious acts against nuclear facilities or during*

> *transport of nuclear materials, on the other, receive the attention warranted by their significance' (IAEA, 2001, p. 3).*

Although it addresses different risks, this definition relies on that of safety culture. It also led to the characterization of nuclear security as "*the prevention and detection of, and response to, theft, sabotage, unauthorized access, illegal transfer or other malicious acts involving nuclear material, other radioactive substances or their associated facilities*." (IAEA, 2008a, p. 3). It is replicated in subsequent IAEA documents (for example: (IAEA, 2009, p. 3, 2016a, p. 155), and in further academic research on security culture (Batra & Nelson, 2012a; Gandhi & Kang, 2013; Yoo & Lee, 2015).

Definitions of security in the organizational context which are found in academic and policy literatures reveal the same dichotomy encountered for safety, namely between passive and active perceptions. For example, the Society for Risk Analysis (SRA) defines security as: '*the antonym of risk when restricting the concept of risk to intentional acts by intelligent actors (the security level is linked to the risk level, a high security level means a low risk and vice versa).*'(Aven et al., 2015, p. 7).

Opting for an active perspective, Jore proposes a definition emphasizing the interaction of several elements: 's*ecurity can be defined as the ability to prepare for, adapt to, withstand and recover from danger and crises caused by people's deliberate, intentional and malicious acts such as terrorism, sabotage, organized crime and hackers.*' (Jore, 2017a, p. 855).

In contrast with the concept of security, only a few alternative definitions of security culture have been developed. Some studies (Jore, 2017b; Malcolmson, 2009; Reniers et al., 2011) have attempted to review and define security culture, yet, as Malcolmson (2009)highlights in his study on aviation security, there is presently no operable security culture definition that works in an organizational context. Reniers and colleagues (2011) come to a similar conclusion and to fill this gap, propose a definition of security culture applicable to the chemical industry:

> *"security culture in a chemical plant is the extent to which workers within the organizational premises (e.g. plant employees, contractors) regard security as important and the beliefs about how (physical, electronic, organizational, etc.) security should be executed, bearing in mind that hazardous substances are being handled in large quantities in the plant. These*

> *values and beliefs will evolve into certain norms about how to handle chemical company security." (p. 1242).*

The work of Reniers et al. (2011) is one of the first attempts to integrate safety and security cultures; potentially in alignment with international institutional imperatives to further integrate safety and security concepts and methods (IAEA, 2016a, 2016b; The Hague Nuclear Security Summit, 2014). It also resonates with integrative safety-security approaches found in the literature (Aven, 2007a; Gandhi & Kang, 2013; Hahn, 2011; Khripunov & Kim, 2008; Kim & Kang, 2012). However, Reniers et al.'s work also raises problems and questions. First, the definitions of safety and security cultures are not mutually informed; i.e., the concepts do not account for the mutual shaping of the two cultures. Second, their conceptualization provides a managerial or top-down vision of culture (grounded in functionalist perspective), which insufficiently takes into account bottom-up enactments (highlighted in interpretive perspectives).

2.3. An anthropocentric focus

Although the functionalist and interpretive perspectives represent different, by and large opposing, views of safety culture (and by extension, security culture), they do share a common feature: both have an anthropocentric focus of safety culture, which is oblivious to the role of non-human actors in the construction of culture. As Rollenhagen argues, safety culture remains "*basically a people oriented concept*" (p. 270), which fails to account for the role of non-humans as constitutive element of safety culture.

As illustrated in section 2.1 above, scholars associate culture with individual or group traits, such as "beliefs", "perceptions", "attitudes", "values", and "behaviors", leaving little to no room for the incorporation of non-humans as active elements into safety culture and security analysis (Cooper, 2016; Gilbert et al., 2018; Glendon & Stanton, 2000; Grote & Künzler, 2000;

Guldenmund, 2007, 2018; Hopkins, 2016; Neisser, 2014; Pidgeon, 1998). Similarly, as argued by Neisser, security culture is solely '*focused on social practices and institutions*' (2014, p. 92). This anthropocentric bias is indebted to sociological works on culture, which have for a long time stressed that: "*everything that is not nature has to be seen as culture*" (Antonsen, 2009, p. 3). This dominant perspective prevents a proper and more complete understanding of the values and agencies of non-humans (such as dosimeters, physical barriers, security cameras or incident reports) in the dynamic performance of both cultures. Overall, this anthropocentric focus of the research on safety and security cultures may, to some extent, be explained by the following false syllogism: Safety and security cultures both deal with culture and culture deals with humans. Therefore they both deal with humans. The anthropocentricity of research on safety and security cultures represents the second gap this paper addresses.

Concurring with Healy, '*a "safety culture" [or security culture] that is not embodied or reflected in organizational and material realities may prove to be not only unproductive, but counterproductive'* (2004, p. 288). However, despite this lack of systematic attention to non-human agents in safety and security cultures, some scholars have included in their thinking ideas about the potential impacts of hardware, physical environment or software – albeit tentatively (Glendon & Stanton, 2000; Grote & Künzler, 2000; Guldenmund, 2007, 2000; Naevestad, 2009; Pidgeon, 1998; Yoo & Lee, 2015). For instance, Yoo & Lee, in their security culture questionnaire asked employees to what extent guidance documents or training and education programs impact security awareness (2015). Guldenmund (2000), Grote and Künzler (2000) and Glendon & Stanton (2000), in their analysis of safety culture, argue in favor of considering both software and hardware. Naevestad acknowledges that research on safety culture '*lack[s] a proper conceptualization of the relationship between culture, technology and structure in high-risk organizations'* (2009, p. 126). Furthermore, the model of Reniers et al. (2011) opens up the analysis of safety and security cultures to include the impact of technologies and procedures.

These developments are promising, as they enable the much-needed reflection on the potential role of non-humans in safety and security cultures enactment. However, even though several authors plead for a greater integration of non-humans in research around these concepts (Haavik, 2011; Healy, 2004; Le Coze, 2013; Naevestad, 2009; Rollenhagen, 2010), non-human objects and factors – when considered - are still by and large perceived as external influences on culture, rather than appreciated as actors that constitute and actively shape the culture in which they are embedded (Akrich et al., 2006; Latour, 1987).

Having illustrated the emergence and development of the notions of safety and security cultures, including their roots and contending views and enactments, we now turn to co-production and Actor-Network Theory. As we point out below, these concepts and approaches allow us to address the gaps identified above: the asymmetrical treatment of security culture in relation to safety culture (which raises issues of proper conceptualization, as well as practical issues of efficacy and organization) and the need to consider the role and potential of non-humans in safety and security contexts.

3. Bringing co-production and ANT into the safety-security relations

A relatively limited number of studies have addressed both safety and security cultures in an encompassing manner (Aven, 2007a; Dupont & Reniers, 2010; Gandhi & Kang, 2013; Hahn, 2011; Hessami, 2004; Khripunov & Kim, 2008; Kim & Kang, 2012; Koenick, 2011; Reniers et al., 2011). In order to tackle the gaps of the subordination of security culture to safety culture and the overlooked role of non-humans, we take inspiration from the interdisciplinary field of Science and

Technologies Studies (STS) which considers how science and technology affect society – and how society, in turn, affects scientific research and technological innovation. To address the two gaps identified earlier and therefore bringing symmetry in the analysis of both cultures, we specifically rely on the concept of co-production and on Actor Network Theory.

3.1. Co-production

Broadly understood, co-production implies that science is not just a force that shapes and changes society, but is in turn shaped by social forces (Latour, 1992; Shapin & Schaffer, 1985). Rather than a complete theory or model, co-production is an idiom: an invitation to consider how science and technological orders evolve together with the socio-political order (representations, identities, discourses, and institutions) in specific contexts (Jasanoff, 2004). Developed by Jasanoff (2004), among others, it sensitizes us to the mutual shaping of technology, science and society, and has proven useful in the study of natural and man-made disasters. In this perspective, technology and society should not be seen as two separate spheres, but rather as interacting components of a complete system, which mutually construct each other. For instance, in her analysis of the evolving relations and the mutual impact between the 1983 Bhopal industrial disaster and law, Jasanoff highlights '*the black-boxed relationships of co-production that link the development of material technologies with contextual social practices such as the law*' (2014, p. 95).

Arguing that material technology is too often analyzed as an independent device disconnected from its environment, Jasanoff proposes to study how it is framed within specific governance and sectorial boundaries.

She speaks of "civic epistemology" to denote '*institutionalized preferences for styles of evidence and argumentation that are sustained in a durable community*' (Willems, 2014, p. 44). When these implicit styles, codes and frames are made explicit, for instance with controversies and disruptions, it becomes

clearer why particular sociotechnical constellations take the forms they do. These controversies reflect a range of '*already existing frames within which social actors think and act. Focusing on the effects of such transformative events can bring more clearly into view salient differences'* between the cultures of different communities (Willems, 2014, p. 41). The researcher is supposed to analyze the controversial, potentially disruptive, moments when new orders emerge or when existing orders clash. During these episodes, everything is in flux and the discourses are loaded with different justifications and frames.

As it seeks to capture the dynamic co-shaping of two elements, co-production is well suited for the symmetrical analysis of safety culture and security culture. Security and safety are usually linked to different regulatory and legal frameworks. Co-production draws attention to the potential tensions or collisions arising from the development of specific devices standing at the boundary points between the two cultures. By focusing on the mutual evolution of safety and security elements rather than treating them as isolated entities, it provides a useful lens to examine both concepts in dynamic relation to one another.

3.2. Actor-Network Theory

Actor-Network Theory (ANT) has been developed by scholars such as Akrich, Callon, Latour and Law from the 1980's onwards. It is best understood as an epistemological approach, which asserts that "the social", originating in the term "association", is defined by constantly shifting networks of relationships (Latour, 2005; Strum & Latour, 1987). These networks consist of continuously enacted local and contextual interactions between actors, which can be both human and non-human. Actors' identities are defined and re-defined through their relationships, which also participate in defining, creating and stabilizing these relations (Callon, 1985; Strum & Latour, 1987).

According to Strum and Latour, humans are "*social players actively negotiating and renegotiating what their society is and what it will be*" (1987, p. 789) .They organize themselves practically by mobilizing various resources, including material forms and technologies (e.g., labels or turnstile gates in a high-risk organization). These resources embed norms and values, which allow actors to meaningfully coordinate and negotiate their behaviors, relationships and activities (e.g., what is the chemical in the container and who can enter the building). The institutionalization of such complex processes signifies that negotiations are closed down on the social level: actors who decide to implement these processes acquire '*the ability to organize others on a large scale, even when those others are not physically present*' (Strum & Latour, 1987, p. 793).

ANT provides useful tools and principles for the empirical examination of security and safety cultures' enactment.

First, it suggests that social realities are best understood by *following actors* (also called actants in ANT vocabulary), both human and non-human, and by describing their behaviors and interactions with other humans or non-humans that are part of an actor-network. Different from mainstream sociological approaches, ANT argues that the social is not simply out there, and cannot be explained by relying on predefined concepts or social theories that are then applied to the study at hand (Strum & Latour, 1987). To get a grasp of a particular object, phenomenon or issue, ANT demands to unravel and analyze all relations linking actors with each other as a network. To capture the intricate and complex features of enactment, ANT prescribes the methodological precept of generalized symmetry, which means that all entities in a network can and should be described in the same terms. The underlying rationale is that differences between entities are only generated in a living network of relations, and should not be presupposed. This approach is empirically determined by following actors in their dealings and relations with others (Latour, 2000b).

ANT allows analysts to highlight the interconnections between humans and non-humans and examine the agencies developed by all, including material artifacts such as containers, buildings, and trucks. By avoiding overgeneralizing social patterns, it enables the development of complex,

dynamic and localized understandings of the network and the way actors are (re)defined through their interactions.

Second, ANT asserts that the actors interacting in the network may have diverging and incompatible interests. Consequently, the stability of the network is acquired only when interests, stakes, values are aligned (Latour, 1987). This alignment '*occurs through a process where the actors' interests are translated (i.e. reformulated, modified, or changed) into more generally agreeable expressions, so that several actors may support the resulting translation*.' (Aanestad, 2003, p. 7). Some actors tend to occupy central positions with a specific status of spokesperson within the network, or an *obligatory passage point* (Callon, 1985). This concept enables to detect the actor(s) structuring the network, as they establish an '*indispensable channel through which all other actants must pass.'* (Scoles, 2018, p. 278). Identifying such actors and the translation process they coordinated is key to understanding the dynamics of safety and security cultures. It also facilitates detecting and tracing the actors interacting within these (safety and security) networks (Heller, 2002). For instance, an evacuation door or turnstile gate is both figurative and literal obligatory passage points, through which all other actors (employees, regulations, badges, etc.) have to pass to interact within the network, whether to evacuate in case of an emergency or to simply enter the premise for their daily work. Therefore, they both enable and constrain others actors' behaviors.

ANT has proven useful to the study of safety and security in domains such as bioterrorism. For instance, Mainz (2008) studied bioterrorism risks through an analysis of anthrax powder in "letter bombs", while Pohler and Schillmeier (2010) examined the agency of the SARS virus. While technically not a work of ANT, Diane Vaughan in her book "The Challenger launch decision", shows how defect rubbers (O-rings) were at the origin of the Challenger space shuttle accident in 1986. She demonstrates how the presence of O-rings in the shuttle was the consequence of, and reinforced, a deviant safety culture inside NASA, which put the safety of the mission at threat (Vaughan, 1996).

These studies highlight that artifacts, technologies and ideas may be considered in relation to human actors. Non-humans develop their own strategies and interact dynamically with humans; they are not to be taken as passive or external objects. In a nutshell, such analyses account for the social relations in which non-humans play an active role, thereby avoiding the pitfall of reducing social issues to human interactions.

4. Addressing the gaps: symmetry between and within safety and security cultures

Both co-production and ANT invite us to question the view that cultures, and "social" issues more globally, are only about human relations, beliefs, or attitudes. They urge us to account for the mutual shaping of human and non-human worlds (second gap). These approaches move beyond the conventional understanding that culture is a social construct, which can somehow be separated from the technologies that it gives rise to, and which in turn shape it.

Based on this, we argue for bringing symmetry in the analysis of safety and security cultures, by highlighting their mutual influence, as well as within the two cultures, by considering both human and non-human actors. Before illustrating how several features of ANT and co-production can be usefully applied to the study of safety and security cultures, we argue for a theoretical redefining of our understanding of both concepts. Drawing on these STS approaches, safety culture and security culture can be defined as mutually shaping networks that connect humans and non-humans in a given sociotechnical system; which through their interactions co-produce a certain level of protection against harm caused by malevolent agencies for security culture and non-malevolent agencies for safety culture.

In this section, we use two examples to illustrate the application of the two STS approaches for the study of safety and security cultures: the labelling of hazardous material and the "four eyes" principle. These examples lean on the literature and are informed through fieldwork undertaken by the first author in a high-risk organization.

4.1. Security dimension of safety devices: labelling of hazardous materials

The labelling of hazardous materials implemented in high-risk organizations may illustrate the security implications of safety devices (Keller et al., 1980; Su & Hsu, 2008; Wang & Chi, 2003). Such labelling can be understood as a process aimed at storing, classifying, and communicating the location, characteristics and hazards of specific materials. To give an example, a label of a nuclear or a corrosive substance directs attention to interactions with other human or non-human actors in and outside the organization. This label is directly connected to a specific material, container, storage facility, building, intranet platform gathering and sharing features and locations of hazardous materials within the organization, and to employees using or searching for these substances. The label also implies learning, trainings, label glossary categorization procedures, national regulations and shared international standards. Embedded within a global and shared knowledge order, it participates, locks in, and reinforces social ties. An employee manipulating a substance does not have to carry out a full analysis of the material before using it. Through her manipulation of the material following standard operating procedures and received knowledge, she participates in performing the labelling network, whilst relying on a proper enactment from the other actors.

The network of hazardous material labelling therefore performs specific assumptions, values and injunctions through the interactions of humans and non-humans composing the

network. For example, a hazardous materials inventory through an intranet platform of a high-risk organization, promotes the values of collaboration and transparency by connecting the labels and the storage with different employees of the organization,. These different actors co-produce a whole knowledge order operating on the assumptions, norms and practices of communality and sharing. By making visible and sharing the hazardous elements, their composition and potential risks, a label facilitates the safe manipulation and combination of these materials. In this way, this non-human participates to increase the visibility, the transparency and the prudent use of those materials (IAEA, 2019); thereby contributing to the enactment of safety culture in an organization.

The labelling of hazardous materials also has implications for safety culture. Making labels visible comes with the risk of increasing an organization's vulnerability to malevolent attacks; as does strict adherence to the values of openness, sharing and transparency. Confidentiality and access control, which are key to sustaining an effective security culture, are thus potentially weakened.

4.2. Safety dimensions of the security principle: the "four eyes" principle

The "four eyes" principle encountered in some high-risk organizations (Bodenschatz & Irlenbusch, 2019; Graff Lambsdorff, 2015; IAEA, 2019; Osaci et al., 2018; Schikora, 2010) can be defined as an '*internal control mechanism that requires that any activity by an individual within the organization that involves material risk must be controlled, double checked by a second individual that is independent and competent*' (Open Risk Manual, 2020)[22]. It is set up in some (areas of) high-risk organizations and is designed to avoid sabotage by implementing control by a peer. These measures, in appearance only

[22] Open Risk Manual: https://www.openriskmanual.org/wiki/Four_Eyes_Principle

connecting two humans with one another, actually involve a multitude of other actors, for instance the legal documents which enforce compliance, the protected areas in which the measures are applicable, the materials, techniques and artifacts manipulated in these protected areas, the fences, walls, doors and gates delimiting these areas, or the inspectors controlling the application of such measures. By tying all those actors together, this principle enforces and facilitates compliant behavior of workers.

In contrast with the previous example of a hazardous material labelling network, this network performs values and injunctions of vigilance, mutual control and possibly, suspicion. It runs counter to, as Schikora highlights (2010), the values of mutual trust, cooperation, self-control and well-being promoted in safety culture thereby possibly creating tensions between safety and security cultures. The "four eyes" principle therefore concomitantly shapes the conditions for a safety culture.

4.3. Combining co-production and ANT to the analysis of safety and security cultures

Through these two examples, the combined use of co-production and ANT provides a framework to detect, trace and analyze safety and security cultures networks pertaining to non-humans and their agencies, as well as their underlying values. It thus promotes a symmetrical vision of humans and non-humans as both having agency; that is, as active participants in networks or systems. Safety and security cultures characterize the networks composed of a wide number of actors, which, through their interactions, participate in (re)defining themselves, as well as the overall network to which they belong. In this view, analyzing networks demands safety-security researchers to closely follow actors interacting within these networks and analyzing their interplay with others. Overall, applying co-production and ANT to the empirical analysis of safety and security cultures

in high-risk organizations permits, as illustrated above, to focus on interactions between actors (both human and non-human) which participate to enact both cultures. It also enables to unveil the values, agencies, strategies they perform. Consequently, it allows to analyze how these two cultures mutually shape each other.

As highlighted in section 2, safety and security cultures are often seen as synergetic, two sides of the same coin (Flory, 2013). However, commenting on the global interactions between safety and security, Jore argues that, '*although security has become an omnipresent aspect of modern societies, the concept of security in itself has drawn surprisingly little scholarly attention compared to similar concepts such as risk and safety*' (2019, p. 157). As it has been insufficiently addressed as a concept on its own, the literature tended to discuss security culture only through the lens of safety by focusing on their similarities. In consequence, the comparison of those two concepts misses a thorough reflection on their contextual and dynamic mutually shaping influences.

As illustrated by the two examples discussed, acknowledging the mutual shaping and influence offers a contextual and dynamic grasp of how safety and security cultures are characterized and how they interact. Our combined approach urges us to analyze safety and security cultures as dynamic interplay; that is, as a mutual shaping within a regulatory, social and institutional setting or context. Through this lens of mutual enactment, safety and security cultures are seen as arrangements which are shaped with and through other elements of culture. They are co-produced, in ways that are generative as well as potentially incompatible or mutually exclusive. To draw a thorough image of safety and security cultures' interplay, tensions also demand to be scrutinized and accounted for, rather than ignored or downplayed. Maintaining that both safety and security cultures can always be enacted simultaneously presents a flaw in the dominant reasoning about safety and security interplay. Overall, despite their important added value in the study of safety and security cultures, co-production and ANT approaches present some limitations and jointly applying them poses some challenges that deserve to be discussed.

As stated above, co-production remains an idiom, an invitation to think about the mutual shaping of scientific, technological elements with societal ones. It remains relatively vague concerning the status of scientific, technological and societal elements. Are technologies and science part of society? Can we analyze technology, science and society symmetrically, by mobilizing the same vocabulary? These questions are often left unanswered by scholars who deploy the co-production idiom.

To that respect, ANT proves useful, as it provides heuristics to identify and explore patterns of co-production within a heterogeneous actor-network. However, the network only exists through interactions and relations within it, which raises the question whether anything exists outside or beyond what the ANT researcher has identified; i.e., the categories s/he is able to trace. There are no "larger" structural forces which constrain or enable the networks under examination. The main issue for ANT researchers then is to decide the bounds of investigation, be they historical, temporal or spatial, as well as which dimensions of the world are to be taken into consideration. This places a lot of weight on the researcher; it also suggests that important features could escape unnoticed. To give an example, in the case of safety and security cultures, the IAEA guidelines and other international and national regulations may be understood as interconnected actors within the network. However, they could also easily be missed by the researcher if she confines herself to staying within one part of the network, e.g. by focusing only to the interactions within the site of an organization's enclosure.

Second, and in relation to the previous point, ANT seeks to provide an all-encompassing way of seeing (and assembling) the social. Contrary to mainstream sociology approaches, it seeks to equip researchers with all the necessary epistemological, theoretical and methodological tools for a thorough analysis (Latour, 2005). This makes it difficult to combine ANT with other (sociological) approaches which, for their part, insist on drawing analytical and "real" distinctions between micro and macro levels of analysis for instance; or between elements that many would say are external to the network, such as market forces and capital flows in the global political economy.

Such limitations taken into account, we believe both frameworks are useful and potentially productive. Ideally, the idiom of co-production and ANT approach would be used as sensitizing approaches and as heuristics to improve and further our understanding of safety in relation to security and culture.

5. Conclusion

This article seeks to further our understanding of safety, security, and culture based on a literature review of these concepts within the context of high-risk organizations. It identifies two important gaps in our understanding of safety-security: the subordination of *security culture* to *safety culture* and the anthropocentricity focus of research on both notions. The paper states the case for more solid and reasoned theoretical foundations to address these two gaps. To this end, it introduces Science and Technology Studies (STS) concepts and approaches, specifically co-production and Actor-Network Theory. Through two concrete illustrations, *i.e.* the labelling of hazardous material and the "four eyes" principle the article highlights how combining co-production and ANT opens onto a more symmetrical analysis of safety and security cultures in high-risk contexts, such as the nuclear arena.

By focusing on the dynamic interplay between non-human and human elements, and by refraining from making *a priori* distinctions between procedures, technology, and culture, both co-production and ANT provide a meaningful corrective to anthropocentric perspectives. Contrary to dominant safety and security approaches, they avoid essentialist explanations for events, behaviors, and eventualities. Instead, they consider how various elements interact to prompt specific events or behaviors, and explore the circumstances and the assumptions underlying them. ANT is especially relevant as it explicitly proposes a symmetrical approach to humans and non-humans. It also provides multiple tools to detect, trace and draw the network of interactions

between actors in safety and security culture networks. Co-production, for its part, is especially useful to designate and consider the mutual shaping and the co-evolution of safety and security cultures. Combining both approaches brings a much-needed symmetry to the analysis of safety and security cultures.

In these ways, they can make a meaningful contribution to further theoretical and empirical research on safety and security cultures in high-risk organizations, which will benefit both scholars and practitioners. Providing a conceptual framework which highlights both the interaction between safety and security cultures, and the role played by human as well as non-human actors in their interaction, we hope this article contributes to future empirical explorations of safety and security cultures in high-risk organizations.

Chapter 2: The "judicialization" of emergency management in Belgium: from a safety regime toward a security one[23]

Colin Glesner, Catherine Fallon

Abstract: This paper analyzes changes in emergency management in Belgium that have accompanied growing security concerns in Western countries since the 9/11 terrorist attacks in the US. Using an instrumentation approach, we show how the adoption of a particular regulatory instrument helped put police and judicial actors center stage and gave a more prominent place to the inquiry. We show how the instrument is hampering cooperation, communication and trust in rescue services and may undermine the collective intelligence at the core of emergency responses. We argue that these changes are indicators of the rise of a new "emergency management security regime" that contradicts the original safety regime applied since the 1960s.

Keywords: Emergency Management; Judicialization; Safety; Security

[23] Glesner, C., Fallon, C. (2021). The "judicialization" of emergency management in Belgium: from a safety regime toward a security one. *The Journal of Emergency Management.* (under review)

1. Introduction

At 7.58 am on March 22, 2016, two explosions resounded at Brussels National Airport. The first news mentioned not only many dead and injured but also the imminent collapse of the airport building. Rescue services in the vicinity were rapidly informed and rushed to the airport. They still did not realize they were facing the first of the two terrorist attacks that struck the Belgian capital that day[24]. Upon his arrival a few minutes later, the West Flemish Brabant fire service commander was ready to lead the emergency response.

"Indeed my first thought was that as I am the highest ranked in the fire service, I should lead this emergency response [according to the EM procedure]. However, as soon as I spoke with my colleagues, I was informed it was a terrorist attack. Based on that information, we concluded that the emergency response should not be led by the fire services but by the police, so we handed over leadership to the police." (commission attentats, 2016, p. 528)[25]

This decision to shift leadership of emergency responses to the police represents the starting point of our inquiry. Up to 2016, the Belgian emergency management (EM) approach applied since the 1960s gave the multidisciplinary emergency response leadership to the fire services. Why at the outset of the 2016 Brussels Airport terrorist attack, did the rescue services, decide to hand over emergency response leadership to the police? How did this decision affect EM? The decision was not trivial and was based on the rationale that an emergency should be managed differently depending on whether its origin is malevolent or not. To go further in the rationale behind this decision, a "security-related crisis" (such as a terrorist attack) should not be managed in the same way as a "safety-related crisis" (an industrial accident or a natural catastrophe).

[24] Although in this article we focus on the Brussels National Airport terrorist attack in which 18 people died and 92 were injured, on the same day another explosion also occurred in the Brussels' metro station "Maalbeek" in which 17 people died and 106 were injured.

[25] Translation form the Dutch by the author.

In the American context, scholars including Tierney and Waugh analyzed the impacts of major terrorist attacks, such as 9/11, on the existing emergency management framework (Tierney, 2007; Waugh, 2005). Tierney warns against the increasing role of law enforcement agencies and the development of "special purpose" initiatives that may undermine emergency response practices and lead to suboptimal EM. Contending that crises of different natures, such as terrorist attacks or industrial accidents, may have similar features and consequences, they, among other scholars, plea to stick to an "all-hazard" EM approach that considers that managing crisis situations is not impacted by their conditions of emergence and that emergency management applies regardless of cause.

Based on this assertion, the present paper assesses the rationale and implications of differentiating safety-related and security-related EM in Belgium. More precisely, by characterizing EM in Belgium and examining how it was impacted by the increase in terrorist attacks in Western countries from the beginning of the 21st century, this paper analyzes the impacts of the security related concerns on EM objectives, principles, and practices.

We focus on EM regulatory instruments to analyze policy changes using the instrumentation approach developed by, among others, Lascoumes and Le Gales (Lascoumes, 2007; Lascoumes & Le Gales, 2007). More precisely, our inquiry traces and examines how EM regulatory instruments have evolved over time and shape emergency management practices, principles, and goals, thereby participating in the production of EM "policy regimes". The specific research question we aimed to answer was "how do the new regulatory instruments developed to address security concerns, influence the EM regime in Belgium?".

We show that the Belgian EM regime primarily developed after the 1960s to tackle safety-related emergencies such as natural catastrophes and major industrial accidents. We argue that the changes made in the most recent regulatory instruments in response to the need for better security-related crisis management have major consequences for the "EM safety regime". More particularly, we show how these instruments have given an increasingly prominent role to security-oriented

rescue services and judicial actors in emergency responses. We demonstrate how this modification reshuffled power relations, incorporated new EM objectives and undermined the conditions of cooperation between operational and strategic emergency actors and consequently the overarching EM principle of collective intelligence. Practically, we show how these regulatory changes contributed to the emergence of an "EM security regime" that shapes the core values of EM not only for security-related crises but for all types of emergencies.

Overall, our inquiry and the Belgian case study applies novel approaches to examine the emergence of security concerns in EM. and similar inquiries conducted in other countries.

In section 2, we introduce our theoretical framework based on the instrumentation approach and the concept of policy regime. In section 3, we present the methodology we used to collect our data and conduct our analyses. In section 4, we demonstrate how EM in Belgium developed by enforcing an EM safety regime and how regulatory instruments dealing with security-related emergencies helped bring in an EM security regime. We conclude that these security-oriented transformations and the EM security regime do not only apply to security-related emergencies but affect all types of emergency responses, even safety-related ones. Based on our conclusions, we urge field actors to question these changes in order to find ways to preserve collective intelligence.

2. Approaching the emergency management policy regime through its instrumentation

Guaranteeing protection against hazards is among the central responsibilities of the state in support of its citizens (De Larrinaga & Doucet, 2008; Dillon & Lobo-Guerrero, 2008; Haddow et al., 2017). Rather than a pure institutional and normative vision of a voluntarist and perfectly informed state delivering protection and services, we follow Rose & Miller (2010) and consider "the government beyond the state". Governing calls on a wide range of institutions, practices, ideas and interest groups (P. J. May & Jochim, 2013). Authoritative actions (executive orders, statutes, laws, and procedures) are only part of the policy regime. '*Policies are made by a variety of different actors interacting with each other […] each with different interests and resources, and all operating within a climate of uncertainty.*' (Howlett, 2009, p. 84). Analyzing the US response to the COVID-19 pandemic, Carter and May define policy regimes as '*governing arrangements for addressing policy problems giving due consideration to rationales, institutional design and constituencies.'* (2020, p. 266). Going beyond a purely institutional or administrative perspective, we argue that such a lens is relevant to present EM while emphasizing the importance of informal channels for communication and cooperation (Hood et al., 1999).

Considering government as a wide and heterogeneous set of practices used by a variety of actors, our analytical approach follows a Foucauldian vision by putting regimes of practices center stage. We specifically focus on the norms and standards, and the regulatory, fiscal, economic, incentive or communicational instruments through which authorities are established and rules accomplished (Dean, 2010). To qualify the characteristics and transformations of the EM policy

regime, we call on the principles of the political sociology approach to public policy instruments developed by Lascoumes and Le Gales (2007). These authors consider a public policy instrument as a socio-technical device that incorporates a concrete concept of the politics/society relationship '*that organizes specific social relations between the state and those it is addressed to, according to the representations and meanings it carries.*' (2007, p. 4). Instruments develop as aggregates of actors, producing specific representations of the issue and problematization of the stake. And finally, as argued by Kassim and Le Gales, '*every instrument constitutes a condensed form of knowledge about social control and ways of exercising it.'* (2010, p. 6).

In that respect, our approach offers a practical way to analyze the transformation of policy regimes by specifically tracing changes in public policy instruments in terms of actors, representations and problematization. Constructing the history of the instrument means following the groups of actors and their policy rationales, as they create power relations and have political effects. The design of public action tools results from a dynamic - often chaotic - process of bringing together information, adapting to constraints and arbitrating between divergent development paths. The translations made by technical instruments involve the constant linking of information and actors and are regularly subject to reinterpretation and controversy. Policy instrumentation is analyzed through different moments as a way to orient relations between political-administrative actors and citizens, in the form of specific arrangements mixing technical (measuring, calculating, the rule of law, procedure) and social components (representation, symbol). A good approach for research is to consider instruments over long periods of time (20 years or more) as local processes of "translation" of patterning, struggle around social order and resistance, as they produce devices, agents, institutions, or organizations (Law, 1992).

This instrumentation analysis borrows its genealogical approach from Foucault. It can be summarized as a method of investigation focusing on what is apparently "without history" in order to unearth the traces of hidden constraints and power relations entrenched and enacted in and through policy instruments (Foucault, 1997; Gutting, 1990). This constructivist approach to policy

instruments supposes an interpretive perspective that analyzes the complex local ongoing interactions within the arrangement.

In the following section, we detail the methodological procedures we used to collect the data required to reconstruct a meaningful description of the Belgian EM regime and its development in the wake of 9/11.

3. Data collection and management

This paper assesses how the Belgian EM regime evolved through the upsurge of security threats in the 21st century. More specifically, it examines how recent regulatory changes influenced the EM regime in Belgium. With its long and intense industrial history and having recently faced serious terrorist threats, in that respect, Belgium resembles many Western countries. Like in other countries including in the USA, the general EM framework in Belgium is managed at the federal (national) level but also gives an important role to provinces and municipalities (local level) in producing emergency plans and responding to emergencies (Brunet et al., 2018; Haddow et al., 2017). To answer our research question, we traced regulatory instruments, as well as forms of cooperation and the organization of leadership, techniques and tools that formalize and materialize emergency management in Belgium to obtain a better understanding of how they evolved. Our inquiry specifically traced federal legislation (laws and royal decrees (RD)) but also the pilot projects, parliamentary debates, RD reports and political discussions[26].

We added primary and secondary data selected from a broader project (the first author's PhD thesis) on EM in Belgium from November 2017 until October 2020.

[26] As some of these documents were confidential, we obtained access to them through the National Crisis Center on condition of not divulging their technical details.

From all this fieldwork, we selected data covering the impacts of security-related emergencies on EM regimes (table 6). We conducted 20 interviews with actors involved in emergency management (planning and response) from all the main EM disciplines (see table 7). Data saturation was reached by combining the use of a saturation grid with feedback from the field and data triangulation (Brod et al., 2009; P. Fusch et al., 2018; P. I. Fusch & Ness, 2015). The interviews were conducted in French and lasted between 60 and 90 minutes. The excerpts selected for this article were translated into English by the authors. The interviews addressed four main questions aimed at understanding how the Belgian EM regime has evolved, particularly recently, with a specific focus on the role played by EM regulatory instruments in practices.

Table 3: Four main questions addressed during the interviews
In your experience, how are emergencies managed at the operational and strategic level?
In your experience, how has EM multidisciplinarity evolved over time?
In your experience, how has emergency management evolved over time?
In your opinion, how have recent regulations impacted emergency management?

In addition to obtaining insights into the perceptions and practices of EM actors, the interviews also allowed us access to the specific research field via key EM actors, reports on previous emergency managements, recent emergency exercises but also confidential regulations (for instance, RDs on emergency planning against terrorist attacks (Gouvernement de Belgique, 2016, 2020), drafts of regulations and preparatory works.

We analyzed reports on the management of four major emergencies that recently occurred in Belgium. Although we paid special attention to the 2016 Brussels terrorist attacks, all the reports provided insights as they not only summarized the lessons learned from the management of these crises but also provided hints about the current EM regime and how it has evolved. We also

observed five emergency exercises at operational level. Our observation of the exercises and their debriefings was based on the non-participatory observation method (J. Cooper et al., 2004).

Table 4: Main elements analyzed during participatory observation of emergency exercises
How do participants understand changes in regulations? What are the direct impacts of regulations on the emergency response at operational level? What are the actors' overarching objectives?
What role do participants play in the emergency response? How do EM actors collaborate and communicate with each other? Are there any new actors in the network?
What are the specificities of security-related versus safety-related crises?

All data were coded and analyzed based on a reflexive thematic analysis (Braun & Clarke, 2006, 2019) using Nvivo 12 software (Melbourne, 2012). Reflexive thematic analysis enabled us to identify the features of the Belgian EM regime and how it has changed, as described in the following section.

Table 5: Data collected

Primary data: 20 semi-structured interviews	Interviewees' affiliations		1
	National actors		2
	Provincial actors		2
	Municipal administrative personnel in charge of emergency management		2
	Rescue service disciplines	Police	4
		Fire services	4
		Emergency communication service	1
		Medical rescue professionals	2
Primary data: non-participatory observations	5 emergency exercises: - a staged terrorist attack at a Belgian airport 2017 - a staged fire at a Belgian nuclear research center in 2018 - a staged road accident on a highway near Brussels in 2018 - a staged fire at a Belgian chemical factory with escaping chemicals in 2019 - a staged hostage taking and terrorist attack at a Belgian nuclear research center in 2020.		

Secondary data	Four reports on the management of several major emergencies that occurred recently
	- Parliamentary commission reports on Brussels terrorist attacks on March 22, 2016 (Commission attentats, 2016; La chambre des représentants de Belgique, 2018) - Municipal report on the Leopold street explosion in Liège in 2010 (CELINFO, 2010); - The police report on the St. Lambert Square shooting in Liège 2011 (Police de Liège, 2012), - The municipal report on the storming of the "Pukkelpop festival", 2011 (Stad van Hasselt, 2012)

Using cross-fertilizing regulatory analysis of primary and secondary field data, we analyzed how instruments are materialized in practice and assessed their consequences for the Belgian EM regime. Data triangulation helped us unearth traces of hidden constraints and entrenched power relations enacted in and through EM regulatory instruments. We revealed the role played by instruments in reshaping assemblages of EM actors, bringing new values to the fore and influencing the EM regime.

4. The Belgian emergency management regime

4.1 Materialization of the Belgian EM regime through its instrumentation framework

The first national law on emergency management in Belgium was issued in 1963 (Gouvernement de Belgique, 1963), furthering law on safety, security, public peace and public health (Brunet et al., 2018; Gouvernement de Belgique, 1836). The 1963 law was drawn up in the context of the Cold War, when fear of possible nuclear bombing reigned. The law defined protection of the population and of the patrimony as overarching objectives (art. 1). Even though the law did not use the term "emergency management" or "emergency planning", it gave the government the right to establish civil protection programs in the case of major crises (art. 2). Article 2 was referred to in further regulations that also obliged local authorities to produce emergency plans, thereby marking the emergence of municipality-driven emergency planning and management. The law also delegated the response to such kind of emergencies to a series of organizations, thus representing the first EM milestone to which all further developments of EM regulatory instruments refer.

A few years later, in an national[27] and international context of increasing numbers of serious industrial accidents (U. Beck, 1992; Kletz, 1999), the focus on emergency management shifted from threats associated with the Cold War threat to non-malevolent industrial catastrophes. A royal decree (RD) passed in the late 1960s used an EM approach to be applied in all kinds of emergencies

[27] Notably, a fire in a large department store "*Innovation*", in Brussels that caused the death of 267 people in 1967.

(also called the "all-hazards model" (Waugh & Streib, 2006)) based on civil protection services under the authority of local political actors (1967, Art. 1). Like in other countries, from the second half of the 1970s until the beginning of the 1990s, Belgian EM incorporated the lessons learned from major nuclear and industrial catastrophes (Seveso, Three Mile Island, Bhopal, Chernobyl) (U. Beck, 1992; Jasanoff, 1994; Power, 2007).

In 1988, the Government decided to further formalize EM communication and coordination between the different types of rescue services (fire fighters, health services, police and logistics) (art. 3. 1°) at national level through the creation of the National Crisis Center (NCC). For the first time, it also enforced the specific obligation to draft emergency plans (art. 3. 4°). The Decree also recognized the public as a stakeholder in emergency situations by mandating the NCC to guarantee that comprehensible and uniform information is provided to the public in case of national and international events (art. 3. 5°).

In 2003, after a decade marked by multiple major industrial, food and natural catastrophes (mad cow disease, dioxin, large-scale flooding[28]) and in the aftermath of the 9/11 terrorist attacks that painfully revealed the terrorist threat to the Western world, Belgium adapted the 1963 law by passing a new law and a RD (Gouvernement de Belgique, 2003a, 2003b). Both reaffirmed the importance of firefighters in leading emergency responses but also multidisciplinarity as principle underlying EM coordination and communication patterns.

Three years later, an industrial safety-related emergency (gas explosion in an industrial site at Guislenghien in 2004) spurred the publication of a major EM regulatory instrument aimed at addressing problems of coordination and information between the different services, between public and private actors, as well as vertical coordination between local and federal authorities. The 2006 RD (plus four subsequent ministerial memoranda in 2006 and 2009) details emergency planning and EM responses by specifying the missions of EM actors and their interactions

[28] More information on these crises can be found in (Berg, 2004; Hansel, 1999; Lebailly, 2003)

(Gouvernement de Belgique, 2006a, 2009b, 2009c, 2009a). it is less a transformation of the EM safety regime than a formalization of existing EM principles that had been applied since the 1960s. Indeed, this RD was developed bottom-up based on field practices.

> *'The RD materialized the procedures we used. It clarified things but didn't introduce any major changes.' (Interview with a former member of the fire service, March 2019)*

Firstly, the RD organized EM functions in five disciplines, functions that were previously filled by the existing rescue service (table 6). Secondly, it maintained the strong local anchorage of the EM regime: crises are to be handled by local authorities and municipal rescue services unless the scale of the emergency requires the response to be scaled up to the provincial or federal level. Thirdly, it set up crisis management cells such as strategic disaster management committees (headed by the appropriate political authority) and Emergency Operation Centers (EOC) (analyzed by Perry, 2003). In safety-related EM, the legal formalization gives the leadership of the EOC to the most senior firefighter. In all crises, the strategic responsibility is kept firmly in the hands of the appropriate political authority: in local crises, the mayor, for provincial crises, the Governor, and in national crises, the Minister of Interior.

Table 6: EM rescue services in Belgium

EM functions and related services	**Rescue services**	**Political authorities**
Discipline 1: Rescue	Undertaken by the civil safety services and mainly by the (local) fire services	Under the authority of the head of the strategic committee, depending on the phase
Discipline 2: Medical services	Undertaken by medical professionals from hospital services	Under the authority of the public health inspectors organized at federal level

Discipline 3: Policing	Undertaken by the judicial and administrative police services (local or federal as appropriate)	Under the authority of the head of the strategic committee, depending on the phase
Discipline 4: Logistical support	Undertaken by the army or civil protection services	Under the authority of the Interior Minister at the federal level
Discipline 5: Information	Undertaken by political-administrative communication teams	Under the authority of the head of the strategic committee, depending on the phase

The 2006 RD is often cited by field actors as the first legal instrument encompassing the whole EM framework in Belgium.

> *"Its interest was formalizing and concentrating the procedures and principles in one document that were already present here and there. It set existing practices in stone." (Interview with a member of fire services in the province of Liège, October 2018)*

The RD combines the approaches of successive regulatory instruments developed since 1963, while reinforcing different principles including multidisciplinarity, EM professionalization, involvement of the public, etc. By stating the need for a cyclic approach for emergency preparedness based on the drafting of plans, multidisciplinary exercises and post-crisis debriefing, the law encourages a learning process aiming at reinforcing risk analysis, planning, the functions of the different disciplines) as well as the main principles guiding operational interventions.

At the same time, this formal step failed to express what is at the core of the EM regime, the collective intelligence required to manage a crisis successfully. While planning is an important multidisciplinary activity, interventions are not managed "by respecting the plan" but by responding adequately to a specific event (Brunet et al., 2018; Waugh & Streib, 2006). The successive regulatory

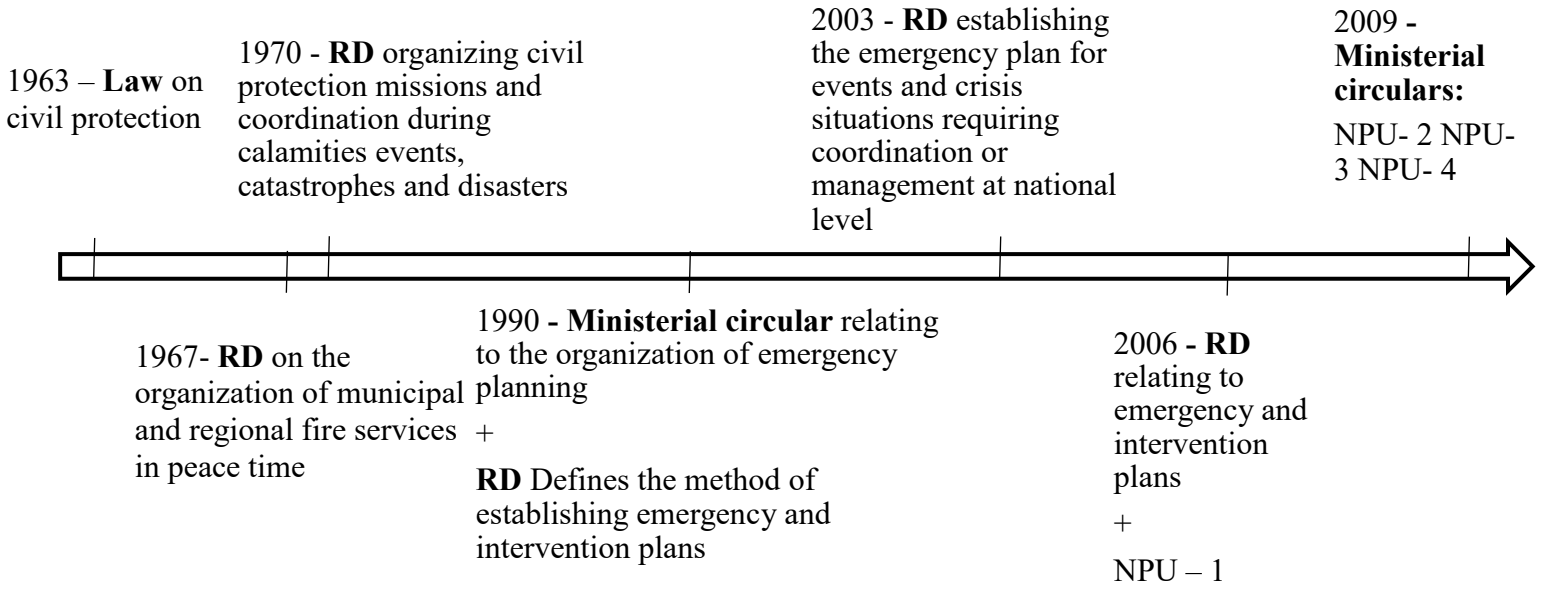
models only transcribed what can be formalized but not the professional ways of intervening, nor attitudes toward operational interventions, nor the informal communication and collaboration procedures that are developed within and between professional organizations (Ansell et al., 2010; Farazmand, 2007; Waugh & Streib, 2006). Professionals assert that "we are always taken by surprise" during a crisis: rescue services have to face uncertainties and to be flexible and innovative to adapt their intervention to the very specific crisis they are facing. Some professionals underlined the importance of developing "collective intelligence", defined as:

> *'a good horizontal mode of organization, a group dynamics that emerges in complex situations. Collective intelligence enables […] some sort of alchemy between EM managers. It creates something better than the sum of the individuals.' (Interview with a fire officer in Glesner, 2018, p. 205)*

Collective intelligence as a capacity is facilitated by professional development and by the building up of mutual trust between actors and is acquired through exercises and interventions. It is too qualitative a characteristic to be formalized legally, but a legal framework helps its emergence.

The 2006 Decree was rewritten in 2019 based on a large participatory process with round table sessions including operational professionals from the different disciplines and political-administrative actors from different levels. The 2019 RD first clarifies and strengthens the roles of local authorities. Second, it increases the coordination of means between EM actors and synergies by creating a function entitled *emergency planning coordinator* in charge of coordinating EM within municipalities (art. 1/16°) on the one hand, and by creating a *national safety portal* (art. 1/25°) enabling direct information sharing between all EM actors in the country on the other. In addition, it professionalizes the EOC director's function and formalizes dedicated training courses that are also geared toward the development of soft skills like those mentioned above (art. 17§2). In that way, the decree strengthened the EM regime developed since the 1960s.

Timeline 3: Regulatory instruments for emergency management until the 2006 RD



Overall, these regulatory instruments defined values, principles and practices as well as a specific group of actors that together contributed to building the Belgian EM safety regime to be applied to all types of crises (see table 7).

Table 7: Features of the Belgian EM safety regime
Overarching objective: save the population and the patrimony
Response to safety-related crises
Institutionalization of emergency management
Professionalization of rescue services
Multidisciplinarity
Developed using a bottom-up approach
Involvement of the population
Locally-driven emergency response
Open communication to support collective intelligence

4.2 Security concerns as stressors of the EM regime

During the parliamentary commission on the 2016 Brussels terrorist attacks, a local firefighter declared:

> *'On March 22, we were first called out because of a fire alarm. It didn't enter our minds it was a terror alarm. Even when we saw the smoke, we still didn't envisage a terrorist attack. So, we started out by thinking about other causes than terror […]We have to do our job, but we have to take care not to destroy evidence.' (testimony of an airport fire service commander before the Commission attentats, 2016, p. 63)*

According to this excerpt, safety and terror are not confronted by firefighters with the same philosophy (Discipline 1). In case of a terrorist attack, the emergency not only concerns safety issues (fire or building stability) where the primary goal is saving lives and property, but also terror: searching for evidence for subsequent legal proceedings and, if necessary, neutralizing the perpetrator. The two last missions are the responsibility of Discipline 3 including local and federal judicial and administrative police and the justice department. Firefighters are aware of the fact that in the case of a terrorist attack, they will need to adapt the intervention. A further point concerns organization and multidisciplinary cooperation: which discipline should be responsibility for organizing cooperation and leadership of the emergency response at the operational level?

The preceding section made it clear how Belgian regulatory instruments led to the development of tools for EM professionals belonging to different disciplines thereby creating the conditions for what we refer to as the "EM safety regime". In practical terms, the 2006 RD is often described as a milestone of this regime. However, the 2006 RD involved a small modification that would have significant consequences by preparing the way for new forms of operational leadership in the EOC: the political authority heading the strategic concertation committee during a crisis could select a specific coordinator to lead EM operations depending on the nature of the

emergency. While, before 2006, the first discipline usually led the EOC (for crises that were generally perceived as safety-related), the article states that the discipline leading the EM can differ depending on the nature of the crisis. For example, in the case of terrorist attacks, the third discipline (policing) would take the lead, thereby clearly revealing orientation towards security on the part of the legislator:

> *The leading position of the EOC is held by the member of the fire services present in the intervention area with the highest grade. […] The competent authority can designate a leader from another discipline, more concerned by the emergency situation, to lead the EOC. (Gouvernement de Belgique, 2006b, art. 15§2))*

In the first years following publication of the decree, the modification was not considered to be disruptive and had no major consequences. Neither strategic nor operational modifications were introduced by the rescue services (and surely not by the third discipline) following the creation of this tool, which, for that matter, was hardly acknowledged as a change.

The first question arose during the response to a shooting incident in downtown Liege in 2011 when the firefighters doubted they should be leading the EM and invited a police officer to take over the EOC leadership.

> *'We met the commander of the fire services who said: 'listen, I think I shouldn't be leading the EOC, I think it should be you! So I found myself de facto leader of the EOC.' (Interview with a police officer who acted as EOC during the St. Lambert shooting in Liège in October 2018)*

The range of application of this measure became apparent at national level during the terrorist attacks in Brussels in 2016. Indeed, the first discipline (headed by the commander of the West Flemish Brabant fire service) decided to hand over leadership of the crisis management to the third discipline (policing). The shift in leadership to the third discipline led to major uncertainties and dysfunctions. Indeed, although some kind of improvisation is inherent to crises, management by the third discipline and communication and coordination between services was identified as specifically problematic.

> *After handing over the EOC leadership position to the police, we did not see them in the field[…] There was no multidisciplinary coordination. (testimony of a commander of the fire service before the Commission attentats, 2016, p. 529)*

Faced with this lack of coordination, and only two months after the Brussels terrorist attacks, the Belgian government passed an emergency and confidential RD in May 2016[29]. This new RD lays down the main principles to be respected during emergency responses to a terrorist attack (Gouvernement de Belgique, 2016). Firstly, it affirmed that in the event of security-related crises, the operational lead must go to the third discipline (judicial and administrative police) and it largely reinforced the position of power and the prerogatives of the judicial police and judicial power actors during the emergency response phase. Secondly, the strategic management of a terrorist attack automatically went to the Federal Interior Minister, thereby giving prominence to a federal top-down approach. Thirdly, the number of federal EM committees was increased to include actors who had not previously been directly linked to EM: e.g. civil and military secret services and the terrorist threat evaluation cell (French acronym *OCAM*). In our view, all these modifications marked a first divergence from the all-hazard EM approach and the safety-oriented regime that had been in place since the 1960s.

The principles established in the 2016 RD on the EM of terrorist attacks were reaffirmed in the new RD issued in 2019 (see section 4.1), which recognized the specific nature of security-related crises thereby affirming the need to shift from the all-hazard approach in such events. Moreover, by setting out the rules for professionalizing the EOC director's function[30] (see section 4.1), it definitively abandoned the first discipline's prerogative to lead operational emergency responses.

[29] This RD is confidential. Although we were allowed to read it, we are not allowed to divulge any more information about its content than that given here.

[30] To become an operational director during an emergency, the person needs to possess an operational director's certificate awarded on completion of a training course.

In 2020, a new RD on emergency planning in response to terrorist attacks was passed by the government to replace the 2016 RD. More than simply up-dating it, the confidential 2020 RD[31] strengthened security-oriented changes first introduced in a short paragraph in the 2006 RD and confirmed the different approaches to security-related crises (see above). Firstly, it dramatically increased the power of the judicial actors in operational and strategic committees where they now have a leading position. It by default centralized terrorist emergency responses at the federal level under the authority of the Interior Minister and reinforced the importance of the judicial investigation and the search for evidence: the prosecutor's office is associated with the strategic committees and also directs the work of the police rescue team at the operational level. At the same time, the decree imposed a global reduction in the number of actors sitting on each committee in order to limit the diffusion of potentially sensitive information to the fewest possible actors (Gouvernement de Belgique, 2020). In so doing, it affirmed the importance of having the prosecutor control communication channels. Altogether, these changes strongly reinforced the judicialization of the EM framework, which is expected to further modify the forms of communication since the prosecutor imposed new barriers limiting some information sharing. For instance, a separate confidential logbook is reserved for the judicial committees whereas all the disciplines currently use a centralized Incident Communication Management System (ICMS) that details the transfer of information between services at strategic and operational levels.

Overall, the search for evidence implies a new form of confidentiality thereby reducing trust between operational actors and controlling communication, which could undermine collective intelligence. Based on our data analysis, management of the 2016 (terrorist attack) events indeed highlighted dysfunctions in communication and coordination between EM actors and especially with the judicial actors in the third discipline and with the public.

[31] This RD is confidential. Although we were allowed to read it, we are not allowed to divulge more information about its content than that given here.

> *'Afterwards we realized the police had also intervened somewhere else but they didn't inform us about it.' (Interview with a provincial crisis manager concerning the 2017 airport emergency exercise, January, 2019)*

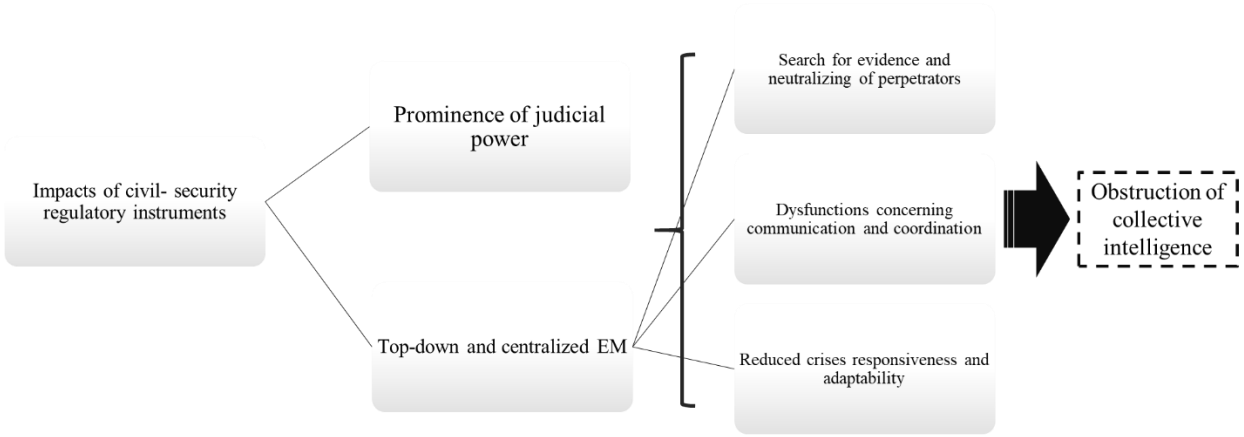
> *'It is always difficult with judicial actors, they are not accustomed to taking part in emergency responses and when they do, they are reluctant to collaborate, to provide the necessary information. The inquiry dominates their mindset rather than the EM.' (Interview with a member of the fire services in Liège, February 2019).*

This situation is certainly not unique to the Belgian case study and has also been observed in several security-related crises notably in the USA.

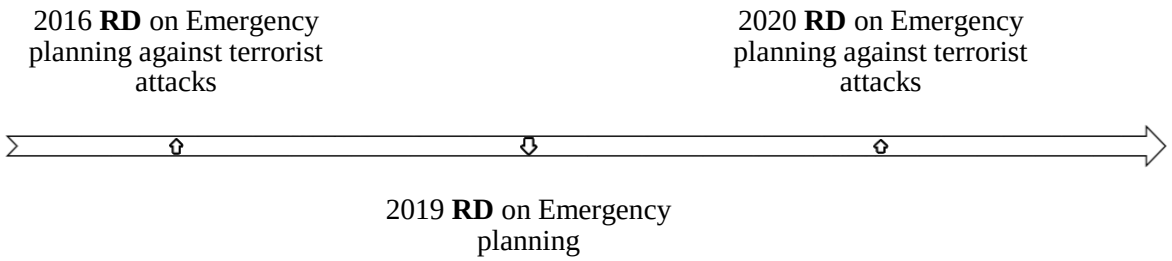
> *'Both the Oklahoma City bombing and the 9/11 World Trade Center attack led to sharp clashes between different groups of initial organizational responders. There were those who saw these occurrences primarily as criminal attacks necessitating closure of the location as a crime scene, and those who saw them primarily as situations where the priority ought to be on rescuing survivors.' (Quarantelli et al., 2007, p. 23).*

However, as shown in section 4.1, at the core of EM lies a "collective intelligence" supported by some form of multidisciplinarity and mutual trust between EM actors of the different rescue services. Trust is therefore a core value of the Belgian EM regime that is being jeopardized by recent changes in security regulations. Furthering Beck's thought, unlike non-malevolent risks, terrorist threats make it necessary to "*replace active trust with active mistrust"* which in return affects the collective intelligence of the emergency response (2002, p. 44).

Figure 1: Impacts of security-related EM regulatory instruments on the EM regime



Timeline 4: Emergency management regulatory instrument after 2006 RD



These testimonies show how, by allowing the reorganization of the EOC leadership in security-related crises, the 2006 RD opened the way for another approach than the one developed

in the framework of the EM safety regime. Subsequently, by reinforcing the role of the third discipline and particularly of the judicial actors in the emergency response, the 2016 and 2020 RDs modified the dynamics of cooperation within the network. By imposing much stricter control of information, they departed from the multidisciplinary communication model based on nonhierarchical leadership as well as a communication process that was attentive to the specificities of the different actors involved in each discipline. We argue that, in so doing, they helped create, in a top-down way, another EM regime we call the "EM security regime", whose features can be summarized as follows.

Table 8: Features of the EM safety and security regimes

Features of the EM safety regime	Features of the EM security regime
Overarching objective: save the population and the patrimony	1st overarching objective: save the population and the patrimony 2d overarching objective: search for evidence and neutralize perpetrators
Developed an all-hazards approach mainly oriented toward safety-related crises	Specifically developed to respond to security-related crises
Institutionalization of emergency management	Leadership transmitted to the third discipline, D3
Professionalization of rescue services	Association of judiciary services in D3 at strategic and operational levels
Multidisciplinarity	Reduced multidisciplinarity, judiciary services are new in the field
Involvement of the population	Non-involvement of the population
Locally-driven EM	Federal and top-down EM
Open communication supporting collective intelligence	Controlled communication

5. Discussion: the future of emergency planning

In the previous section, we described changes in EM in Belgium that took place through a sequence of transformations of the institutional frameworks, the actors involved in the network, and the operational vision of their main missions. Our empirical analysis recalls how a minor modification in one regulatory instrument reshaped emergency operational responses by giving new actors the opportunity to reinforce their position in the network. The increasing role of judiciary actors in emergency management created new values, principles and goals that led to the emergence of what we call the "EM security regime" and to reduced collaboration, ultimately leading to suboptimal emergency responses (section 4.2).

> *'Even when we saw the smoke, we still did not imagine it could be a terrorist attack. We started out with a philosophy other than terror. If we has been told 'this is a bomb attack, you have to leave', that would have given a completely different picture of our intervention.' (testimony of a fire service commander before the Commission attentats, 2016, p. 63).*

EM actors engaged in both safety and security interventions are supposed to develop different patterns of leadership, communication, trust, and cooperation depending on the origin of the crisis (malevolent crisis or non-malevolent crisis). Based on our fieldwork, we consider that these changes not only concern security-related emergencies but inform all types of emergency responses. The reconfiguration of policy goals, strategic leadership and actors' coordination does not only impact responses to terrorist attacks but all sorts of emergencies. To go further in this line of thought, we ask what are the impacts of such modifications on emergency responses in general?

Judicial actors and their practices have increased their presence in emergency responses, and through the search for evidence and neutralization of perpetrators, the inquiry itself plays a leading role in all types of emergencies. For instance, our field observations of emergency exercises

revealed that representatives of the public prosecutor now take a preemptive seat on all these strategic committees to guarantee sufficient judiciary involvement in the event the emergency situation turns out to be malevolent.

This rising presence seems to worry emergency actors in all services who fear being singled out or even held accountable for potential mistakes. Rescue services are increasingly questioned about their interventions during crises and these new concerns now influence operations undertaken by the discipline by impairing open communication, professional intervention as well as the quality of debriefing and post-crisis learning. Ultimately, this could negatively affect the quality of emergency management.

These developments need to be coupled with the increasing control and questioning of experts in general. To give an example, in 2012, seven Italian seismologists were condemned to six years imprisonment and to pay 7.8 million euros damages to the plaintiffs for inadequate risk assessment during the 2009 earthquake in Aquila (Italy) (Nosengo, 2012).

Such developments are also feared by EM actors interviewed during our fieldwork:

> *Many people have already expressed their reluctance to take initiatives that stray from the plans out of fear of being pointed out and even sued for bad management. Many say that if this goes on, they will come to the EOC with their lawyer. (Interview with a member of the fire services in Liège, March 2019)*

More recently, following the response to the catastrophic flooding that hit Belgium in July 2021, the judicial prosecution services searched the buildings of the National Crisis Center, the Royal Meteorological Institute, and the Governor of the province of Liège on August 12, 2021 in order to determine potential responsibilities during the crisis response.

These examples illustrate how the EM security regime affects all types of emergency responses, even safety-related ones. They show how the EM safety regime that developed from the 1960s when it was primarily locally-driven based on multidisciplinarity, involvement of the population, open communication, and considered "collective intelligence" to be its overarching

value, is now being reshaped. Indeed, the recent emergence of an EM security regime has made the search for evidence the second overarching objective of EM. It also reduces communication, coordination, and trust between EM actors by calling for some form of closure. These changes are anything but marginal and may seriously undermine the "collective intelligence". This trend confirms the possibility of conflict between security and safety EM practices, however this issue is currently understudied by scholars.

In this context, we urge EM scholars and practitioners to examine and address these changes and the impacts the reconfiguration of actors and principles may have on emergency responses.

However, we are not arguing that the presence of judicial actors in EM is necessarily negative. They indeed have an important role to play in understanding how and why a crisis emerged and evolved. Therefore, far from calling for the eviction of judicial actors from EM, rather we plead for more reflection and consultation with other actors about their roles and their relations with the different disciplines and organizations involved in EM. Judicial power is currently involved in emergency responses but holds itself apart and rarely interacts with the other actors. We therefore call for research on how to further and better integrate judicial actors in the EM process as a whole, i.e., from prevention to lessons learned. To this end, we strongly recommend examining the changes that have been made and their impacts on emergency responses. New forms of communication and collaboration between EM actors but also with the population need to be invented to preserve mutual trust and collective intelligence. We argue that such changes can only be made by EM field actors in a bottom-up approach. Their expertise and adaptive capacity was obtained from their operational experience and they are hence the most knowledgeable about the threats such changes pose to their interventions in various contexts.

6. Conclusion

EM applies to all types of emergencies regardless of their origin and should be tackled using all-hazard models. This view is widely shared among academics and institutions (Department of Homeland Security, 2007; Rodriguez et al., 2007; Waugh, 2005). Focusing on the Belgian EM case study and using an instrumentation approach, we revealed how the rise of security concerns in Belgium in the context of recent terrorist attacks resulted in a new EM regulatory framework that departed from the all-hazard approach and undermined the Belgian EM safety regime developed since the 1960s. The introduction of an apparently anodyne regulatory tool in 2006 led to the reorganization of actors by giving a more important role to the police and judicial actors. Succeeding regulatory instruments enabled the judicial actors to play an increasingly dominant role in emergency responses. Consequently, these changes led to values, principles, and practices that diverged from existing ones and which together led to the emergence of an EM security regime. This new EM regime is driving the security-related emergency responses but is also increasingly influencing the safety-related ones.

Indeed, the judicialization of EM means that the search for evidence has become the second main objective of emergency responses and has undermined multidisciplinarity dynamics by reducing coordination, communication, and trust between EM actors. It has also reinforced a top-down approach. These transformations particularly question collective intelligence, which is the cornerstone of efficient emergency responses.

Based on our conclusions, we call for further empirical analysis on the rise of the EM security regime in other contexts. More generally, we call for reflection on the impacts of our societies on judicializing and securitization.

Finally, we argue that by coupling emergency management studies with the instrumentation approach, this inquiry provides scholars and practitioners with an insightful methodological and

theoretical reflection to finely analyze and address changes in EM in other temporal and geographic contexts. We are convinced that the Belgium case is not isolated and that such investigation would be useful in other countries.

Chapter 3: Two sides of the same coin? Exploring the relation between safety and security in high-risk organizations[32]

Colin Glesner, Robbe Geysmans, Catrinel Turcanu

Abstract: While safety in high-risk organizations has been high on the agenda for multiple decades, these organizations are now increasingly concerned about security threats. In this light, academics and institutions have set forth the vision of a synergistic integration of safety and security, warranted by their common goal to protect people and the environment. However, it is not always clear how this vision should be enacted on the work floor. While safety and security policies share some elements, recent studies point out that their practical enactments may diverge and lead to potential tensions.

Using an empirically grounded inquiry within a nuclear research center, this paper analyses how safety and security practices interact. Our analysis reveals that, while they contain similar management frameworks and practical means, safety and security interactions are also characterized by various tensions. Mobilizing paradox theory, we highlight how these tensions are (to a large extent) rooted in three underlying paradoxes: trust vs. distrust, transparency vs. confidentiality and movement enablement vs. movement restriction. We discuss the practical implications of these findings and, based on these, we argue that an integrated approach to safety and security should –rather than sideline tensions- promote the creation of "tension venues". Such tension venues offer spaces for reflection, and as such would enable the co-creation of innovative

[32] Glesner, C., Geysmans, R., Turcanu, C. (2021). Two sides of the same coin? Exploring the relation between safety and security in high-risk organizations. *Journal of Safety Research.* (Accepted for publication)

measures to articulate safety and security. **Keywords:** Safety, Security, Relations, Tensions, Paradoxes

1. Introduction

Safety has long been a major concern for high risk organizations. Its conceptual and practical developments evolved together with the rise of new and complex technologies, and the catastrophic events they sometimes induced (eg. the Bhopal gas disaster, or the nuclear accidents at Chernobyl and Fukushima). With the increase of potential security threats in the wake of 9/11, high risk organizations became increasingly aware of the need to address not only safety, but also security considerations, in order to protect their workers, the general public and the environment. This has led to important policy and organizational changes.

In the nuclear field, for instance, organizations are now required to demonstrate resilience against a wide variety of risks and threats, including potential malevolent, intentional attacks. As a result, measures are taken such as the installation of fences and security cameras or the introduction of information privacy policies. A number of important questions surface in this context of heightened security measures. For instance, do such organizational changes influence safety, and if so, in which way? Are safety and security measures complementary or contradictory? Are they evolving in disparate spaces and hence unconnected?

When discussing the interactions between safety and security, many scholars and policy makers emphasize their common protection objective, thereby focusing on similarities and synergies (Cambacédès & Chaudet, 2010; Dupont & Reniers, 2010; Flory, 2013; Gandhi & Kang, 2013; IAEA, 2004, 2010, 2016b, 2019; Johnston, 2004; Kim & Kang, 2012; Kriaa et al., 2015; WENRA, 2019). This vision portrays safety and security as two elements that mostly enhance each

other and are sometimes perceived as "two sides of a single coin" (Chen et al., 2019; Cusimano & Byers, 2010; Flory, 2013; Hashim & et. al., 2011; Reniers et al., 2011; Reniers & Dullaert, 2007). The common use of concepts and methods such as the graded approach[33], defense-in-depth[34], passive systems[35], (safety or security) cultures[36], or training and education programs and exercises are frequently mobilized to highlight the synergistic features of safety and security (Batra & Nelson, 2012a; Cambacédès & Chaudet, 2010; Cusimano & Byers, 2010; Gandhi & Kang, 2013; IAEA, 2010, 2016b, 2019; Kim & Kang, 2012; Kriaa et al., 2015; WENRA, 2019).

Integrating safety and security would, following this view, avoid potential tensions. Thereby it sidelines tensions by singularly focusing on commonalities and overlaps. The nuclear industry clearly exemplifies this vision. International guidelines in this field contend, for instance, that *'security measures and safety measures have to be designed and implemented in an integrated manner to develop synergy between these two areas.'* (WENRA, 2019, p. 7). In other words, the integration of safety and security should be grounded on the common elements of safety and security, as these are the foundations for creating synergies (Flory, 2013; IAEA, 2016b, 2019; Koenick, 2011; WENRA, 2019).

However, despite sharing an overarching protection goal, safety and security deal with different types of hazards. While the former aims at preventing the occurrence of non-malevolent adverse events, the latter deals with malevolent actions (Jore, 2019). According to literature, the demarcation point between safety and security lies in the intentional character of the hazard. While safety strategies are developed to prevent errors and the effects of catastrophes (e.g. floods or

[33] According to the IAEA '*the graded approach consists of analysing the risk with a view to defining measures that are appropriate and proportional.*' (IAEA, 2010, p. 11).

[34] Originally developed to cope with safety risks, it refers to '*layers of overlapping provisions […] that if a failure should occur it would be compensated for or corrected*' (IAEA, 1996, p. 1). It has, from 9/11, be increasingly thought as a concept applying both for safety and security (IAEA, 2010).

[35] A passive system is defined as '*a component whose functioning does not depend on an external input such as actuation, mechanical movement or supply of power.*' (IAEA, 2016a, p. 123). In that respect, according to IAEA, they both intend to '*avoid human errors may make it more difficult for potential aggressors to tamper with these systems*' (IAEA, 2010, p. 15).

[36] For definitions and reflection the concepts of safety and security cultures, see Glesner et al. (2020).

storms), security deals with actions deliberately intended to adapt and circumvent defenses in order to cause harm (Gandhi & Kang, 2013; Jore, 2019; Kim & Kang, 2012; Pettersen Gould & Bieder, 2020; Reniers et al., 2011). Unlike in the context of safety, in the context of security, humans are at the same time subjects to be protected from harm, and potential targets who might willingly avoid protective measures in order to cause harm. Like Brooks & Coole conclude:

'Safety and security have similar goals, to provide social wellness through the management of foreseeable risks. At the abstract level, there is little to distinguish these concepts; however, at the professional knowledge level, safety and security stem from distinct basis.' (2020, p. 63).

Moreover, several scholars have pointed out that safety and security also comprise discrepancies and tensions (Bieder & Pettersen Gould, 2020; Brooks & Coole, 2020; Glesner et al., 2020; Jore, 2019; Pettersen & Bjornskau, 2015; Schulman, 2020). These tensions emerge mainly through the practical enactment of safety and security in specific organizational contexts (Bieder & Kenneth Pettersen, 2020; Pettersen & Bjornskau, 2015; Schulman, 2020). However, as indicated by La Porte, there is a lack of empirical studies and "thick descriptions" clarifying to what degree or in which ways '*safety/security […] re-enforce each other; or conversely, impede each other sufficiently to prompt tension and conflict*' (2020, p. 76).

This paper intends to fill this gap by presenting empirically grounded insights into the relations between safety and security, which in turn inform theory by introducing the concept of tension venues. Interviews were conducted with actors managing or working on safety and security in a nuclear research center (NRC). We also retrieved data from participatory observations at a workshop and multiple meetings in which safety and security interactions were discussed with and among employees of this NRC. We use these data to explore how relations between safety and security are characterized by actors centrally involved in safety and security enactment in a specific high-risk organization. Through this exploration, a range of tensions between safety and security are identified and discussed. To make sense of their origins and provide with ways to deal with

them, we mobilize studies on paradoxes (Lewis, 2000; Miron-Spektor et al., 2018; Poole & Van de Ven, 1989; Poole & Van Den Ven, 2004; Schad et al., 2016). We apply the "dynamic equilibrium model" to the study of safety and security relations, which proposes cyclic and innovative ways to deal with tensions by reinforcing commitment to competing agendas (W. K. Smith & Lewis, 2011). Furthermore, we discuss ways to address ensuing challenges and advocate the creation of "tension venues" in high-risk organizations. These tension venues offer an opportunity to collectively identify the potentially productive character of tensions, and innovative ways of managing safety and security through articulating their respective requirements.

We begin by presenting the qualitative methodology underpinning our analysis. Subsequently, we analyze how the relations between safety and security are experienced by actors in the field. In the last section, we reflect on the ensuing challenges and propose ways to enhance safety and security management by promoting and discussing the creation of tension venues.

2. Methodology

2.1. Exploring safety and security in a nuclear research center

Data used for this study were gathered in the frame of a broader ethnographic study taking place in a nuclear research center (NRC) in Belgium, from October 2018 until June 2019. The mission of the studied NRC is to develop safe and peaceful innovative applications of nuclear

technologies. The organization, due to the presence of infrastructures such as nuclear reactors and its use of hazardous nuclear and non-nuclear materials, faces a wide variety of safety-related risks. Moreover, in the aftermath of 9/11, and particularly the more recent 2016 Brussels terrorist attacks (Boustras, 2020), security related measures have been requested by authorities. To face these hazards the NRC has over time increased both its safety and security regime, although the latter only more recently.

In practice, safety and security in the NRC are expected to be enacted by all employees through their daily activities and more specifically managed and controlled internally through an organizational service specifically in charge of safety and security management (SSMU). This service is divided into different units, of which one is focused on security, while the others are dealing with different aspects of safety (e.g. nuclear safety, industrial safety) or the integrated management.

Furthermore, safety and security in the NRC is audited and controlled by the National Nuclear Regulator (NNR), whose mission comprises the control of safety and security at nuclear facilities, and participation in the operational licensing of these facilities. As an external actor, the NNR hence has an in-depth understanding of, and involvement in, the management and enactment of safety and security at the NRC. For this reason, part of our data gathering and analysis also focused on the role played by the NNR.

2.2. Data collection

For the purpose of this analysis, data addressing the relation between safety and security in the NRC's everyday operations were selected from a broader ethnography conducted in the studied

NRC. Empirical data were collected through semi-structured interviews with actors managing safety and security in the SSMU units, as well as with other employees involved with safety and/or security aspects in the framework of their job. These data are complemented with participatory and non-participatory observations at a workshop, multiple meetings with employees and between safety and/or security managers, as well as training courses on safety and security given to employees. Data were collected until a point of data saturation was reached. Saturation was ensured through coupling the use of multiple methods (triangulation) with a saturation grid method and feedback from field actors (Brod et al., 2009; P. Fusch et al., 2018; P. I. Fusch & Ness, 2015).

2.2.1. Interviews

We conducted interviews with members of the 5 units of the SSMU. In total, 10 interviews were conducted with at least one member of each unit, depending on the size of the unit. We interviewed one respondent with a management position at the SSMU, and conducted 2 interviews with respondents working in the nuclear safety unit, 3 interviews with members of the security and guarding unit, 2 interviews with members of the industrial safety unit, 2 interviews with respondents working at the integrated management unit, and one interview with a member of the nuclear installation safety unit.

Additional interviews were conducted with one on-site firefighter volunteer, one staff member involved in non-proliferation research and training, one staff member working on safety and security research, one staff member involved in emergency planning and exercises, and one project manager of a new building construction in which radioactive materials were to be used. Finally, three interviews were also conducted with employees of the national nuclear regulator, with

a member of the safety department, a member of the security and transportation department, and a member of the general management.

The duration of interviews varied between 50 minutes and 1h45min. They were conducted in English, Dutch or French, according to the preference of the interviewee.

The interviews were conducted in a semi-structured fashion, meaning that they followed a thoroughly elaborated (and validated) question guide (see Table 9), while the order and formulation of questions varied depending on the flow of each individual conversation. The interview guide was developed following an initial literature review on the concepts of safety and security and refined through participatory observations, discussions with safety and security managers and exploratory interviews. Overall, the guide covered four common central questions that were elaborated into multiple sub-questions depending on the interviewee's function or responsibility. Moreover, two specific questions were discussed with members of the NRC and NNR.

Table 9: Questions guide
Based on your function, how would you characterize safety and security?
According to you, how are safety and security in the NRC managed?
In the frame of your work, to what extent and in which ways do you interact or collaborate with the other departments/units (NRC/NNR)?

According to you, how are safety and security relations characterized in the NRC?
In your daily work, how do you experience safety and security performance in your organization (only for employees of the NRC)
From an external point of view, how would you characterize safety and security relations in the NRC (only for the employees of NNR)?

2.2.2. Workshop

Besides interviews, data were also collected from a workshop in which safety and security relations were discussed with NRC employees. These data provide additional insights into how employees perceive safety and security and their interaction and how are they articulate in the NRC.

The workshop, which was conducted in English and lasted about 1 hour, took place in April 2019. Moderated by the first author, it gathered eight employees of the NRC, who were asked to reflect on the relation between safety and security in their everyday working experiences. The participants were divided into two groups which were asked to play the role of safety or security managers. The first part consisted in thinking about the multiple practical safety-security relations, selecting the most relevant and discussing the implications from their respective perspectives. The workshop had therefore a double objective: broadening employees' perspectives on safety and security relations, while also retrieving useful data four our inquiry.

2.2.3. Internal meetings and courses

Finally, we engaged in multiple participatory and non-participatory observations (Jorgensen, 2015; Kawulich, 2005) at meetings and training courses. The first author participated in three training courses (From December 2018 until March 2019) on security at the NRC. These training courses are organized by a member of the security sub-unit and are intended for employees of the NRC. During participatory observations, specific attention was directed to how security measures were presented, as well as how employees and the trainers discussed security and its impacts on safety.

Furthermore, observations took place at several meetings. Two meetings (in November 2018 and in April 2019) were attended during which representatives from all SSMU sub-units were gathered. The meetings focused on safety and security events that occurred in the course of the previous months, with a particular focus on their consequences and impacts. These meetings represented the only systematic meetings assembling different members of each unit during the duration of the study. Another meeting was attended during which the head of the internal fire brigade and a member of the security unit discussed the labelling of doors of the site (e.g. access control doors, anti-fire doors, anti-radioactivity doors, evacuation doors). Finally, observations took place at a meeting during which the new access control of a nuclear installation within the NRC was presented (January 2019). The meeting assembled 15 employees of the concerned installation who in a first part were asked to think about how malevolent persons could perpetrate a terrorist attack in their building and how to prevent it, and in a second part received a presentation on the access control system followed by a Q&A session.

Informed consent was obtained by all respondents and participants (written, orally and recorded for the interviews and orally for the workshop and the participatory observations).

Table 10 summarizes all data underlying the results reported in the present study.

Table 10: Primary data selected for this inquiry

Organizational context			No.
National nuclear regulator (NNR)	General Management		- 1
	Security department		- 1
	Safety department		- 1
Nuclear research		Management	- 1

center (NRC)	SSMU	- Nuclear safety unit - Industrial safety unit - Integrated management - Nuclear installation unit - Security and guarding unit	- 2 - 2 - 2 - 1 - 3
	Employees working on safety and security	- Employee firefighter volunteer - Researchers working of safety and security issues - Employee working on emergency planning - Project manager of a building construction in which radioactive materials were to be used.	- 1 - 3 - 1 - 1
	Workshop on safety and security relation	- Employees from one department of the NRC	- 8

Participatory observation of three training courses on security	- Employees from the NRC	- 6-12 participants per course
Non participatory observation of two meetings on incident reporting systems	- Members of each unit of the SSMU	- 7-8 participants per meetings
Non participatory observation of safety and security concertation meeting	- member of the security unit and - head of the internal firefighter service	- 1 - 1
Meeting on the presentation of the new access control of one nuclear installation within the NRC	- members of the security unit - employees of the concerned nuclear installation	- 2 - 15

2.3 Procedure and analysis

2.3.1 Conceptual underpinnings

Data were analyzed with the objective of obtaining deeper insights on how safety and security procedures, technologies and cultures are managed and relate to each other in practice (Braun & Clarke, 2006, 2019; Flick, 2014; Sullivan & Forrester, 2018). Inspired by the descriptions of organizational dynamics and agendas in literature on paradoxes (e.g. Schad et al., 2016; W. K. Smith & Lewis, 2011), we depicted three sensitizing concepts (Bowen, 2006) that drove our data analysis: "*relations*", "*synergies*" and "*tensions*". *Relation* is here defined as the aspects that connect two or more things or elements as well as the influences these things or elements have on each other. In our understanding, relations imply both the overlaps and interactions between elements -such as units but also between humans and technologies-, or lack thereof. For instance, setting up meetings between different units of the NRC can be understood as a relation; but, the absence of meetings, if this impacts the functioning of one or both units, can also be seen as a relation. We understand *synergies* along the lines set by the International Atomic Energy Agency (IAEA) when discussing nuclear safety and security: '*[Synergies are] elements or actions in one area enhanc[ing] also the other area.*' (Koenick, 2011, p. 7). Synergies are thus instances in which safety measures and security measures improve each other. Following Stohl and Cheney, we define *tensions* in this context as '*the clash of ideas or principles or actions*' related to safety or security and '*the discomfort that may arise as a result*' (2001, pp. 353–354). Tensions may occur around specific situations, objectives, practical measures, organizational factors or policies, technologies or processes mobilized to enact safety and/or security.

As mentioned in section 1, some of the tensions may be rooted in divergent principles underlying safety and security governance. Paradox theory (Lewis, 2000; W. K. Smith & Lewis, 2011) was chosen as the theoretical framework for analyzing tensions, as this offers conceptual tools as well as practical steps to identify, accept their generative potential, and find innovative solutions to deal with inherent tensions in organizations. Leaning on Smith and Lewis' views, we understand paradoxes as '*contradictory yet interrelated elements that exist simultaneously and persist over time; such elements seem logical when considered in isolation, but irrational, inconsistent […] when juxtaposed'* (W. K. Smith & Lewis, 2011, p. 387). Far from portraying paradoxes as negative, paradox theory contends that they can also be foundational and constitutive for the organization (Seo et al., 2004; W. K. Smith & Lewis, 2011). From this perspective, if properly characterized, analyzed and engaged with, tensions can be positive and productive, and might be used as '*drivers of cognitive organisational reorientation (Fiss & Zajac, 2006), organisational creativity (Woodman et al., 1993) and organisational learning* (Huzzard & Ostergren, 2002).' (Hahn, 2011, pp. 19–20).

In the framework of this theory, the dynamic equilibrium model was proposed to answer the call already formulated by Lewis in 2000, who contended that

> *'comprehending paradox requires more than defining its characteristics; it requires a guiding framework: a tool to help researchers explore paradoxical tensions, reinforcing cycles, and their management.' (p. 761).*

This model is developed to analyze tensions and their underlying roots. It '*suggests that tensions are inherent and persistent and depicts how purposeful and cyclical responses to paradox over time enable sustainability*' (W. K. Smith & Lewis, 2011, p. 382). According to this model, paradoxes can only be grasped through the analysis of tensions that arise in specific situations. By creating means to deal with persisting and emerging forces, the model aims at creating virtuous cycles intended to foster organizational sustainability. To achieve this, it firstly brings conceptual clarity with the tensions that are experienced. It strives to order the messy tense relations by defining how they are characterized. In a nutshell, it intends to render latent paradoxical tensions salient. Secondly, it

proposes means for actors to embrace these tensions via strategies of "working through" them and thereby build management strategies of paradoxes' acceptance. This entails viewing tensions as opportunities. As Smith and Berg noted,

> *'by immersing oneself in the opposing forces, it becomes possible to discover the link between them, the framework that gives meaning to the apparent contradictions in the experience.' (1987, p. 215).*

Thirdly, acceptance provides with means to undertake resolution strategies. Resolution undertakes the search for paradoxical tensions responses through purposeful iterations of various alternatives. Several means can be mobilized to resolve tensions. Poole and Van de Ven proposed four resolutions strategies, namely, accepting the paradox, situating the opposed agendas in different spatial locations or different temporal locations or eliminating the opposition by finding new ways to synthetize them (1989). Beech and colleagues further the first option by proposing an alternative to overcome the paradox consisting in valorizing and maintaining the opposition (2004).

2.3.2 Thematic analysis

Using the NVivo 12 software, a reflexive thematic analysis was conducted to organize and describe our dataset (Braun & Clarke, 2006, 2019). Specifically, we undertook a 3-step coding process as developed in classical thematic analysis (Flick, 2014). An initial coding was first carried out to systematically label and produce codes for each semantic unit of our data. These codes remain close to content and meaning of the specific coded data excerpt. In a second step, a focused coding highlighted the most significant codes. Finally, we undertook theoretical coding in order to develop an integrated conceptual and theoretical framework (Thornberg & Charmaz, 2014). This coding allowed to develop a final template comprising themes and subthemes pertaining to safety and security interactions. Themes, in that respect, were reflexively and actively developed at the

intersections of our "*theoretical assumptions, [our] analytic resources and skill, and the data themselves"* (Braun & Clarke, 2019, p. 6) (see table 11).

Table 11: Final template

Themes		Subthemes	Final codes
	Synergies	Overarching objectives	- Same goal - Security part of safety
		Theoretical synergies	- Risk management cycle - CBRN approaches - Safety and security cultures
		Practical synergies	- Emergency management - Exercises - Emergency response plans - Defense-in-depth - Graded approach

Tensions rooted in organizational and interpersonal relations	Physical separation	- Different buildings - Protected areas - Access controlled area
	Lack of collaborations	- Security technologies installation - Building of a radioactive facilities - No systematic units meetings - Inspections - Units maturity
	Lack of communication	- Yearly service meeting - No encountering - Few informal interactions
	Interpersonal tensions	- Interpersonal clashes - Rise of security unit - Inflexibility - Maximalist thinking

Safety and security Relations	Tensions rooted in safety and security paradoxes	Movement facilitation vs. movement restriction	- Lockdown procedures - Evacuation system - Control - Barriers - Guarding - Evacuation gates - Badging system - New main entrance - Design basis threat
		Transparency vs. confidentiality	- Need-to-know principle - Hazmats labelling platform - Mindset - Culture - Silos-thinking - Secrecy - Security incident reports

		- Trustworthiness - Cybersecurity
	Trust vs. distrust	- Limitation of safety openness - Insider threat - Four eyes principle - Installations maps - Confidence - Sweeper employees - Responsibility for others safety - Top-down security measures - Employees non engagement in security management

	Tension venues	Safety and security units cooperation	- Incident reporting system meeting - Safety and security emergency exercises - Concertation meetings - Employees trainings - Access control system presentation
		Technologies and artifacts	- Incident reporting system platform - Emergency response plans

This inquiry followed an abductive approach. This entailed analyzing the data while collecting it, thereby allowing us to reorient and strengthen our research. Following such an approach allowed us to feed back and forth into the data analysis, data gathering and literature review (Reichertz, 2014). Such an approach allowed us to mobilize the paradox literature and assess safety and security relations along this lens. Eventually, results were obtained that synthesize and bring novel insights to the characterization and classification of safety and security relations.

The scope of this research implied dealing, at times, with sensitive information. During the writing process we therefore always remained watchful to not disclose potentially sensitive

information. To ensure this, as well as to abide to the ethical requirements, we submitted the last version of our manuscript to the key stakeholders for comments. Related to this issue, the nature of the inquiry prevented us from accessing some of the data. Some of the specific inner workings of safety or security enactments in the NRC were therefore not accessible to us.

3. Practicing safety and security in the nuclear field

3.1. Safety and security synergies

When expressing their views on safety, security and their interactions, respondents with management positions typically drew on a narrative of synergistic interactions. Indeed, we found that actors widely acknowledged the common overarching aspirations of safety and security:

> *'Safety and security share the same goal […] Here [...], we promote a culture for safety which also encompasses aspects such as security, environment, quality or health.' (Interview with a member of the management at SSMU)*

> *'We promote an integrated approach of safety and security. They have to be thought together. All these things should be tackled coherently and consistently both by the operators and by us. [...] On paper we can see that they have many elements in common.' (Interview with a member of the management of the NNR).*

Next to similarities with regard to their main objective, some respondents also highlighted some common elements in the practical approaches taken to reinforce safety and security. For

instance, some mentioned how the "graded approach" to risk management or the "defense-in-depth" strategy, which were both developed in the field of safety, were increasingly also used in the field of security. Furthermore, a common reliance on the development of emergency planning was pointed out, as respondents highlighted how it promotes similar concerns and principles for safety and security.

> *'The general structure of emergency planning and plans is common. Emergency plans aim to structure the response to a crisis whatever it is […]. Whether it is a terrorist attack or an accident, the general response process remains the same.' (Interview with a member of the safety department of the NNR)*

According to our respondents, these commonalities allow the fields of safety and security to learn from each other, develop common frameworks, emulate and induce synergistic relations.

3.2. Safety and security tensions

Aside of the aforementioned synergies, our analysis revealed, convergent with Schulman (2020), a discrepancy between safety and security relations in theory and in practice. Many respondents perceived the actual implementation of an integrated approach to safety and security as challenging or even unrealistic, due to the different tensions between safety and security that they experienced in practice. The link between a theoretical "synergistic integration", on the one hand, and the relations between safety and security in practice, on the other hand, thus prove far from straightforward:

> *'the [vision] we had on the safety security interface is a good way forward. But this is the conceptual [aspect], in practice, this is problematic […]' (Interview with a member of the management of the NNR).*

Based on their everyday experiences at the NRC, respondents discussed a variety of tensions regarding the relation between safety and security. While we do not intend to provide an exhaustive list of tensions, we will present and discuss those that have been identified by our respondents as most relevant in characterizing safety and security relations.

In their everyday working experience, respondents have encountered tensions between safety and security both through their collaboration (or non-collaboration) with other actors at the NRC, but also through their engagement with technologies and procedures mobilized to manage safety or security. As an example of the latter, lockdown security procedures were designed to respond to potential malevolent on-site event by preventing access into or out of the facility. These procedures, however, counter the safety objective of allowing fast evacuation in case of on-site accidents. At the same time, it was noted how specific procedures for emergency rescue services set up to facilitate the access of fire, medical or other first responders to the site, clearly diverge from the principle of "restricting access" enacted by access control systems.

In this light, several respondents also raised the issue that the necessity to get clearance for being allowed to access the site and to pass around fences and through gates significantly slows down potential interventions and reparations from external subcontractors on the site.

> *'I need someone from an unknown company and I need him because he is a specialist to repair something very urgent. I can put five guards around this person and he can do his job and everything will be fine, but because this person is unknown for the security unit, they will not allow him access to the site.' (Interview with a member of the nuclear safety unit at SSMU).*

Such potential tensions have been signaled also by other studies in nuclear and non-nuclear industries (Batra & Nelson, 2012; Hahn, 2011; IAEA, 2019; Kim & Kang, 2012; WENRA, 2019). In such situations, the question is then to what extent these tensions are recognized and negotiated, and which objective takes priority, and under what circumstances. In other words: what should be prioritized and when; and what to do in case of potential mutual hindrances?

Another example of tension regularly mentioned, related to the diffusion of information about hazardous materials or substances. While safety is seen as promoting a transparent diffusion of information to improve collective learning on risks, security restricts information access on a "need-to-know" basis (see also Batra & Nelson, 2012; Bieder & Kenneth Pettersen, 2020; IAEA, 2019; WENRA, 2019). During a training course on security, a participant hence remarked how:

> *'not being able to share documents is sometimes problematic. For example, we have information about how to properly handle specific materials or substances that could be useful for other colleagues but we cannot send them the documents.'*

Furthermore, several respondents highlighted tensions that originated in the different amounts of trust that safety and security measures put in persons. A recurring topic in this instance was the "four eyes principle". This principle is defined as an '*internal control mechanism that requires that any activity by an individual within the organization that involves material risk must be controlled, double checked by a second individual that is independent and competent*' (Open Risk Manual, 2020). The use of this principle as a security measure is designed to avoid sabotage by making peers control each other. However, this assumption impacts on trust relations between colleagues, which are recognized as important in ensuring safety.

> *'Well, [the four-eyes principle] creates a lot of mistrust. So on paper, it looks very good that people can have an eye on each other but in practice, I do not know…' (Interview with an employee of the NRC dealing with safety and security)*

Globally speaking, these tensions are perceived as negative by respondents. They generate mistrust, they hamper or slow down the enactment of safety or security. Moreover, by causing confusions and inertia , tensions reduce the safety and security units interactions, hence creating a sort of vicious cycle.

> *[Security unit] installed X-ray detectors in different places. But because these are ionizing sources, they need to be authorized by us. However, last week, I found out that they changed a machine without warning us and therefore without any authorization. When we ask them,*

who did this, they answer they do not know[…] Because of such things, our relations are not easy. (Interview with a member of the nuclear safety unit at SSMU)

Overall, such an excerpt demonstrates how tensions undermine respondent's missions, increasing the gap between employees respectively dealing with safety and security, and hence potentially hampering the management of safety and security. In the next section we look more in detail at some of the origins of the aforementioned tensions.

3.3. Roots of safety and security tensions

Overall, a distinction can be made between two main origins or "roots" for the identified tensions: organizational factors such as management structures and organizational cultures, and paradoxes underlying safety and security relations.

3.3.1. How organizational factors contribute to safety/security tensions

Data revealed that some tensions may derive from organizational factors, specifically, how an organization structures safety and security responsibilities, tasks and management. In the NRC we studied, safety and security were managed by structurally and physically separated units, a situation we also encountered at the NNR. Moreover, systematic collaboration between these distinct units was perceived as lacking, making it *'difficult to comprehend the other's job and requirements'*

(interview with a member of the integrated management unit at SSMU) and obscuring discrepancies. For instance, in the frame of a new building construction:

> *'Safety units and security units respectively send their recommendations to [the project manager] on, for instance, where security or evacuation doors should be installed but they do not meet to discuss potential overlaps.' (interview with a project manager of a building construction).*

At the time of the fieldwork, this situation has been identified as a source for tension by several respondents. They pointed out that a lack of collaboration at the beginning of a project hinders the timely identification of potential problems with regards to the interactions between safety and security.

In that respect, many field actors portrayed the security unit as less inclined to discuss and negotiate and therefore stated they had difficulties to collaborate. According to respondents, this may be partly explained by the fact that, at that time, the security unit had not reached the same level of organizational maturity as the safety units.

> *'The problems of collaboration are also a problem of maturity. For safety, it dates from the 1960's and they are very well advanced. But for security, it is from 2011. People still need to be recruited.' (Interview with a member of the management of the NNR).*

Coupled to this, the actors populating safety and security units overall had divergent professional backgrounds. '*In the safety units employees have rather a scientific and engineering background […]. In the security unit, we have hired actors with another type of background'.* (Interview with a member of security unit at the SSMU).

The difference of requirements, the units' difference of history but also the differences of professional and educational cultures may explain that '*the relations between some actors have already been strained.*' (Interview with a member of nuclear safety unit).

3.3.2. Tensions rooted in safety and security paradoxes

More significant in the light of this paper are those tensions which are rooted in what we call safety-security paradoxes. As mentioned in the introduction, and following Lewis, we can summarize paradoxes as contradictory yet interrelated elements (2000). Schad and colleagues contend that, "*while seemingly distinct and oppositional, these elements actually inform and define one another, tied in a web of eternal mutuality*" (2016, p. 6). Overall, a paradox is here understood as antagonistic underlying logics behind some practical instances of safety-security tensions.

We identified three paradoxes: transparency versus confidentiality; trust versus distrust; movement enablement versus movement restriction. Each of these will be discussed in more detail below.

A first paradox, namely transparency versus confidentiality can be identified as underlying some of the tensions experienced by our respondents. This can be traced back to the antagonistic aspirations of actively restricting and containing versus actively sharing knowledge, information or data. While security mostly relies on confidentiality, safety largely emphasizes transparency. The former thus seeks to prevent knowledge, information or data from falling into wrong and malevolent hands, and therefore restricts access to information by applying, among others, the "need-to-know" principle. The latter leans on transparency and fosters the sharing of information and the greatest awareness to engage in continuous learning and to prevent adverse safety events from occurring.

> *'[Security] does not communicate unless necessary. From the safety point of view, you communicate unless not necessary. It's a different kind of approach.' (Interview with a member of the nuclear safety unit at SSMU)*

Secondly, some of the experienced tensions relate to the paradox between trust and distrust. Security mostly implies a certain form of control or distrust towards and among actors of the organization in order to prevent the occurrence or mitigate the effects of an adverse event. Opposite to this, safety essentially relies on trust.

> *'You want to work in confidence and never hide things but it is not always wise to display information. This we have learned in the last decade in Europe.' (Interview with member of the security department of the NNR)*

This paradox has also to do with whom are the ones to protect and whom are the ones to be protected from. For safety, employees are actors to be protected from hazards. They are the prime actors to be preserved and therefore need to act in a trustful environment in which they can rely on each other. Safety can be increased only if all participate and support each other. Also when it comes to security, employees are actors to be protected against threats. However, employees may at the same time be the very actors who threaten their colleagues and the environment. They may be both the source of the threat and the ones to be looked after. Insider threat has indeed since several years been raised as a major concern in high-risk organizations (Frost, 2004).

As seen in section 3.2, mutual control between employees with a view on potential insider threats may hamper the communication and information sharing promoted by safety. Opposite to this, lack of vigilance may also increase an organization's vulnerability to potential malevolent insiders.

A final paradox which emerged from our data concerns the inconsistency of enabling versus restricting movement. This paradox is different than the others as, it does not apply to all safety and security relations. Indeed, we can think of instances in which security measures intend to facilitate movements (e.g. by promoting swift transportation of hazardous materials) or conversely of instances in which safety measures intend to restrict movements (e.g. radioactivity through reactors' physical protection systems). In this respect, safety and security might even be

seen as synergistic regarding the restriction of access to highly protected areas within a nuclear facility (Gandhi & Kang, 2013). Yet, despite these potential similitudes, safety and security measures were overwhelmingly accounted by respondents as opposing around the movement restriction or enablement. Indeed, safety measures were primarily perceived as intended to foster and enable movement. This is, for example, the case when potential victims of a safety incident need to be evacuated, or when emergency services and first responders need to rapidly take action in controlling the potential consequences of such incidents. The existence and regular testing of evacuation procedures is an obvious example of such movement enablement. In contrast, security were overwhelmingly reported as aiming at avoiding the access of malevolent persons or, in case of intrusion, to contain them in a specific area/building of an organization, thus restricting movement. Lockdown procedures and access control systems both illustrate this.

> *'When safety wants people to go out, security wants to freeze the situation.' (Interview with an employee of the NRC working on risk management)*

More generally, security is associated to an ensemble of measures restricting and inhibiting movements and behaviors while safety was more related to measures that empower and facilitate. The resulting tensions are rooted in fundamentally opposed courses of action determined by decisions such as: should the movement be restricted or facilitated? And if so, when? These tensions may be experienced by actors in the NRC in charge of evacuation management and actors in charge of access control, as well as by employees on the field. As shown also by the example discussed above, when an urgent repair was needed, movement enablement and restrictions necessarily overlap and create clashes on specific cases and places.

Reflecting on respondents' experiences with tensions in safety/security relations, we highlighted in this section that many of these tensions can be traced back to paradoxes between safety and security. In the remainder of the paper, we reflect on how paradoxes can be handled, highlighting that in an organizational context, they can also be generative.

4. Embracing paradoxes

As illustrated in our analysis, safety-security relations are experienced in practice in various ways. The common features they share help transfer skills and competence from one field to another and offer opportunities to exercise and improve both. Our analysis also revealed a range of tensions, which become evident only when looking closely at safety and security in the field. We explored their roots, and contended that some of these tensions may be linked to organizational factors. Such tensions have been addressed in organizational literature (K. Smith et al., 2017; Mumby, 2005; Shapin & Barnes, 1977). However, our inquiry also highlighted tensions rooted in three paradoxes that articulate safety and security relations. This questions the commonly encountered policy vision silencing safety and security tensions or stipulating that they can be avoided or overcome due to their commonalities.

While taking into account both safety and security is a laudable protection effort, the tensionless synergistic vision mostly associated to it (Gandhi & Kang, 2013; Leveson, 2020; Shokr, 2019; WENRA, 2019), might very well hamper their integration. Indeed, we contend that safety and security tensions cannot be overcome through greater managerial and organizational integration because many tensions are rooted in safety and security paradoxes.

In order to productively deal with safety and security relations in the field, we mobilize paradox theory with the aim of thoroughly unveiling and embracing paradoxes. This approach helps us theorize and account for the relationship between safety and security as rooted in paradoxical relations from the perspective of their generative potential. In particular, the "dynamic equilibrium model", developed Smith and Lewis (2011), proposes practical ways to unveil and deal with paradoxes. According to this model, paradoxes influencing the relations between safety and security, if taken seriously into account in dedicated spaces, can be positive and productive, and

might be used for organizational learning and innovation. Such dedicated spaces would allow all organizational actors (management, employees, safety and security managers…) to make tensions salient, understand their roots, and work through towards creative solutions. Drawing on this, we propose the creation of what we call tension venues to explore tensions and thereby tap the potential power of paradoxes (Lewis, 2000). In our view, such tension venues comprise several characteristics. In practice, they could be physical or virtual spaces within organizations, and can take the form of regular meetings, briefings or debriefings, virtual platforms, amongst others. They should provide the framework and analytical tools needed to uncover and manage tensions and could be either specifically set up by the organization's management or emerge from field practices. Through these tools, they invite field actors to take up the issues they faced and mobilize tools in order to continuously manage tensions which are at least cyclic or iterative.

Tension venues should have as objective to render latent tensions salient and unveil and describe the issues at stake out of the organizational messiness. Such venues are intended to put the multiplicity of perspectives and tensions at the fore, reflect upon them, analyze their temporal and spatial context with the purpose of unveiling and dealing with the paradoxical roots upon which they arise. Tension venues valorize actors' multiplicity of meanings: while inviting actors to open up to other's perspective, they permit actors to keep their own core values and principles. In that respect, tensions venues enable actors to be "in" without corrupting their own visions. They then are intended to characterize tensions and highlight the potential paradoxes at their roots. They help managers to dive into the roots of tensions and distinguish the tensions upon which they can act through organizational changes and the paradoxical tensions that are inherent separations. Based on that, these spaces enable to develop an acceptance, curiosity and empathy for the existence of underlying divergences and paradoxes. Finally, such venues enable resolution mechanisms through which responses to paradoxical tensions can be looked for. Indeed, such

venues permit actors to raise tensions and analyze the paradoxes upon which they lean, share their stances and perspective and find ways to overcome them.

In the course of an interview touching upon safety and security inspections in the NRC, we were told how such inspections where conducted in hospitals in which radiological materials were used:

> *'in some hospitals, safety and security inspections are concomitantly conducted. I have personally heard about a case in which the safety inspector wanted to put a safety signage warning about the presence of radiological materials but the security inspector did not want it there because it could give precious information to malevolent persons. They discussed and together found another place, less visible to the public, to put the warning signage. Institutionalizing such common safety and security inspections would also represent a great added value for [the NRC].' (Interview with a member of the safety department of the NNR).*

In this case, the common inspection can be observed as a tension venues in which actors accepted the opposed requirement and resolved it by spatially moving the radioactive signage to lessen the negative consequences upon security.

However, like Beech and colleagues argue, such an approach does not imply dichotomies to be transcended, merged, overcome or avoided (2004). We indeed contend that tensions, if embraced through tension venues, might be approached as mutually beneficial. Tension venues open up insights about how tensions develop and enable to find ways to live with differences and articulate them. Like Seo and colleagues contend, "*we should be skeptical of interventions that oversimplify the change process, ignore possible tensions, or take extreme responses to handling the tensions among them*." (2004, p. 101).

In the NRC, such spaces could take the form of inter-humans venues such as meetings. For instance, the "incident reporting system meetings" that take place, in the NRC, on a weekly basis and that gather employees from safety and security units who discuss safety and security-

related incidents and how to solve them. This recurring meeting could be a place in which safety-security tensions are discussed, their paradoxical roots are embraced accepted and managed. Next to it, other elements might also be used as tensions venues. This is the case for briefings or debriefings of emergency exercises that take place multiple times a year in the NRC. During them, safety and security requirements are unveiled and discussed by the exercises' participants and observers and in which specific tensions that arose in the course of the exercise can be pinpointed and their roots analyzed. At the NRC, training courses are given to employees in which the organization's measures to enact safety or security are presented. Employees and trainers could take this opportunity to detail specific tensions, express their opinions about them and the ways to deal with them and discuss with the others about them. Finally, for each new project or facility construction, the NRC holds a presentation during which the project leader explains the purposes and excepted outcomes. Such events are dedicated venues for employees to raise concerns about potential and already existing tensions between safety and security and discuss with the project leader.

Although none of these venues are oriented and dedicated to the analysis of tensions, we contend, that they could be reframed to apply the different steps of the dynamic equilibrium model and thereby become tension venues. Developing tensions venues within organizations, dedicating spaces for reflection on potential tensions and their underlying paradoxes offers an opportunity to enhance the adaptive capacity of organizations in high-risk contexts, hence contributing to an organization's survival by stimulating organizational creativity and learning (Bijker et al., 2014).

5. Limitations

Among the elements discussed in this article, several questions remain unanswered and could be the subject of future research. In particular, this article leans on a single case study within a NRC to characterize the tensions between safety and security, which were traced -at least partly- to three underlying paradoxes. It would therefore be interesting to follow safety and security relationships in other organizations in order to analyze whether additional sources of tensions, paradoxical or otherwise, might emerge. Such research would give more empirical depth and sharpen the reflections on the paradoxes between safety and security.

Furthermore, we have proposed, but not validated empirically, the setting up of tension venues. Future research could focus on characterizing these tension venues and assessing how organizations could implement them in practice. Reflections on how tension venues should be structured; whether a specific person should be assigned the role of mediator; or which actors should and should not be involved require further data and were thus beyond the scope of this paper. In so doing, this article paves the way to future empirical research and theoretical reflections in order to implement safety and security tension venues in organizational domains and beyond.

6. Conclusion

Overall, this empirical inquiry extends and deepens existing understandings of how safety and security relate. It reveals that while they share a common goal of protecting people and the environment and similar management frameworks (*e.g.* defense-in-depth) and practical means (*e.g.* emergency exercises), safety and security relations are also characterized by various tensions, mostly in their practical implementation. We identified two intertwined types of tensions: those rooted in organizational and interpersonal relations and those rooted in paradoxes. Based on this and mobilizing the paradox theory, we argued that a coherent approach to safety and security should not sideline tensions but place them in the center of attention. While tensions are often perceived as weakening the organization, they have a generative potential, enhancing the organization's adaptive capacity. Leaning on the "dynamic equilibrium model", we promote approaches that recognize the existence of tensions and their underlying paradoxes through creating "tension venues", *i.e.* spaces dedicated to put tensions at the fore and reflect on their roots thereby enabling the development of innovative measures to articulate them.

Even though this analysis was situated in a specific context, it is relevant to any organizational context concerned with both safety and security, thus not only in the nuclear field but also in other organizations in hazardous industries. Through this inquiry and discussion, we do hope to spur new studies in various contexts with the aim to enrich the examination of the relations between safety and security as well as to inspire novel ways to address their inherent tensions.

Chapter 4: Studying the role of objects in safety and security enactment: opening the gate to the non-human[37]

Colin Glesner

Abstract: Since the 9/11 terrorist attacks, safety and security in high-risk organizations have increasingly been considered together. However, how they are inter-related through their material enactments is rarely studied. Mobilizing an Actor-Network Theory approach, this article uses an entrance gate as an entry point to analyze how the flux of humans and non-humans is managed in a nuclear research center. It specifically shows how gates participate in enacting antagonistic access control and evacuation programs of action, and argues that failing to account for non-humans when managing safety and security relations in an organizational context may miss potential tensions. In turn, this may result in sub-optimal protection of organizations against hazards. Novel insights are provided into a practical, holistic management of the interoperability of safety and security.

Keywords: safety; security; Actor-Network Theory; access control; site evacuation; non-humans

[37] Glesner, C., (2021). Studying the role of objects in safety and security enactment: opening the gate to the non-human. *Journal of Safety Science.* (Under review)

1. Introduction

Over time, high-risk organizations have developed a wide array of technologies, artifacts, procedures and practices to prevent or mitigate the variety of hazards they face. In the institutional and academic literatures, this range of elements has been categorized as preventing (and/or mitigating) either non-intentional risks, or intentional malevolent threats. Non-intentional risks have been assigned to the safety category, and intentional malevolent threats to that of security. In the organizational literature, the spotlight was already increasingly on safety starting in the 1970s, whereas security only emerged in the aftermath of the 9/11 attacks (Bieder & Pettersen Gould, 2020). Since then, both concepts have increasingly been considered together (Aven, 2007b; Batra & Nelson, 2012b; Cusimano & Byers, 2010; Gandhi & Kang, 2013; IAEA, 2010, 2016a, 2019; Jore, 2019; Kim & Kang, 2012; Reniers et al., 2011; WENRA, 2019).

Some scholars, however, argue that most scientific advances concerning the interplay between safety and security have been on the conceptual level, while their practical and material interactions are still understudied (Brooks & Coole, 2020; Glesner et al., 2020; Jore, 2019; La Porte, 2020). This paper addresses the practical enactment of safety, security, and their interactions, with a particular focus on the role played by material objects ('non-humans') in this enactment. To this end, it mobilizes Actor-Network Theory (ANT) (Akrich, 1987; Callon, 1985; Gieryn, 2002; Latour, 1993a; Law, 1990), which makes it possible to study relationships between humans and non-humans.

ANT has already been used in both security and safety studies (Balzacq & Dunn Cavelty, 2016; Cidell, 2012; Healy, 2004; Komasová, 2021; Mainz, 2008; Neisser, 2014; Pohler & Schillmeier, 2010; Vitalis et al., 2016), but not yet to study safety and security and how they inter-relate in high-risk organizations.

This article fills this gap with an ethnographic exploration of the entrance gate to a nuclear research center (NRC) and traces its connections with other actors. Thereby illustrating the very active role played by material objects in preventing and mitigating safety risks and security threats. By examining the role played by a gate in managing the flux of humans and non-humans through the enactment of the site access control and evacuation network, we show how it crystalizes security and safety enactments in the NRC. In this article, the gate acts as a dedicated infrastructure that opens up reflections on the potential mutual contributions - but also incompatibilities of - safety and security in practice, thus providing valuable inputs for practitioners. We show how clashes between routinized site access controls and exceptional site evacuations occur around and through the gate. By using Actor-Network Theory as a conceptual and analytical lens, we also show how the impact of non-humans on safety/security can be identified, analyzed and accounted for in a variety of contexts.

The main aim of this paper is to improve the effective and concrete management of safety and security-related hazards in high-risk organizations. Ignoring non-humans when managing or studying safety and security relations can obscure potential antagonisms or tensions that may lead to sub-optimal management of the various hazards such organization face.

In the following section, I describe the Actor-Network Theory, the epistemological framework underlying this study (section2). In section 3, I present the case study and trace the different networks interacting in and through the entrance gate of an NRC. In section 4, I discuss how to deal with competing networks by managing their interoperability. I conclude with some contributions to safety and security studies in light of the Actor-Network Theory heuristics originating from our research.

2. Studying safety and security from an Actor-Network Theory perspective

2.1. Actor-Network Theory

Emerging as a critique of "modern" classifications that separate nature and culture, Actor-Network Theory (ANT) was developed from the 1980s on as a way to study and understand the world as an entangled collection of associations or "actor-networks" (see among others Akrich, 1987; Callon, 1985; Callon & Latour, 1981; Latour, 1984; Law, 1987; Strum & Latour, 1987). While ANT is not a clearly demarcated and unified theory, it is best known for rejecting any *a priori* distinction between the elements that compose an actor-network (Aanestad, 2003; Murdoch, 1998; Neisser, 2014). In analytical terms, this implies that both humans and non-humans (e.g. gates or cameras), should be acknowledged and approached in a similar way. Both can be actors, meaning that both have the capacity to act in and through actor-networks (Akrich, 1992). Diseases, such as SARS or COVID-19 (MacMullin et al., 2020; Pohler & Schillmeier, 2010), infrastructures such as bridges (Winner, 1980) or artefacts such as key rings (Latour, 2007) have the capacity to influence the identity and actions of other actors and can therefore be considered as actors in an actor network. The requirement of not *a priori* separating human and non-human actors, is known as the principle of "generalized symmetry" (Callon, 1985). In this context, Gieryn argues that non-humans

> *'give structure to social institutions, durability to social networks, persistence to behavior patterns. What we build solidifies society against time and its incessant forces for change. […] And yet, [they] stabilize imperfectly. They are forever objects of (re)interpretation, narration and representation.' (2002, p. 35).*

ANT also argues that the agency and identity of actors are shaped through their associations: i.e., the links they forge reconfigure them. Actors are defined and redefined through their relations. For instance, a gate works only if it is associated with other actors, such as roads, fences, pedestrians and drivers. This principle is called the "relationality principle"**.** A central question in ANT resides in the analysis of the stability or instability of associations. Through the concept of "translation", scholars analyze whether and how networks are stabilized. In that respect, translation refers to the process through which actors interact, displace and redefine each other with a view to stabilizing (or aligning) all actors of the network (Callon, 1985). According to Aanestad, '*stability (or order, agreement, success, goal achievement) is obtained when the network is aligned. […] Networks may evolve towards a stable state with relatively irreversible and unchangeable inscriptions*.' (2003, pp. 7–8). The stability of a network implies durable and less reversible actor interactions. The stabilization of networks is termed "punctualization" and refers to the success of any actor-network in no longer appearing to be a network but rather as a coherent entity (Callon, 1991).

Being an eclectic and dynamic conceptual and methodological approach, rather than a strict theory, over the years, ANT has been applied and adapted to a huge variety of topics and fields including urbanism, mundane artifacts, architecture, scientific breakthroughs, and technological innovation risks (Callon, 1991; De Munck, 2017; Goulet & Vinck, 2012; Graham, 1998; Latour, 2007; Murdoch, 1998; Neisser, 2014; Norman, 2000; Pohler & Schillmeier, 2010; Strum & Latour, 1987; Wissink, 2013). Also used in the field of risk research, ANT was mobilized by Balzacq and Dunn Cavelty (2016) to analyze how cyber security incidents re-shape the identity of states and regions. They demonstrate that malware are active and fluid objects which, by challenging the security of sovereign states and the stability of their borders, spurred strong political reactions aimed at re-enforcing their territoriality in the virtual realm.

Further, ANT can unravel safety and security concepts and analyze the constellations of actors enacting them. Focusing on the interactions between and changes in the composition of actors involved in enacting safety and security (in our study the entrance gate to the NRC and

associated actors), enables identification of the actions involved. Thereby, ANT contextualizes the study of safety and security and enables analysis of safety and security not as rationally manageable, but as the result of contextual associations of actors. It also provides tools to analyze how agencies are shaped and enacted through the interactions of human and non-human actors and the networks they form. In a nutshell, the world is seen as not made of entities, but of associations (Latour, 2005; Strum & Latour, 1987).

For the analysis, two concepts from the ANT toolbox were deemed particularly relevant: "inscription" and "programs of action". Firstly conceived by Akrich, inscription refers to:

> *'an attempt to predetermine the settings that users are asked to imagine for a particular piece of technology and the pre-scriptions (notices, contracts, advice, etc.) that accompany it. Thus, like a film script, technical objects define a framework of action together with the actors and the space in which they are supposed to act.' (1987, p. 3).*

However, as we will see below, inscriptions do not necessarily determine what an actor does. A hammer, for instance, is not only used to hammer in nails. Through their associations with others, actors may deviate from their original scripts or even abandon them (Ihde, 1995).

Second, the program of action concept can be used to analyze the actions enacted by associations of actors. A program of action refers to what an aggregation of different actors actually does, that is, create a new actor including and transforming the identities of all the different actors that compose it. Put differently, the program of action refers to the actions resulting from the association of different actors (each with their respective script inscribed in their materiality) (Latour, 1994). As an illustration, Latour uses the example of the association of a hotel room key, oral and written instructions to "*please return the key to reception*" with a weight attached to the key, which together fight against the anti-program: undisciplined clients who fail to return the key when they leave the hotel (1992, 1993). Accordingly, the act of resisting a particular program of action requires the development of a competing network of actors, or an antiprogram. Even the program

of enforcing a speed limit is itself a response to a competing program of action in which a driver intends to break the speed limit (Rosenberger, 2014).

More than an aggregation of scripts, the program of action renders the negotiated assignment of actants[38] that creates a novel entity visible, and in that way, redefines all actors. This concept also avoids deploying deterministic insights about the agencies of actors associations. To illustrate this, Latour goes over the National Rifle Association's notorious slogan that it is people - not guns - that kill, and instead claims that '*it is neither people nor guns that kill. Responsibility for action must be shared among the various actants*' (1994, p. 34).

We used ANT in this inquiry because it enabled us to grasp how safety and security are enacted in practice through the analysis of a particular infrastructure and its associations with other actors. The infrastructure in question is the entrance gate of a nuclear research center which, in connection with other actors, materializes what Razac calls the management of site permeability, or the management of the flux of humans and non-humans (2013).

2.2. Ethnographic methodology

The ethnographic study was conducted at the nuclear research center (NRC) to investigate the heterogeneous enactment of safety and security. The mission of this NRC is to develop peaceful applications of ionizing radiation for society; it qualifies as a high-risk organization due to both safety- and security-related highly hazardous technologies, infrastructures and materials it harbors and the experiments it conducts.

The author of this paper did a 3-year part-time internship in the NRC (up to 2 working days a week) from November 2017 until March 2020 and from June to October 2020. Throughout his fieldwork, he used an immersive data gathering method (Star, 1999), in which an insider's point

[38] ANT sometimes uses the term "actant" to escape the anthropomorphism of "actor".

of view was mobilized to trace human and non-human actors and their relations (Atak & Kingma, 2011; Law, 2004; Lillis, 2008; Neyland, 2008). As Bruni argues, '*an ethnographic approach may help to show that matter is not so "inert" and that the monotonous repetition of actions is something that also pertains to ethnographic representation.*' (2005, p. 375).

Within this ethnographic framework, diverse data were gathered through interviews, workshops, participatory and non-participatory observations of meetings, emergency exercises and other enactments of safety and/or security. A logbook was kept throughout the data gathering process. In order to explore the enactment of safety and security, and particularly the role played by non-human actors in this enactment, a specific focal point was selected: the entrance gate of the NRC. By focusing on this gate, I was able to track the associations between different human and non-human actors and to highlight the role they play in the everyday enactment of safety and security.

To provide an empirically rich and strong argument, the claims made throughout the paper are often illustrated with data extracts. However, for reasons of confidentiality, it is not always possible to provide all details of the data collected in the NRC (e.g. the location of the site, graphical representations of the gate, dimensions, exact quotes and NRC internal documents).

Overall, the author's physical presence at the NRC helped him become an insider. It facilitated the collection of a variety of data that would otherwise not have been accessible. This approach threw light on the many roles played by such common infrastructures as gates and doors in the NRC with a special focus on their roles related to safety and security. According to Star, the ethnographic approach makes it possible to "unearth the dramas", to bring to the surface the narratives and the actions inscribed in the *a priori* mundane actors populating the NRC (1999).

Specifically, to analyze the different roles played by the entrance gate, six semi-structured interviews were organized with members of the units that make up the internal NRC department in charge of safety and security management (SSMU) and four other interviews were held with

NRC employees. Non-participatory observations were made at four meetings in which doors and/or gates were discussed within the SSMU or with employees:

- one meeting at which members of the SSMU addressed the classification of all types of doors on the site,
- one meeting of members of the SSMU to discuss incident reports related to doors,
- one meeting concerning the construction of a new building,
- one meeting in which two members of the SSMU presented the new access control system of an installation to the employees concerned.

Additional data were retrieved from a workshop on safety and security relations with NRC employees. Data collected during the observation of three emergency exercises were also used: two of the exercises concerned safety-related accidents involving evacuation, the third concerned a security related attack.

All the respondents who provided the above data gave their written or oral consent to take part in the study. The paper was also shown to different actors at the NRC before submission.

Table 12: Types of primary data selected during the ethnographic study conducted in the NRC

Semi-structured interviews	10
Non-participatory observations	4 meetings 3 emergency exercises
Participatory observations	1 workshop Research conducted within the NRC over a period of several years

The whole data analysis process followed the infrastructure of the entrance gate as well as other gates and doors and the connections they established with other actors in the NRC. Such non-human actors materialize the complexity of the management of permeability. The inquiry provides new insights into how safety and security are enacted, how they inter-relate, and how their management could be improved. To this end, I traced the complex web of relations the gates established with other actors and made sense of how - through these associations - they participated in enacting safety and security.

Despite its advantages, using an ethnographic approach has some limitations. First, it implied a certain lack of distance from the topic of the study. Indeed, the authors' understanding of doors and how they are enacted is a result of active choices and contingencies. To avoid bias throughout the fieldwork as far as possible, feedback on the research topics and results was given to NRC employees on several occasions in the form of talks, meetings and written documents.

3. Gates to safety and security?

Every morning before starting work, NRC employees pass through a multiplicity of gates, starting with the entrance gate. Gates and doors are everywhere, yet they become almost invisible in the employees' daily routines. As Weilenmann and colleagues point out, '*we take them for granted and fail to realize how much work happens at them, around them, and through them*' (2014, p. 123). In the literature, gates/doors and their roles in the organization of time and space, are rarely studied (Murdoch, 1998), but they are far from mundane. Like doors, gates are essential, not only for NRCs, but for our societies in general. Latour (1992) argues that, without them, closed walls would be tombs and holes in walls would deprive walls of their assigned functions, deviating from their script. They are hybrids that serve multiple purposes; they are "*holewall[s]*", or "*half-open being[s]*". Interestingly, their reversibility between being open or closed also distinguishes them from other

material objects and technologies, which often have a "dominant stability" (Latour, 2000a, 2007; Norman, 2000; Rosenberger, 2014). Latour states:

> *'techniques are always involved when asymmetry or irreversibility is the goal; it might appear that doors are a striking counter example since they maintain the hole-wall in a reversible state.' (1992, p. 154).*

Gates and doors are actors that connect and make sense of spaces (Metcalfe & Ferguson, 2001; Murdoch, 1998; Simmel, 1994). They prescribe where to go in and out, they characterize what is inside and outside, and who are the insiders and outsiders. Gates have the ability to bring together and to separate: while, at the same time, by participating in creating an "inner" and an "outer" space, entering and exiting, a gate also transcends their separation. In this particular case, gates partly[39] define what the NRC is and what it is not, what needs to be protected, preserved, shielded from the outside and, conversely, what is the outside to be protected from the NRC. As Simmel argues, a door

> *'represents […] how separating and connecting are only two sides of precisely the same act. The human being who first erected a hut […] cut a portion of the continuity and infinity of space and arranged this into a particular unity in accordance with a single meaning. […] By virtue of the fact that the door forms […] a linkage between the space of human beings and everything that remains outside it, it transcends the separation between inner and outer. Precisely because it can be opened, its closure provides the feeling of a stronger isolation against everything outside this space than the mere unstructured wall. The latter is mute, but the door speaks. (1994, p. 7).*

Likewise, gates and doors are not uniform. They take different shapes, have different characteristics and play different roles. They are made of different materials: PVC, metal plates, glass. They unlock and lock differently, e.g. with a door handle, a key, a badge or a fingerprint. Their also move differently: some slide, others rotate, and yet others swing. Based on these

[39] Only partly because, in ANT terms, the NRC is obviously also composed of actors that are not physically present inside the fences that enclose the site

differences, they have different names: push bar door, turnstile gate, evacuation door., anti-fire or anti-radiation doors, speed gate.

More interestingly, many of these differences relate to distinct rationales and scripts. Gates and doors take different shapes because of the actions, the morale, the roles, the agencies that have been negotiated and inscribed in their materiality (Akrich, 1987; Latour, 2000b). For instance, through their materiality, anti-fire or anti-radioactivity doors primarily transcribe: *"you should not let the fire pass"* or *"you should not let radioactivity pass"*. Some gates or doors mainly warn us *"not to let unauthorized persons or materials pass"*. Revolving doors or turnstile gates, dis-assemble groups of actors and individualize the passing through (Weilenmaan et al., 2014). Evacuation gates and doors, in contrast, mainly aim to facilitate such passing through. Gates and doors therefore perform different roles, since different scripts are entrenched in them, which are themselves negotiated and flexible. By managing the flux of humans and non-humans (or, in other words, the site's permeability) it can be argued that gates and doors all enact safety and security in a specific way.

In the following subsections, the analysis focuses on a specific gate, the entrance gate of the NRC. Compared to many of the other gates and doors on the site, this one is more complex as it requires barriers, recognition systems and several sensors. In this sense, the entrance gate itself is a complex actor-network composed of different artefacts and technologies. This gate was not always exactly the same as it is today. In response to the wave of terrorist threats in Europe between 2015 and 2018, the entrance of the NRC became increasingly complex and associated with an increasing number of actors. Once relatively "light", it was recently transformed into an imposing structure connecting a wide variety of actors.

3.1. Enacting the NRC site access control

To manage the permeability of the NRC, the gate infrastructure does not act on its own but is entrenched in a series of other actors. The roles of the gate, and what it can or cannot do, are shaped through its connections with other actors. Over time, it has connected to other actors in its immediate vicinity, including guards, badging systems, surveillance cameras, as well as roads and road signs. Like the gate, each of these actors also has a script attached to it (Akrich, 1987; Callon, 1991; Latour, 1994, 2000a, 2007). For instance, working in association with badges worn by employees, badging systems identify which people are permitted or not to be present on the site of the NRC. If no roads led up to the entrance gate, it would obviously be a lot harder for the gate to fulfill its role of controlling access to the NRC. And as a last illustration, cameras detect people and make them visible when they present themselves at the gate, thereby helping the gates sort who can enter and who cannot.

Beyond the actors directly observable in the physical proximity of the main entrance, a range of other actors can be identified, illustrating how the main gate infrastructure '*fold[s] up [its] representatives which stand behind [it]*' (Murdoch, 1998, p. 364). Tracing these connections shows they extend to organizational, national, and international actors including laws, guidelines, meetings and organizational units involved in shaping the doings of the main entrance at the NRC. Following these connections brings us to the NRC's internal unit in charge of security and protection, which manages the entrance gate based on strongly formalized and controlled legislations and procedures and is therefore connected to national legislations (such as the national Royal Decree of 2011 on the principles of access control) (Gouvernement de Belgique, 2011). International guidelines also have a very direct impact on what the entrance gate should or should not do, and more broadly on how access control at the NRC is managed. An illustration of the latter can be found in the design basis threat (DBT) scenarios developed by the International Atomic Energy Agency (IAEA). '*A*

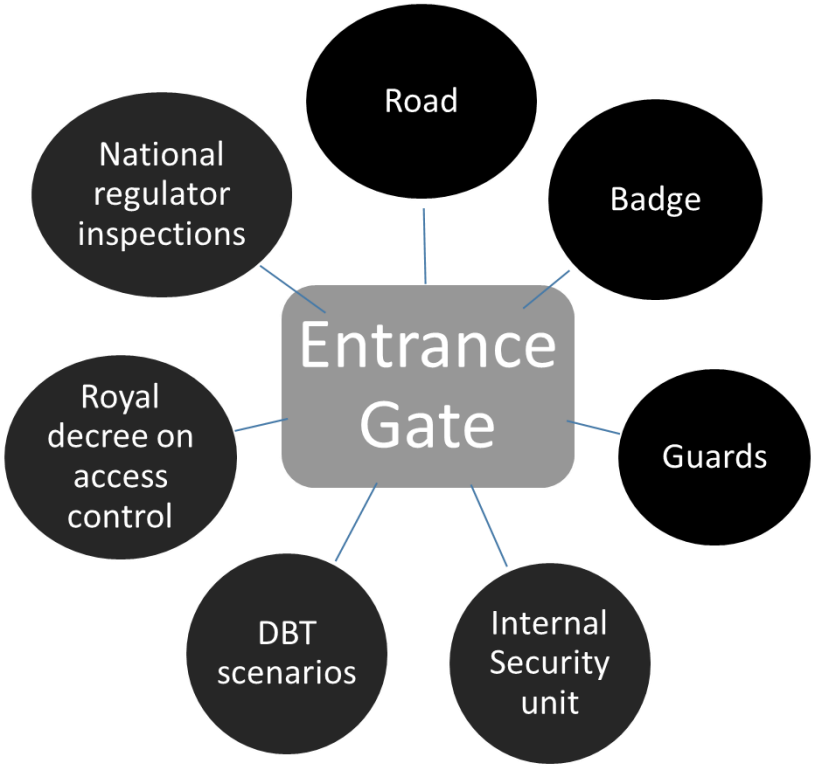
DBT describes the capabilities of potential insider and external adversaries who might attempt unauthorized removal of nuclear and other radioactive material or sabotage. The operator's physical protection system is designed and evaluated on the basis of the DBT.' (IAEA, 2020). DBT scenarios serve as a reference for all nuclear installations worldwide. Furthermore, abidance with DBT scenarios is checked by the national regulator who carries out inspections. Actors such as electricity necessary to make the network function, the fences surrounding the gates, the enterprise in charge of maintenance of the gate, should also be included in the entrance gate's network (figure 2). This network folds and unfolds, like an accordion, a seemingly unlimited number of associations, which through its vascularization enacts the site access control.

By connecting with and around the gate, all these actors mutually shape and redefine their own identity, agency and scripts, forming an actor-network that is focused on enacting a specific program of action: site access control (Akrich, 1987; Latour, 1994). This program of action comprises controlling, restricting, sorting out, and slowing down the passing through of persons and materials, but also deterring some (especially malevolent) actors from entering the site. Although it plays a role in performing safety (e.g. by controlling and helping determine what materials enter and leave the NRC), access control primarily serves the purpose of security by preventing intentional hazards.

Examination of the site access control network showed it forms a prominent, relatively well aligned and "punctualized" network for at least two reasons. First, I just showed how strongly standardized, generalized and formalized the network is through national and international regulatory and procedural "nodes" that act as "immutable mobiles" (see Latour, 1990) and travel '*across time and space to "enroll" human as well as non-human entities into a network that acquires durability and stability.*' (Fenwick & Richard, 2013, p. 122). Secondly the network is routinely enacted by workers. Indeed, accessing the site necessarily means going through the gate. The same actions are repeated every day. Driving along the road up to the gates, badging and waving at the guards have become automatic and integrated actions for employees. This adventure has become so mundane and

common that it has almost become invisible (Star, 1999). Furthermore, the robustness of the gate's materiality makes this network a well stabilized one. The network is well aligned: the links between actors forming this network are tight, and the infrastructure is locked and becomes less and less reversible (Callon, 1991).

Figure 2: NRC site access control network



3.2. Enacting the NRC site evacuation

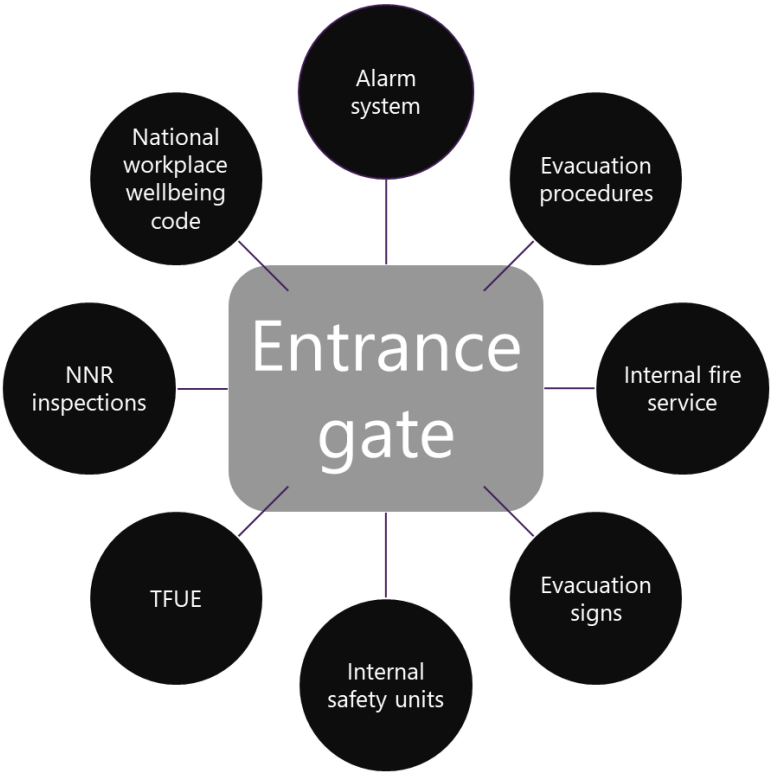
However, although the main entrance gate routinely enacts access control and is set up by the internal security unit, it plays other roles as well. As discussed above, an important aspect of managing site permeability includes letting actors in and out of the NRC grounds. And as also mentioned above, a gate or a door differs from a wall or a fence precisely in its hybrid feature, i.e. its capacity to open and close (Razac, 2013). A gate is interchangeably a wall or a path. Observing emergency exercises is revealing in that respect, as it clearly showcases how, during such exercises, the gate needs to align with another program of action: that of site evacuation.

When an emergency procedure is triggered, e.g. in the case of a fire at the NRC, other actors come into play and interact with the gate. When the fire alarm rings, the fire services are activated, along with evacuation procedures. In such a situation, employees may be required to evacuate the site by going out through the gate. Inversely, external fire services, including firefighters, trucks and other materials, need to enter the site through the same gate. In such situations, the gate needs to interfere as little as possible with the ongoing actions. Since the gate is temporarily made invisible (by remaining open), it cannot act following its script of slowing down and stopping, hence it is disconnected from the network enacting access control. Instead, the gate associates with other actors including fire detectors, alarm systems, fire services, evacuation procedures or evacuation signs. In turn, these actors form another actor-network enacting a different program of action: "site evacuation". This program of action consists in organizing, facilitating, and securing the site's ins and outs. And this, in order to mitigate accidents.

Like the site access control network, the site evacuation network extends and connects to a wide variety of actors. For instance, NRC site evacuation is managed by the unit in charge of safety, which builds on principles established in the workplace wellbeing code (*Code du bien-être au travail*, 2017). This code transposes the European directives implementing article n°153 of the

Treaty on the Functioning of the European Union (TFEU, 2007). Inspections are carried out by inspectors from the Belgian federal public service, employment, labor, and social dialogue. The farther the network is traced, the longer the list of actors becomes.

Figure 3: NRC site evacuation network



3.3. Networks overlaps and contradictions

The two previous subsections showed how the entrance gate represents only one actor among the bigger networks that manage NRC site permeability. Unlike the portcullises found in a wide range of places a few centuries ago, or reinforced doors, which can still be found nowadays, at first sight, the entrance gate of the NRC appears to be rather weak to manage site permeability. It is only when one focuses on the associations it establishes with other actors (cameras, laws, units, guards, fire services) that its strength becomes apparent. The gate's materiality fades (in contrast with portcullises or strong gates), but is distributed to a multiplicity of actors that together enact site permeability. This reconfigures the way of enacting safety and security in a more decentralized, dematerialized, and distributed way, thereby hampering direct perception of the relationship between safety and security.

Tracing the associations of the NRC entrance gate with other actors made it possible to grasp the complexity and the distribution of managing the site's permeability. The entrance gate is only one actor, albeit a crucial one, as it is situated at the point of intersection of two networks enacting opposing programs of action. Analyzing these programs of action revealed that the networks intersect, but also contradict one another in different ways. First, in contrast with an access control that is routinely activated, site evacuation is only triggered when adverse events (real or simulated) occur. Second, while the main function of the access control network is to prevent hazards from occurring, the site evacuation network is usually activated when a hazard has already occurred. Third, the site evacuation network mainly deals with accidents (as malevolent attacks are typically mitigated through lockdown procedures), while access control forestalls adverse events of malevolent and intentional origin. To summarize, the evacuation network mainly deals with safety-related events, while the access control network aims to tackle security-related events.

From an ANT perspective, a gate is hence a fascinating subject of analysis. It is indeed only through its association with other actors that its agency can be revealed. As Gieryn showed in the analysis of a building, it is impossible to affirm that a gate will be what humans make of it (2002). By tracing the networks enacted around the main gate, we can gain insights into underemphasized aspects of safety and security management: the roles and impacts of non-humans. So far, my analysis showcased how, through its associations with other actors, a gate ultimately enacts two opposing programs of action: on the one hand, security by controlling access to the site, and on the other hand, safety by enacting site evacuation. This antagonism is observable through the enactment of respective networks at play around it, but it is also inscribed in the materiality of the gate and through the networks in which it interacts. The associations of actors holding respective scripts construct a new actor network with a specific program of action. In the following section, I discuss the practical implications of this finding.

4. Articulating competing programs of action: managing interoperability

As shown above, the entrance gate's infrastructure alternatively associates two different networks that apparently perform antagonistic programs of action. As the two opposing networks are enacted around (at least) one common actor (the entrance gate), they need to regulate and organize each other in order to achieve interoperability. Translating both networks at the same time does not seem to be feasible: a swift evacuation/entrance is difficult to simultaneously align with meticulous site access control. Concretely, when the site evacuation network activates, the access control network needs to temporarily deactivate and vice versa, when one aligns, the other needs to de-align. For an actor situated at the intersection of two antagonistic networks, such as the

entrance gate, this requires being able to switch from one network to the other. Preventing the occurrence of hazards (both safety- and security-related) means the translation and alignment processes must remain be and reversible. The interoperability of the networks for site access control and site evacuation is thus a key stake in the management of safety and security at the NRC.

However, managing interoperability is not straightforward. The articulation of competing programs always involves uncertainties, ambivalences, transgressions and resistances (Murdoch, 1998). Several obstacles can be pinpointed. First, as shown in section 3, scripts are inscribed in materiality; in some cases, they are more stable and hence difficult to re-orient. In the NRC, some gates and doors built to restrict or allow access have translated this script in their very materiality. While this is less obvious for 'lift barriers', which can be deactivated when in the vertical position, it is much more difficult to deactivate gates or doors like turnstiles or revolving doors in which the slowing down and individualization of passing through is inscribed in steel bars. Second, achieving reversibility while remaining aligned is counter-intuitive and paradoxical and indeed contradicts a recurring finding in ANT studies: usually, the tighter a network is aligned, and the more "punctualized" it becomes, the less reversible it is (see the weighted hotel key example in section 2.1) (Latour, 2007).

Based on this case study, I postulate that, on the one hand, the access control network is stabilized because it is routinely enacted and well aligned, while the evacuation network is only sporadically activated and is consequently less stabilized. On the other hand, precisely due to its stability, the access control network is very hard to reverse. However, it can be argued that because it is so rarely activated, evacuation is more easily deactivated and consequently more reversible. Here the weight of routine linked to the access control network clashes with the exceptionality of the evacuation network. The routine enactment of the access control network, where actors act according to a clear and well-rehearsed program of action, has difficulty responding to exceptional enactment, in which the interrelation between actors is less smooth. This tension may lead to dysfunctionalities. As it is often argued that danger arises when workers get used to their work,

routinized access control is vulnerable to unexpected safety related events. In a nutshell, trying to make the two networks reversible while keeping their alignment is the main difficulty in managing the interoperability of access control and evacuation networks.

At the level of the NRC, managing site access control and evacuation interoperability, first requires recognizing that the two networks actually coexist and are intertwined. Concretely, the actors responsible for managing security in the NRC need to realize that the measures they take to adapt a gate may have an impact on many other aspects, including evacuation of the site. The reverse is also valid for the employees who manage the NRC evacuation network. Overall, actors in charge of the NRC site protection should not strive for an NRC that is as safe *or* as secure as possible, but for an NRC that is as safe *and* secure as possible.

The case study used in this article reveals that tracing non-humans in the enactment of safety and security is also a prerequisite for such a success: analyses showed that access control and evacuation and, hence, safety and security, need to be managed in a dynamic, holistic, and at the same time, contextualized way. It is of utmost importance to avoid favoring one over the other, but instead, circumstances need to be identified in which the two can (co-)operate as smoothly as possible. Interoperability of access control and evacuation need to be managed in terms of co-existence, rather than mutual exclusion.

The preferred solutions should therefore neither stifle nor pretend to overcome antagonisms, in this particular case, between site access control and evacuation, but more globally, between safety and security. The solutions should incorporate the evolving and complex features of the relations between access control and evacuation and balance them. In practice, interoperability can be improved by setting up spaces or venues of collaboration and exchanges between employees responsible for managing the safety and security networks, in which this duality of programs of action is examined and discussed. Such venues could unveil the different associations between the actors and the different programs of action they help enact. In this way, they could help safety and security practitioners broaden their understanding of the potential

impact of the measures they take. The very associations between actors and the ties that unite them can then be negotiated and/or called into question. For instance, in the NRC, such venues could take the form of NRC inter-unit meetings in which safety and security units discuss internal incidents related to access to the site. They could also be materialized through emergency exercises in tandem with staged safety and security-related crises, for instance, a terrorist attack resulting in the burning of a building on the NRC site.

5. Conclusion

Based on an ANT approach and focusing on non-humans, this paper has emphasized the role of materiality in safety and security enactments. Using the case of the entrance gate of a nuclear research center as an example, the paper traced two overlapping actor-networks. It showed how these networks enact partially antagonistic programs of actions, i.e. access control and site evacuation, the former belonging more to the realm of security, and the latter to that of safety.

This paper makes two main contributions. First, it demonstrates how non-humans are not just tools but have a real impact on safety and security that can only be grasped by tracing the associations they have with other actors. Indeed, tracing and characterizing the networks and programs of action in which non-humans (for instance, a gate) participate, makes it possible to analyze the relations they develop with other networks and overlaps. Such analysis will unveil the intertwinement of actors and the complexity of evaluating the impacts of specific measures undertaken to improve the safety or the security of an organization. The clash between routinized site access control and the adaptability required for site evacuation in the case of extreme safety events was showcased here. The example of the entrance gate could be extrapolated to other non-humans enacting safety and security, for instance the labeling of hazardous materials (Hazmat) or surveillance cameras. These need to be analyzed not simply as tools, but through the lens of their

complex relations with other actors. Based on this study, I argue that not taking non-humans into account when managing or studying safety and security relations may lead to failure to identify potential tensions or issues, and consequently to sub-optimal management of the various hazards high-risk organizations face. By suggesting a more contextual and holistic approach - notably setting up venues for collaboration and exchanges between employees involved in managing the safety and security networks – this study encourages practitioners to be attentive to the active and evolving roles non-humans play and the influence they have on other actors and offers solutions to better manage safety and security.

Second, many studies using an ANT approach found that networks tend to become less reversible when their alignment becomes stronger through what ANT calls "punctualization". Tracing the networks presented in this paper underlines the need to enable continued reversibility while simultaneously achieving strong alignment. Interoperability implies that both access control and evacuation networks require reversible alignment. This is not without consequences because it shows that managing interoperability cannot be achieved without, to some extent, weakening one or the other. This insight is helpful for practitioners. Indeed, effectively managing interoperability is only possible when all the entanglements and impacts an actor has are taken into account. Concerning the case study presented here, this means for example that the respective units responsible for access control and evacuation should both be involved in the management of the entrance gate, to be able to innovatively articulate these antagonistic requirements.

Overall, this article aimed to open the black box of safety and security and to raise the awareness of professionals of the complex, active and evolving roles of non-humans. Although the study was conducted in a particular type of high-risk, organization, the insights gained are applicable to other contexts and topics. This article paves the way for future research on the roles played by other non-humans (such as surveillance cameras or hazmat labels) in the enactment of an organization's safety and security.

III. General discussion

After a period of not considering safety and security together, terrorist attacks at the turn of the 21st century heightened awareness of their interrelations. Several authors endeavored to demonstrate the many resulting similarities and synergies and developed integrated approaches to the concepts of safety and security (Aven, 2007a; Cipollaro & Lomonaco, 2016; Gandhi & Kang, 2013; Hessami, 2004; IAEA, 2004; Kim & Kang, 2012; Reniers et al., 2011).

However, these developments have not clarified how these concepts are linked from a practical point of view. Indeed, several authors recently pointed to the fact that, along with synergies and similarities, tensions and divergences between these two concepts exist and remain understudied. Among others, based on conceptual and analytical hunches, La Porte and Schulman, argue that the operational dynamics in high-risk organizations, which are influenced by safety-related and security-related hazards, are intrinsically ambiguous and unexpected (La Porte, 2020; Schulman, 2020). Dealing with them therefore demands a form of adaptability that is likely to create instability and tensions between safety and security applications in the field. Assimilating safety and security management is consequently challenging. On that basis, the same authors argue that further empirical studies on how safety and security are enacted and how they relate practically are needed to obtain a deeper and contextual understanding of their relations and go beyond the functionalist approach.

In line with this recent plea, this thesis builds on the hypothesis that apprehending safety and security relations should not be limited to a general conceptualization of these concepts but rather trace their interplay empirically through their practical enactments. To do so, using case study research, this thesis analyzes the ways in which security and safety are enacted and how they enter into relationships. Indeed, although I do not contest that at the abstract level, safety and security share the same overarching goal, *i.e.* protecting an entity (an organization, a population etc.), I argue that their practical enactments may not only involve similarities. Assimilating safety and security is not a trivial process and should be contextually assessed (Schulman, 2020). I therefore conducted the analysis by starting from the field, tracing safety and security enactments

through two case studies. On the one hand, I undertook an ethnographic inquiry in a nuclear research center (NRC). Having evolved in response to major nuclear accidents in the 20th and 21st centuries and having been impacted by the 2016-2017 terrorist attack threats, the NRC is a specifically dedicated field to monitor how safety and security networks interplay on the site. On the other hand, emergency management (EM) in Belgium represents an interesting case study to follow safety and security relations beyond their specific enactment at a particular site using the examples of different crises at the societal level. More specifically, the fieldwork I undertook for this case study enabled me to track how recent security concerns have influenced the regulations, values and practices that comprise the EM safety regime and the security regime in place in Belgium. Cross-fertilized, the results of these two field studies reveal multiple general trends in these concepts and their interrelationships. In that way, I provide elements to answer the general research question of this thesis: **how are the relationships between safety and security shaped in and through practice?**

Each of the four chapters represents each a piece of a puzzle which, when assembled, reveals the general patterns of the relationships between safety and security. I used ANT and complemented it with two other STS approaches, the instrumentation approach (Lascoumes, 2007) and co-production (Jasanoff, 2004) to make sense of the data gathered in the field.

In concrete terms, each of the four chapters sheds a different light on the subject, but also allowed me to identify common points and trends. Through this discussion, I highlight the cross-cutting results to raise new questions and to deepen our understanding of safety and security concepts and their relationships. Although these reflections have theoretical and conceptual aims, they also have the objective of grasping how these concepts are enacted in the field and how to manage their interactions. The discussion thus strives to produce both theoretical knowledge and to identify practical applications.

In the following section, I focus on the main findings of the thesis that answer the research question. Thereby I show how the thesis provides novel insights into the study of safety and

security relations and how it makes it possible to go beyond some of the confusions and oppositions that remain in the literature. In the second section, I discuss and provide theoretical and practical insights into how to tackle safety and security tensions. In the third section, I reflect on the contextual boundaries, the limitations of this thesis as well as potential avenues for future research.

1. Disentangling safety and security relations

1.1. Safety and security as dynamic and interacting networks

The literature on safety and security remains interspersed with confusion and epistemological oppositions. The opposition between the active and passive vision has influenced conceptual developments in safety and security. The latter vision, dominant in the literature, perceives safety and security as a state rather than a process. It corresponds to the absence of risk or threats (Amundrud et al., 2017; Atkins, 1991; Aven et al., 2015; Hessami, 2004; Leveson, 1993; OECD/NEA/RWMC, 2014; Schnieder et al., 2009). The former vision tends to understand safety and security as sets of measures and elements whose overarching objective is to prevent the occurrence of risks or threats (ENSREG, 2013; Rollenhagen, 2010).

By tracing the practical enactments of safety and security in different fields of analysis, I argue that safety and security cannot be approached in a passive way as "being safe" or "being secure". Safety and security can only be grasped as networks of actors who together participate in

protecting an entity (for instance, an organization or a society) against specific risks and threats. Extending Boholm and colleagues' reflection on the concept of safety to include security, I argue that, '*given an absolute [or passive] concept of safety [or security], the existence of safety [or security] implies the nonexistence of risk [or threat], but such a conception is problematic, since it arguably is unattainable in real life*.' (2016, p. 321). Moreover, in practical terms, as stated by Jore, implying that safety and security are a state and correspond to 'non-events', makes it more difficult for actors to justify the need to protect an entity (for instance, an organization or a society) (2019). Investing in "being safe and secure" is far more difficult to justify than investing in the construction of a network aimed at protecting against existing hazards. Indeed, in societies characterized by risk, being protected against hazards can only be achieved through the active associations of networks of actors who together participate in protecting against them. "Being safe" understood as a state requires a continuing dynamics of associations and adaptations, and hence is not a status but a process.

Moreover, safety and security interactions cannot be assessed practically by apprehending them as "states" but rather as dynamic constructions. Extending Rollenhagen's reflections to safety and security, I therefore understand them as dynamic arrangements of actors (2010). This requires tracing actors who participate in enacting these safety and security networks. By doing so, it has been shown that safety and security networks are not only constantly evolving but also interacting with each other. The co-production idiom is, in that respect, useful as it raises awareness of the mutual shaping of safety and security. As both are intended to protect against hazards, they have been found to connect and interact around some specific actors on the field. For instance, the presence of a safety exit affects controlled access to a NRC and hence security. Another example: a document labelled confidential for security reasons potentially undermines the potential transfer of important safety-related information. Through their interactions, these actors help shape each other's identity. In this line of thought, I conclude that safety and security should not be thought of separately but assessed in light of each other.

Thereafter, demonstrating how safety and security are complex, ever evolving and mutually shaping networks of actors, gave me new insights into the opposition between the interpretivist and functionalist approaches that also pertain to the safety and security literatures (see chapter 1). In the functionalist approach, safety and security are apprehended as mere packages of measures that are implemented and steered by managers and can be modified through top-down policies to meet specific objectives and achieve intended outcomes. Such an approach runs the risk of missing the links actors have with other networks and therefore not be capable of assessing the potential unintended effects of such or such a measure on safety and security enactment. The examples of the gate and the safety exit but also the ones of hazmat labelling and the four eyes principle, clearly illustrate how the association of specific actors within a network may totally - and unintentionally - influence it.

1.2. Safety and security as networks composed of humans and non-humans

A close examination of the networks and what composes them, enabled me to identify how they are enacted through the interactions and association of a wide variety of actors. In other words, safety and security are not achieved solely by associating human actors. A high-risk organization could not be protected by firefighters dispossessed of their fire truck or their water hoses or guards deprived of their fences, barriers or alarm system. Material objects, infrastructures, generally classified under the term non-humans[40], are particularly important. Mobilizing STS approaches and especially ANT, I discovered that, far for from being mere instruments, they are actors that actively participate in enacting safety and security. Non-humans are not tools but actors, with their own

[40] As explained in the introductory section, the term 'non-human' covers material objects, processes, and regulatory instruments.

agency, that influence both safety and security and their culture. Thereby, such an approach counters the dominant tendency in the safety and security literatures to divide itself between, on the one hand, the concepts of safety and security, massively understood as sets of technical measures, and, on the other hand, safety and security cultures, which include all the human elements related to risk prevention. Separating these two fields of study makes it all the more difficult to analyze the mutual impacts of cultural and technical aspects. By going beyond this dichotomy between technique on the one hand and culture on the other, this approach opened the way for the analysis of how the two are in fact intertwined and influence each other. Based on this approach, I stress how non-humans participate in establishing, perpetuating, and influencing the values and practices that underpin the enactment of safety/security.

Non-human actors also provide entry points to analyze networks that enact safety or security. They are key actors to start the inquiry as they contribute to tracing and unfolding the relationships of actors who participate in the implementation of security and safety. Indeed, as Strum and Latour already put forward in 1987, non-humans bind actors together, they participate in perpetuating the social by making it more stable: '*greater stability can only be achieved with the help of additional resources. […] By using additional resources, social actors can transform weak and renegotiable associations […]into strong and unbreakable units*' (pp. 790–791).

Beyond binding actors together, non-humans also help shape the networks within which they interact. Specifically assessing instruments, Lascoumes asserts that they create *'inertia effects that insure the robustness of an issue or practice and offer much resistance to external pressures*.'[41] (2007, p. 77). For instance, the materiality of a gate contributes to defining and influencing the evacuation networks of a high-risk organization but also that of controlled access. Moreover, tracing changes in emergency planning regulatory instruments in Belgium makes it possible to grasp how they participated in reshuffling the network of actors involved in crisis management and overall, how they impact the Belgian EM policy practices and regimes.

[41] Translation from the French by the author.

If I had not considered non-humans as active actors and had not analyzed their contextual interactions with humans had not been analyzed, it would not have been possible to make sense of the unintended influence of certain measures (e.g. hazmat labels) on other actors. This would consequently have prevented me from dynamically assessing how safety and security shape each other in and through practice.

1.3. Safety and security: about tensions

Based on these results, my analysis revealed that safety and security relations are characterized by a number of tensions. Once again, field analysis, and particularly tracing materiality, revealed points of rupture and divergence. Safety and security meet, clash and even fight through the associations of actors enacting different principles, objectives, values, and requirements. In ANT terms, tensions arise through associations of actors each enacting a network with opposed programs of actions. These tensions engender discomfort that in turn, may lead to suboptimal management of safety and security, for instance.

For instance, in the organizational context, while **hazmat labels** intend to improve a site's safety network by increasing the transparency and openly communicating about risks, at the same time, they overlap the security network and hence undermine the security program of action by facilitating the possibility for actors to locate and use hazardous material to carry out malevolent attacks or sabotage. Further, **lockdown** security procedures were designed to respond to potential malevolent on-site attacks by preventing access into or out of the facility. However, these procedures counter the safety objective of allowing rapid evacuation in the case of on-site accidents. The case study on EM also highlighted instances of tensions and of mutual influence between safety and security networks. Indeed, the use of confidential logbooks for security-related

emergency response and the increasingly prominent presence of judicial actors in EM counters the original practices based on transparency and open communication.

Rather than undermining the enactment of safety and security, these tensions modify the configurations and dynamics of safety and security networks as well as the relations the two networks have with each other. For instance, the 2006 royal decree not only binds the EM security regime to the safety regime, but also reshuffled network relations and resulted in the judicialization of the Belgian EM regime. On the NRC site, the gate infrastructure also allowed me to observe how safety and security tensions arise within a material object and that it is the process of translation that leads to tensions. Moreover, in line with Mol's reflections (2002), there are numerous examples, like the entrance gate, the incident reporting system, the labelling of hazardous materials or the surveillance cameras, of actors and measures enacting safety and security, that do not entirely belong to one network or the other but are involved in enacting both (and others as well). By being part of different networks, they are also different actors and play different roles. And it is precisely from the meeting of the two networks enacting antagonistic programs of action that tensions arise. The tensions do not stem from the opposition of values and principles as such, but from their enactment in the field where the networks overlap.

Beyond simply raising awareness that tensions exist and providing tools to trace them, I describe the roots of these tensions. Indeed, by crossing the data from the two field studies, mainly on the basis of the results of chapter 3, I realized that multiple tensions have common denominators. In the thesis, I trace back the tensions in order to locate their recurrent underlying roots and I highlight the fact that multiple tensions are rooted in three underlying oppositions, called paradoxes. The paradoxes correspond to characteristics enacted by respectively, safety and security, which when separated are relevant but when put aside become inadequate (W. K. Smith & Lewis, 2011). They ingrain in the antagonistic aspiration for safety to enact a form of transparency and to facilitate movement through processes of mutual trust, and for security to

enact confidentiality and to restrict movement through distrust. While very concrete examples of these paradoxes are presented in chapter 3, the case study on the impact of regulatory instruments on crisis management (chapter 2) and the study of the main entrance (chapter 4) are good illustrations of the way in which paradoxes unfold and the tensions that can result from them. Indeed, by inducing more confidentiality during emergency responses the modifications of instruments for crisis management reduce trust between actors thereby revealing the opposition between distrust/trust and confidentiality/transparency. The main entrance gate, is for its part, the result of and at the same time enacts the opposition between enabling and restricting movement.

Furthermore, I suggest that the existence of such paradoxical tensions between security and safety and depending on the context, their variations, is a further argument for not managing safety and security in a global top-down manner. It is essential to understand where tensions originate and what characterizes them. Are we facing organizational tensions or paradoxical ones? And which paradox applies in the case in question?

But at the same time, in my opinion, the reflections on safety and security paradoxes provided in this thesis also represent significant inputs for practitioners. First, they provide a framework on how and why the tensions emerged. They help understand, for instance, why some actors complain about the setting up of a new access control system or a hazmat labelling repository in their department. Reflections on paradoxes provide an analytical grid to help practitioners understand why one measure creates problems while another does not. Second, the paradoxes have a predictive potential for the occurrence of tensions. They may help practitioners foresee with which other organizational or EM aspects the implementation of a new measure may clash. This tool can be used to assess whether a new measure that promotes the movement of a given material or substance could clash with another measure aimed at restricting its movement. Overall, the paradox lens offers both a way to analyze and to foresee safety and security tensions.

Consequently, the paradoxes and their analysis should always be linked to particular and specific events. Identifying the paradoxes that underlie the relationships between safety and security

made it possible to reveal certain trends at the root of the tensions, while simultaneously revealing the complexity of their relationships. However, if this analysis underlines certain recurrences, it does not claim to be exhaustive. It shows that what causes tensions between safety and security cannot be determined in advance and in a general way, but requires careful analysis on a case-by-case basis.

2. Dealing with safety and security tensions: setting up tension venues in the field

As underlined above, addressing the tensions between safety and security is not about integrating the two concepts but rather about contextually examining and managing the intersections between the two groups.

Building on the "dynamic equilibrium" model proposed by Smith and Lewis (2011), the concept of "tension venues" is developed (in chapter 3), as a practical tool to detect, understand and develop innovative solutions to act on these tensions. Tension venues are proposed as spaces that provide practitioners with analytical frameworks and a practical toolkit intended to find and manage specific tensions. They aim to render latent tensions salient, clarify their roots and enable the development of creative solutions. They do so by valorizing the multiplicity of meanings and specificities of each actor: tension venues allow the actors involved to engage without jeopardizing their core values and agencies while working with other actors. In this way, such venues perform the articulations of divergent networks of actors.

But more practically, what do these tension venues look like? How can they be implemented? Chapter 3 describes some practical characteristics of tension venues as physical or virtual spaces, they can be created intentionally or emerge from the field. Starting from this

reflection, I now pursue the concept of tension venue by discussing how they could be implemented. In this context, the literature on the concept of "trading zones" provides practitioners and academics concerned with articulating the tensions between safety and security with useful analytical tools.

Originally developed by Galison, "trading zones" are defined as *'locations in which communities with a deep problem of communication manage to communicate.*' (H. Collins et al., 2007, p. 658). The trading zone literature relates to how two networks manage to cooperate without prior consensus (Star & Griesemer, 1989). Tension venues, analyzed in the light of the literature on trading zones, can be understood as *'the process where ideally the trading partners, in positions of mutual symmetry, aim to develop something in collaboration without knowing or even sharing, at the beginning stage, the consensus of the outcome*.' (Kahila-Tanni, 2013, p. 75). In the framework of tension venues, this process is carried out while the groups at play not only do not share a prior consensus, but also have to accomplish together divergent or even opposing programs of action. According to this vision the tension venues necessarily *'occur and evolve and [are] locally bound in the sense of a context-specific socio-spatial and verbal-material language game.*' (Balducci & Mäntysalo, 2013, p. 61). In the literature, such processes have been illustrated through their implementation within physical spaces such as laboratories (Galison, 1999) or neighborhoods (Calvaresi & Cossa, 2013), but also in scientific and technological fields such as biochemistry or nanotechnology (H. Collins et al., 2007) or even procedures such as the peer review system (H. Collins et al., 2007).

For these case studies, the principles of trading zones could therefore be applied to the examples of tension venues understood as physical and virtual spaces that bring together the different groups of actors mentioned in chapter 3, namely: briefings/debriefings of emergency exercises, inspections, plans for constructing buildings or training courses, but also "lunch talks" or "protection talks" that are set up within the NRC. Under this light, several key characteristics can be highlighted.

2.1. Ad hoc or structured tension venues

First, tension venues can be set up within an established structure or emerge in an ad hoc manner. The first type of tension venues, also termed "structured tension venues", correspond to institutionalized and recurring physical or virtual meetings. Such venues can be created within existing or non-existing spaces. They must be embedded in a predetermined framework with toolkits to detect tensions in specific contexts, not only to identify their roots but also the steps required to deal with them. Training courses specifically focusing on tension venues should be set up to be sure practitioners know and master them. These courses should be given upstream and designed as venues to track down the emergence of tensions. For instance, in the emergency management frame, such a structured tension venue could correspond to the development of an emergency management "lessons learned" framework in the event of a malevolent attack. This framework would establish different types of debriefings (very hot, hot, and cold debriefings) and other information-gathering methods (such as focus groups) to highlight the tensions that arose between the actors involved in the management of the crisis and to identify concrete solutions to improve their coordination in future crises.

The second type corresponds to ad hoc tension venues. As relations between safety and security evolve through actor-networks interactions, tensions may also pop up in the field. For instance, they may emerge from the construction of a new building in a high-risk organization or as the result of new missions assigned to EM actors. To tackle these tensions, tension venues can also be set up on an ad hoc basis, outside existing structures. Such ad hoc tension venues would mobilize the same framework but would be specifically oriented to deal with a tension that has already been detected by practitioners. These venues are therefore necessarily established after the emergence of a tension. In contrast to structured tension venues, their objective is not to trace the emergence of tensions, but rather to analyze their origins and to find ways to articulate them.

2.2. Drawing common bases: developing inter-language or interactional expertise

Whether structured or ad hoc, the tension venues are built around different steps that allow them to design innovative solutions to tackle tensions. The first step in developing a tension venue is to find a connection between the parties involved in, respectively, safety and security management. In addition to organizing the meeting of safety and security networks, tension venues should also be a place in which safety and security inter-language and/or interactional expertise is developed (H. Collins et al., 2007). Such means of communication function as bridges the different parties can use to develop ways to understand each other's requirements, values (called programs of action) and perspectives. Practitioners involved in safety and security management within the frame of a tension venue, should be oriented toward developing either an inter-language, to reach a common understanding, for instance, concerning a protected or a restricted areas or the different types of doors (evacuation, security, fire doors) that present in an organization. Or the venue might be oriented towards developing interactional expertise to precisely understand the meaning of the safety or security concepts the actors respectively mobilize and their implications. For instance, a tension venue would seek to reach a common understanding of how threat analysis differs from risk analysis or what a security scenario-based path analysis actually means. Such processes are necessary bridges to create the common ground needed to detect tensions, analyze their roots and to create the premises for finding generative solutions to tensions.

The creation of an inter-language or interactional expertise can be undertaken by the parties involved themselves (Chrisman, 1999; Galison, 1999, 2013) or via the mediation of another actor (Diedrich & Styhre, 2012). Indeed, depending on the degree of opposition and the nature of the tensions, tension venues might require a mediator to facilitate the research, analysis, and articulation of the tensions. The facilitator could play a supporting role by helping practitioners to develop

ways of communicating and of appropriating the tension venues. In the case of the emergency management "lessons learned" process (see section 2.1), it could be organized by an outside facilitator whose objective would be to start the proceedings, provide the tools, lead the debriefings and focus groups and make sure they run smoothly. The field actors would be led to develop new coordination processes among emergency management actors, for instance.

2.3. Analyzing the roots of tensions: paying attention to non-humans

Detecting tensions and analyzing their roots can be achieved when both parties work together to trace the networks of actors at play and to create safety and security tensions. The interactional expertise allows, in this case actors to use common bases to track and characterize the tensions. Picking up on the analysis I conducted throughout this thesis, I showed that tensions arose around network overlaps and through the interactions of specific actors. I demonstrated how non-humans have agency, i.e. the capacity to produce transformations within networks of actors but also to link different networks of actors together. Non-humans located at the intersection of safety and security networks are potential sources of tension. For instance, the entrance gate to the NRC is an actor specifically dedicated to trace and analyze tensions between safety and security. But at the same time by making tensions visible, non-humans create a need to set up tension venues. For instance, emergency exits or hazmat labels materialize the antagonistic safety and security requirements and may thus serve as potential catalyzers for the creation of tension venues.

2.4. Finding contextualized solutions: the "thinness of interpretation"

In order to increase the generative potential of tensions, tension venues should seek solutions through the "thinness of interpretation" (Balducci & Mäntysalo, 2013). Indeed, according to the trading zone literature, tension venues should not seek to reach a global consensus but rather to exchange and interact around small elements in order to create spaces in which divergent networks can "work together". This has the advantage that especially when groups contain strong oppositions, they can still work together on certain aspects. For instance, even if the paradoxical tension between actors promoting transparency and others encouraging more confidentiality seems difficult to reconcile, it is possible to have these actors work together on specific cases that do not require them to be globally aligned. Tension venues therefore make it possible to build bridges between different networks by working on very concrete cases.

Overall, I am convinced that bringing together safety and security actors around specific issues and allowing them to develop the means needed to understand each other's principles, goals and achievements allows them to accept the existence of tensions and to find ways to articulate them (for example by identifying trade-offs or by shifting the stakes). This may lead to the discovery of innovative ways of dealing with safety and security relations. As I have shown, tension venues do not provide a rigid model aimed at overcoming all types of tensions but rather provide a conceptual framework and practical tools to enable field actors to take over the management of tensions and adapt to their contextual emergence. In that respect, tension venues clearly takes up La Porte's plea:

> *'an important emerging analytical challenge would (and should) be the development of credible skills, norms, and practices associated with "preparing to be surprised" during the deployment of measures expected to improve safety and/or security. Surprises associated with each of these domains are likely to be systematically different' (2020, p. 84) .*

To conclude, based on the reflections detailed in this thesis, I argue that tensions can be dealt with and have generative potential if tackled properly while recognizing antagonisms between safety and security groups. In agreement with Michaud (2011) and Woodman and colleagues (1993), I argue that tensions have the potential to set organizations in motion and could be drivers of organizational learning. Indeed, as tensions emerge, they provide an opportunity to study and understand how safety and security are enacted and what their impacts are. They also force field actors to question the way safety and security are managed and to learn about the elements and spaces that can create tensions. In this way, they also provide an opportunity for field actors to meet, build new relationships, and learn from each other. Furthermore, they make it possible to find innovative solutions to improve the functioning of the organization or the company concerned and their protection against the different risks they encounter (whether they are of malicious origin or not).

Based on these conclusions, I call on practitioners who manage safety and security to be attentive to and, in the framework of tension venues, to design tools and processes that specifically apply to their domains through which contextualized tensions can be detected and acted upon.

3. Limitations and avenues for future research

Of course, a thesis has to begin and end somewhere. At the outset of my research, I wondered how I would be able to write four papers to tackle the research topic. At the end, I look at all the opportunities for potentially interesting research and wonder how many theses would be needed to cover the entire topic of safety and security interplay. Among the variety of topics, the methodological and theoretical approaches considered as well as the many questions asked, at some

point, I had to make up my mind to relinquish some opportunities. There is a French expression that says "*choisir c'est renoncer*" (to choose is to give up). Among the range of - as yet - incomplete research, let me restate some of them. Before concluding this dissertation, I want to critically look back on some contextual elements and limitations that constrained my research and reflection. Optimistically, I believe these elements are also potential avenues for future research and will serve as inspiration for other researchers.

3.1. Going beyond this PhD: extending the scope of safety and security research

3.1.1. Extending the temporal scope

The nature of the crises our societies face varies over time. Hazards become dangers under specific circumstances, become prominent to then slack off. Risk management is therefore inherently evolving and contextual (Aven & Renn, 2010). This thesis began in the direct aftermath of the 2016 terrorist attacks in Belgium and ran parallel to the wave of terrorist threats that Europe experienced between 2015 and 2018, and has continued to face since then. Although these elements are obviously beyond the scope of my study, they nevertheless had a non-negligible impact on my observations and reflections.

Like an infinite number of other elements, terrorist threats are in one way or another linked to my reflections. By unfolding all the associations between actors using the terrorist attacks as a starting point, it is possible to weave a link between my research and these malevolent perpetrators. This influence, resulting from the innumerable associations between actors linking the terrorist threats to my thesis, remains totally contingent. The security turn and the tensions between safety

and security around the protection of organizations and companies observed through this thesis, are therefore of course partly influenced by the ambient terrorist threat. We therefore need to ask ourselves what the results would be of a similar inquiry undertaken in other temporal and geographical contexts. If the observed process seems to have been confirmed over the last two decades, it is necessary to monitor these issues and to analyze whether these trends will get stronger or, on the contrary, weaken over time. It is therefore important to continue to ask ourselves a number of questions.

Will the security policy regime become the dominant mode of governing risks? How will the observed safety and security tensions evolve over time with the appearance of new threats and risks? Will they exacerbate? Or on the contrary, will they slack off? Such questions represent good opportunities for future research. In connection with these reflections, the consequences of this "security turn" for the governance of societies could be the subject of interesting scientific productions. Coming back to Beck's reflections, what might be the impact of this securization in the light of risk society? Indeed, the main feature of a risk society is to be governed through risks (U. Beck, 1992). However, as shown by this thesis, security has its roots in other rationales (namely, distrust, movement restriction and confidentiality) than safety (trust, movement enablement and transparency). What might then look like a "security risk society"? What would a "security risk society" resemble? Surveillance studies by authors in line with Foucauldian and Deleuzian works[42], have for several decades theorized the rise of surveillance society (Dandeker, 1990; Gilliom, 2001; Lyon, 2001). It would be interesting to reflect further on how my observations intertwine with those surveillance studies.

[42] Notably through Foucault's reflections on disciplinary power (Foucault, 1993) and the concept of security instruments (Foucault, 2004) as well as through Deleuze's reflections on the *"sociétés de surveillance"* (Deleuze, 1990).

3.1.2. Extending the geographical scope

My thesis is not only limited in time. The geographical context also influenced my reflections. My fieldwork was only conducted in Belgium and my reflections only refer to Western countries. In the general introduction, I stressed how the concept of safety has evolved with the emergence of risk societies. As I have shown, such developments are correlated with industrialization and the increase in reflexive risks in societies. If today, no countries can be considered to remain totally pre-industrial, the importance of high-risk organizations is still not evenly distributed throughout the globe (Mountjoy, 2017). In such countries, it would be interesting to analyze the role played by safety in the governance of these societies.

Moreover, even though the wave of terrorist threats in Europe from 2015 on had major international consequences, it primarily impacted Western Europe. The observed security turn therefore primarily concerns this geographical area. Regions like the Middle East, Africa or South America have a total different history related to terrorist attacks and societal turmoil than our regions (Laqueur, 2017; Shughart, 2006). Studying the interplay between safety and security in these regions might therefore produce different results. Based on these elements, it would be interesting to study how the governance of security threats and safety risks has developed, and the respective place they share in the governance of societies outside the Western countries. It would also be interesting to conduct the same type of analysis of high-risk organizations and of emergency management in countries with other economic and political systems.

Despite these boundaries set by time and space, I believe this thesis provides important insights. Indeed, I believe the core of this thesis lies in its analysis of emerging elements that challenge an existing paradigm and force the elements to coexist. Although the central focus of this thesis is on safety and security relations, it also contains general insights into how the two elements that present multiple oppositions, but which are, at the same time, intertwined, can be encouraged to co-exist. The lessons of this thesis, although they obviously apply directly to the

management of the relations between safety and security, thus concern a much broader field. I encourage researchers and practitioners to appropriate and extend the reflections of this thesis and to apply them to other domains and other research questions.

3.1.3. The choice of the case studies

The analyses of the relationships between safety and security based on the two case studies sets the stage for further reflections on the relationships between these two case studies. For example, it would be interesting to study the implications of nuclear risk for EM from the angle of the relationships between safety and security. How would a terrorist attack on a nuclear facility resulting in a radioactive release be handled by the external intervention groups and how are tension venues managed between intervening disciplines? How does EM account for the protection of organizations such as the NRC against malicious threats. For instance, what does the existence of both an internal police department and an internal fire department in the NRC imply for EM. Research should also be extended to other infrastructures: Seveso sites or transport critical infrastructures such as railways with high safety concerns are currently also a target for terrorists.

3.1.4. Safety and security in the light of climate change and environmental destruction

In another context, global warming and environmental destruction have an impact on most forms of human and scientific activity. Therefore, studying how they influence the governance of risks in our societies and hence security and safety is more than demanding. Indeed, such hazards represent the paroxysm of the risk society in that it exacerbates all other forms of risk. The destruction of the environment, of habitats for living beings, global warming and its corollaries of

rising and acidifying waters caused by human action will consequently increase the potential for both security and safety crises (IPCC, 2021). Indeed, a society that has been drained by repeated economic crises (caused by economic growth and the impossibility to maintain it) is much less able to maintain and protect its critical infrastructures (power plants, airports, dams, canalized waterways, telecommunication infrastructures, chemical companies, etc.) which, as they deteriorate, could lead to increasingly frequent disasters (Kumar et al., 2021). At the same time, these transformations create social and political tensions that are already perceptible today (Barnett, 2003; Schoch, 2011; Valantin, 2017). More specifically the possibility of massive movements of population (as predicted in a 2021 World Bank report (WB, 2021)) could also increase in security concerns (Abel et al., 2019).

As La porte argues, *'current […] environmental changes will continually increase the relatively hazardous nature of operations such that both increased densities of Safety and Security regimes will be demanded'* (2020, p. 77). This paves the way for potential future research tackling questions such as how to prevent the dangers faced by organizations or societies in a context of scarcity and limited access to resources and increased natural risks and human malevolent threats? Or, how such changes will impact safety and security networks?

3.2. Safety and security cultures as sensitizing concepts for the study of tensions

In light of the results of the other chapters, my reflections around the concepts of safety and security cultures take on another dimension and pave the way for new reflections. If safety and security cultures mark a constructed division between human and non-human aspects, I have shown how they are mutually shaped by humans and non-humans and are not networks that are distinct from those of safety and security, neither are they full-fledged actors of these networks.

Such considerations raise a multiplicity of questions, notably on how to characterize and what role to attribute to safety and security cultures in the framework of safety and security studies. Rather than being perceived as sets of values and principles, should safety and security cultures be understood as angles of approach or sensitizing concepts enabling the analysis and characterization of the values and principles that are intrinsic to the networks of safety and security. These questions also invite reflection on the links between safety and security cultures and safety and security paradoxes. Indeed, these paradoxes are the result of the meeting of antagonistic values and principles between safety and security. Therefore, what could these paradoxes contribute to reflections on security and safety cultures and vice versa? More generally, what links are woven between the cultures of safety and security and these paradoxes? To go further in future research, reflections around safety and security cultures could be mobilized to study the creation of tension venues and how to set them up.

3.3. Trust vs. distrust: safety and security as modes of societal governance

Finally, in chapter 2, I showed how safety and security could impact policy regimes and risk governance. Continuing these reflections, it would be extremely interesting to analyze what safety and security can tell us about the ways dangers are governed at societal level. On the one hand, safety can be analyzed as a mode of governance based on trust. As presented in the introductory section of this thesis, the concept of safety emerged in the context of the industrial risk society and ties the concepts of "risk" and the one of "progress" together. In that respect, safety has developed as much to prevent risks from occurring as to mitigate them to guarantee the economic development of societies. Yet, '*investing in the face of risk[,] presupposes trust.*' (U. Beck, 2002, p. 44).

Trust in the future implied by the concept of progress, but also trust in the actors who compose the world through, for instance, objectives of multidisciplinarity and coordination.

On the other hand, security as a mode of governance presupposes distrust. Indeed, contrary to industrial risks, each terrorist attack represents a form of annihilation of the State (Jasanoff, 2004, p. 1). In security, society is not only understood as an actor-network to be protected in order to make it prosper but also represents the actor-network it needs to be protected from. This implies that the State must also protect itself against its own population (U. Beck, 2002; Dillon, 2007).

These reflections are, in more ways than one, promising for future research. Inquiries could further analyze the impacts of the paradox between trust and distrust on the governance of dangers at societal level, paying due attention to the establishment of trust and distrust within society, between citizens or between employees on the work floor. Indeed, as Beck envisions through his analysis of the threat of terrorist attacks, '*the perception of terrorist threats replaces active trust with active mistrust. It therefore undermines the trust in fellow citizens, foreigners and governments all over the world.*' (U. Beck, 2002, p. 44). This implies a reversal of the attitude towards the population from trust to distrust. Assessing such a statement and its impacts is crucial. These reflections pave the way for in-depth longitudinal studies specifically focusing on danger governance and on their long term impacts.

4. Final Conclusion

Through the two case studies, one of a nuclear research center and the other of emergency management in Belgium, this thesis should be understood as a black box opener. Often apprehended as hollow concepts with no empirical depth or as instruments that are manageable in a top-down fashion, I set out to open the black box of safety and security by removing the opacity surrounding their relationships and raising questions about their enactments and practical interactions.

This thesis highlighted the fact that safety and security correspond to networks developed through the enactment of their own program of action, through the association of human and non-human actors. This research has shown that to account for these relationships and the tensions between safety and security, we need to study - practically and contextually - how these networks unfold and interact. The research also showed that these networks are built around three antagonistic principles advocated by safety or security respectively, namely, facilitation of movement vs. restriction of movement, confidentiality vs. transparency and trust vs. distrust. These three paradoxes emerge at the overlaps of these networks and create tensions. Thereby, I emphasize that these paradoxical tensions cannot be avoided through the integration of the two domains but need to be articulated in order to express their generative potential. To do so, I conceptualized and propose the implementation of structured or ad hoc tension venues.

Finally, this thesis calls for transdisciplinary theorization and management of the relationships between safety and security. Only by bringing together practitioners and academics from safety and security related domains can the ways in which these concepts emerge and are enacted in the field be conceptualized and understood in their entirety. Far from promoting the integration of these two fields within a globalized whole, I recognize the specificities of safety and security and call for their contextualized articulation.

Acknowledgments

Ce manuscrit est trompeur en deux points. Premièrement, son caractère propre et soigné ne reflète pas le voyage tortueux, parsemé de côtes, de changements de direction, de routes non balisées et d'ennuis mécaniques qu'est le doctorat. A la différence des défis que j'ai l'habitude de relever, celui-ci ne demande pas de dépasser des adversaires, mais requiert au contraire de se surpasser soi-même. Deuxièmement, ce manuscrit ne rend pas compte des multiples personnes qui ont permis de faire de ce projet ce qu'il est aujourd'hui. Il est donc grand temps de rendre hommage et remercier les personnes que ce manuscrit était sur le point de passer sous silence. Pour se faire, permettez-moi de passer de manière impromptue du français, à l'anglais et au néerlandais. Qu'il est agréable, après avoir concentré mon intellect et mon esprit sur la production de cette thèse durant 4 ans, de laisser la place à mes sentiments et mes souvenirs et d'écrire avec le cœur.

First of all, I would like to thank Professor Sissel Jore and Doctor Frank Hardeman, members of my jury, whose scientific productions and various interventions have strongly inspired me. J'aimerais également remercier Sébastien Brunet lequel, après avoir fait naître en moi la vocation de l'étude des risques par le biais du cours de « Risques et politique », a accepté avec enthousiasme de présider mon jury.

Pour illustrer le soutien précieux dont j'ai pu bénéficier durant cette aventure tortueuse qu'est le doctorat, la métaphore du voyage à vélo me parait d'autant plus adéquate. En effet, pour arriver au bout de ce périple, je me suis fortement appuyé sur une bicyclette laquelle est tout aussi singulière que robuste.

La monture de celle-ci est dotée tout naturellement de deux roues solides. *The first one is composed of all the members of the Science Policy Support (SPS) group within the nuclear research center. Rich in their diversity, they allowed me to share and confront my observations and reflections throughout the PhD. I would specifically like to thank Hassan, Ferdiana, Stef, and of course Joke (proficiat, je hebt het gedaan!) for your support and your proactivity in organizing activities such as the "PhD get together" that I unfortunately had to decline too*

often. Les rayons de cette première roue sont également Edmond, Marc, Arnaud, Sébastien, Damien, Geoffrey et Guillaume lesquels m'ont accompagnés à travers barrières, caméras de surveillance et contrôles de routine. Je vous remercie tous les 7 de m'avoir autant appris sur le centre, sa diversité et son passé.

La seconde roue correspond au centre de recherche Spiral de l'université de Liège ; ce collectif tout aussi atypique que chaleureux et dont l'identité de chacun de ses membres, est source d'inspiration. Pierre, pour tes conseils judicieux et ta bienveillance. Céline, pour ton entrain et ton engagement. Justine, pour toutes ces marques d'attention et tes encouragements. Isa, pour ta bonne humeur. Max, parce qu'on se retrouve bientôt au sein du SPW. Lucas, parce que tu prends la relève des shorts cyclistes mouillés qui sèchent sur le radiateur. Hélène, pour ta gentillesse, ton sens de l'organisation et tes coupes de cheveux. Mathias, pour tes histoires aussi passionnantes de Chimay et Bruxelles que de Damas ou La Paz. *Kim, om ook in Luik een beetje Nederlands te kunnen praten*. Mohammadi, pour ton parcours de vie inspirant, ton assiduité et tes réflexions avisées. Bonne route à Fanzia, Moufly, Zalissa et à toi. François, parce que tu m'as montré à quel point il faut se jouer de la vie. Tu es et resteras « The BoS » ! Aline, toi qui m'a donné le goût la gestion de crise et de la planification d'urgence. Pour ta gentillesse et pour nos multiples conversations qui je le sais, ne sont pas prêtes de s'arrêter. Juliette, parce que tu m'accompagnes depuis le début dans ce voyage académique (mais aussi festif). Parce que je sais que la relation forte que l'on a nouée perdurera des années. JB, tu es la représentation même de la fidélité et de l'altruisme. Informaticien, traducteur, poète, *gamer* et surtout véritable ami, je ne pense pas que tu cesseras un jour de m'impressionner. Pour toutes ces choses-là, pour vous et pour tous les nouveaux venus, merci !

Pour me diriger à travers les chemins tortueux et escarpés de la thèse, un guidon solide était par ailleurs indispensable. Je me considère particulièrement chanceux d'avoir pu compter, au sein de mon comité de thèse, sur des personnes extrêmement dévouées, patientes et positives. *Ik had het geluk mijn doctoraat te kunnen beginnen met jou, Michiel, als promotor, en het te kunnen beëindigen met jou in mijn proefschriftjury. Je hebt mij begeleid en geïnspireerd, zowel bij mijn veldonderzoek als in het leven in het algemeen.*

Robbe, je vertrouwen, je vooruitziende blik en je beschikbaarheid ('s morgens vroeg en in het weekend) hebben me vaak in staat gesteld mijn kop uit het zand te halen. Catrinel, your investment, your positive attitude and your support have been extremely valuable to me. Catherine, multitâche et infatigable, tu t'es impliquée tellement fort dans ce projet que l'éventualité d'abandonner, n'a jamais été pour moi une option ! Vos remarques et encouragements m'ont donné le boost nécessaire dans la dernière ligne droite.

Par ailleurs, le handball est sans aucun doute le pédalier de ma bicyclette. Plus qu'un sport, il est un mode de vie. Le handball m'a permis tous les soirs de déconnecter, de libérer mon cerveau et mon énergie pour reprendre de plus belle l'étape du lendemain. *Dank aan de Handbalclub Tongeren bij wie ik nu al meer dan 10 jaar mijn passie kan beoefenen.*

Les éléments qui précèdent ne pourraient fonctionner sans un cadre résistant. Celui-ci représente tant la colonne vertébrale que les racines de mon parcours doctoral. Ce cadre est fait dans un alliage composé d'une sacrée bande de potes de Tongres, de Sach, de Wills, de Tilou, des labras, d'Axel, de Geoffrey, du Guil's et bien sûr du Voutch ! Milles mercis pour ces soirées préparées ou improvisées et pour ces rires à gorges déployées. Un bon cadre comprend également la famille, cet ancrage. Je pense aux cousins, Robin, Clem et Justine mais aussi à la famille Natalis-Tamo qui m'a accueilli comme l'un des leur. Bien sûr, je pense aussi à mon frangin, Flo, pour qui je suis fier d'être le cadet. On a tout fait ensemble et nul besoin de mots pour prouver à quel point les liens fraternels sont forts ! À mes grands-parents, dont la simplicité, le relativisme et l'altruisme me donnent des clés pour avancer dans ce monde qui vacille. Finalement, à mes parents, auxquels je dois tout ce parcours. Vous m'apportez tout depuis 27 ans. Pour tout ça, merci à vous ! Vous comptez tellement pour moi !

Finalement, je regarde en arrière et contemple ce parcours. Et dans chacune des milles images qui me viennent en tête, tu es au centre. C'est à toi, Juliette, que j'aimerais dédier le dernier paragraphe de ma thèse. Si ce vélo et tous ses composants ont rendu ce périple possible, j'aurais été incapable de l'accomplir sans la meilleure partenaire de voyage qui soit. Tu es un exemple de spontanéité, de générosité mais aussi de jusqu'auboutisme. Tu m'a permis de garder le cap durant

ces longs mois (dé)confinés. Tu sais tout ce que je pense de toi mais je ne te l'avais jamais écrit. Je t'aime plus que tout mon cœur ! J'écris ces dernières lignes en regardant droit devant moi. J'y entrevoie toutes les opportunités qui s'offrent à nous et je m'impatiente déjà d'ouvrir ce nouveau chapitre de vie avec toi !

References

Aanestad, M. (2003). The Camera as an Actor: Design-in-Use of Telemedicine Infrastructure in Surgery. *Computer Supported Cooperative Work*, *12*, 1–20.

Abel, G. J., Brottrager, M., Crespo Cuaresma, J., & Muttarak, R. (2019). Climate, conflict and forced migration. *Global Environmental Change*, *54*, 239–249. https://doi.org/10.1016/j.gloenvcha.2018.12.003

Akrich, M. (1987). Comment décrire les objets techniques? *Technique & Culture*, *9*, 17.

Akrich, M. (1992). The De-scription of Tehcnical Objects. In W. E. Bijker & J. Law, *Shaping Technology/Building Society. Studies in Sociotechnical Change* (pp. 205–224). MIT Press.

Akrich, M., Callon, M., & Latour, B. (2006). *Sociologie de la traduction. Textes fondateurs*. Presses Des Mines.

Alcadipani, R., & Hassard, J. (2010). Actor-Network Theory, organizations and critique: Towards a politics of organizing. *Organization*, *17*(4), 419–435. https://doi.org/10.1177/1350508410364441

Alexander, D. (2002). *Principles of emergency planning and management*. Oxford University Press.

All European Academies. (2017). *The European Code of Conduct for Research Integrity*. All European Academies.

Allison, G. (2004). *Nuclear Terrorism. The ultimate Preventable Catastrophe*. Times Books.

Amundrud, O., Aven, T., & Flage, R. (2017). How the definition of security risk can be made compatible with safety definitions. *Journal of Risk and Reliability*, *231*(3), 286–294.

Ansell, C., Boin, A., & Keller, A. (2010). Managing Transboundary Crises: Identifying the Building Blocks of an Effective Response System. *Journal of Contingencies and Crisis Management*, *18*(4), 195–207. https://doi.org/10.1111/j.1468-5973.2010.00620.x

Antonsen, S. (2009). Safety culture and the issue of power. *Safety Science*, *47*, 183–191.

Argenti, F., Landucci, G., Spadoni, G., & Cozzani, V. (2015). The assessments of the attractiveness of process facilities to terorrist attacks. *Safety Science*, *77*, 169–181.

Atak, A., & Kingma, S. (2011). Safety culture in an aircraft maintenance organisation: A view from the inside. *Safety Science*, *49*, 268–278.

Atkins, B. (1991). *Building a Lexicon The Contribution of Lexicography*. *4*(3), 167–204. https://doi.org/10.1093/IJL/4.3.167

Aven, T. (2007a). A unified framework for risk and vulnerability analysis covering both safety and security. *Reliability Engineering and System Safety, 92*(6), 745–754. https://doi.org/10.1016/j.ress.2006.03.008

Aven, T. (2007b). A unified framework for risk and vulnerability analysis covering both safety and security. *Reliability Engineering and System Safety*, *92*(6), 745–754.

Aven, T. (2017). How the definition of security risk can be made compatible with safety definitions. *Journal of Risk and Reliability*, *231*(3), 286–294.

Aven, T., Ben-Haim, Y., Boje Andersen, H., Cox, T., Lopez Droguett, E., Greenberg, M., Guikema, S., Kroeger, W., Renn, O., Thompson, K. M., & Zio, E. (2015). *SRA Glossary*. Committee on Foundation of Risk Analysis.

Aven, T., & Renn, O. (2010). *Risk Management and Governance*. Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-642-13926-0

Baiocchi, G., Graizbord, D., & Rodríguez-Muñiz, M. (2013). Actor-Network Theory and the ethnographic imagination: An exercise in translation. *Qualitative Sociology*, *36*(4), 323–341. https://doi.org/10.1007/s11133-013-9261-9

Balducci, A., & Mäntysalo, R. (2013). *Urban Planning as a Trading Zone*. Springer Publishing.

Baldwin, D. A. (1997). The concept of security. *Review of International Studies*, *23*(1), 5–26. https://doi.org/10.1017/S0260210597000053

Balzacq, T., & Dunn Cavelty, M. (2016). A theory of actor-network for cyber-security. *European Journal of International Security*, 1–23.

Barnes, B., & Dolby, R. G. A. (1970). The scientific ethos: A deviant viewpoint. *European Journal of Sociology*, *11*(1), 3–25.

Barnett, J. (2003). Security and climate change. *Global Environmental Change*, *13*(1), 7–17. https://doi.org/10.1016/S0959-3780(02)00080-8

Batra, A., & Nelson, P. (2012a). *Safety, safeguards and security in Indian civil nuclear facilities* (Scientific Report NSSPI-12-010; p. 96). Nuclear Security Science and Policy Institute.

Batra, A., & Nelson, P. (2012b). *Safety, saferguard and security in Indian civil nuclear facilities* (NSSPI-12-010; p. 96). Nuclear Security Science and Policy Institute.

Beck, M., & Kewell, B. (2013). *Risk: A study of its Origins, History and Politics*. World Scientific Publishing.

Beck, U. (1992). *Risk Society: Towards a New Modernity*. Theory, Culture & Society.

Beck, U. (1996). Risk society and the provident state. In S. M. Lash, B. Szerszynski, & B. Wynne, *Risk, Environment and Modernity* (pp. 27–43). Sage Publications.

Beck, U. (2002). The terrorist Threat. World Risk Society Revisited. *Theory, Culture & Society*, *19*(4), 39–55.

Beck, U. (2003). La société du risque globalisé revue sous l'angle de la menace terroriste. *Cahiers Internationaux de Sociologie*, *114*, 27–33.

Beech, N., Burns, H., de Caestecker, L., MacIntosh, R., & MacLean, D. (2004). Paradox as invitation to act in problematic change situations. *Human Relations*, *57*(10), 1313–1332. https://doi.org/10.1177/0018726704048357

Berg, L. (2004). Trust in food in the age of mad cow disease: A comparative study of consumers' evaluation of food safety in Belgium, Britain and Norway. *Appetite*, *42*, 21–32. https://doi.org/10.1016/S0195-6663(03)00112-0

Bernard, B. (2014). Safety culture as a way of responsive regulation: Proposal for a nuclear safety culture oversight model. *International Nuclear Safety Journal*, *3*(2), 1–11.

Bernstein, P. L. (1996). *Against the gods. The remarkable story of risk*. John Wiley & Sons Inc.

Bieder, C., & Pettersen Gould, K. (2020). *The Coupling of Safety and Security Exploring Interrelations in Theory and Practice*. Springer Publishing.

Bielenia-Grajewska, M. (2020). Communicative Approaches to Risk Management in Complex Systems Through the Prism of Actor-Network Theory. In I. Williams (Ed.), *Contemporary Applications of Actor Network Theory* (pp. 15–32). Springer. https://doi.org/10.1007/978-981-15-7066-7_2

Bigo, D. (2006). Internal and External Asperts of Security. *European Security*, *15*(4), 385–404.

Bijker, W. E., Hommels, A., & Mesman, J. (2014). *Vulnerability in Technological Cultures. New Directions in Research and Governance*. The MIT Press.

Bloch, M. (1998). *How We Think They Think*. Westview Press.

Blokland, P. J., & Reniers, G. L. L. (2020). The Concepts of Risk, Safety, and Security: A Fundamental Exploration and Understanding of Similarities and Differences. In C. Bieder & K. Pettersen Gould, *The coupling of safety and security Exploring the interrelations in theory and in practice* (pp. 10–16). Springer International Publishing.

Bloor, D. (1976). *Knowledge and social imagery*. Routledge & Kegan Paul.

Blumer, H. (1954). What is wrong with Social Theory. *American Sociological Review*, *19*(1), 3–10.

Bodenschatz, A., & Irlenbusch, B. (2019). Do two bribe less than one? – An experimental study on the four-eyes-principle. *Applied Economics Letters*, *26*(3), 191–195.

Boholm, M. (2012). The Semantic Distinction Between "Risk" and "Danger": A Linguistic Analysis. *Risk Analysis*, *32*(2), 281–284.

Boholm, M., Möller, N., & Hansson, S. O. (2016). The Concepts of Risk, Safety, and Security: Applications in Everyday Language. *Risk Analysis*, *36*(2), 320–338.

Bonneuil, C., & Fressoz, J.-B. (2013). *L'Evénement Anthropocène: La Terre, l'Histoire et Nous*. Média Diffusion.

Bonneuil, C., Murard, N., Chauvel, L., Ramaux, C., & Lantz, P. (2002). A plusieurs voix sur la société du risque. *Mouvements*, *3*(21–22), 162–177.

Boustras, G. (2020). The interface of safety and security; the workplace. In C. Bieder & K. Pettersen Gould, *The coupling of safety and security. Exploring interrelations in theory and practice* (pp. 96–103). Springer International Publishing.

Bowden, G. (1995). Coming of Age in STS: Some Methodological Musings. In *Handbook of Science and Technology Studies* (pp. 64–79). Sage Publications.

Bowen, G. A. (2006). Grounded Theory and Sensitizing Concepts. *International Journal of Qualitative Methods*, *5*(3), 12–23.

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, *3*(2), 77–101.

Braun, V., & Clarke, V. (2019). *Successful Qualitative Research: A Practical Guide for Beginners* (2nd ed.). Sage Publications.

Brod, M., Tesler, L. E., & Christensen, T. L. (2009). Qualitative research and content validity: Developing best practices based on science and experience. *Quality of Life Research*, *18*(9), 1263–1278. https://doi.org/10.1007/s11136-009-9540-9

Brooks, D. J., & Coole, M. (2020). Divergence of safety and security. In C. Bieder & K. Pettersen Gould, *The coupling of safety and security. Exploring interrelations in theory and practice* (pp. 62–73). Springer International Publishing.

Brunet, S. (2007). *Société du risque: Quelles réponses politiques?* L'Harmattan. https://orbi.uliege.be/handle/2268/5487

Brunet, S. (2018). *Reconvertir la pensée industrielle, pour de nouvelles pratiques politiques*. Couleur livres A.S.B.L.

Brunet, S., Fallon, C., Ozer, P., Schiffino, N., & Thiry, A. (2018). *Risques, Planification d'urgence et gestion de crise*. La charte.

Bruni, A. (2005). Shadowing Software and Clinical Records: On the Ethnography of Non-Humans and Heterogeneous Contexts. *Organization*, *12*(3), 357–378.

Burgess, P. J., Reniers, G. L. L., Ponnet, K., Wim, H., & Wim, S. (2018). *Socially responsible innovation in security. Critical reflections*. Routledge New Security Studies.

Buzan, B. (1991). New patterns of global security in the twenty-first century. *International Affairs*, *67*(3), 431–451. https://doi.org/10.2307/2621945

Callens, S. (2015). Ulrich Beck (1944-2015) et la société mondiale du risque. *Développement Durable et Territoires*, *6*(1), 1–7.

Callon, M. (1985). Eléments pour une sociologie de la traduction. La domestication des coquilles Saint-Jacques et des marins pêcheurs dans la baie de Saint-Brieuc. *L'Année Sociologique*, 40.

Callon, M. (1991). Techno-economic networks and irreversibility. In J. Law, *A sociology of monsters. Essays on power, technology and domination* (pp. 132–161). Routledge.

Callon, M., & Latour, B. (1981). Unscrewing the big Leviathan or how do actors macrostructure reality and how sociologists help them to do so. In *Advances in Social Theory and Methodology: Toward an integration of Micro and Macro Sociologies* (pp. 277–303). Routledge & Kegan Paul.

Calvaresi, C., & Cossa, L. (2013). A Neighbourhood Laboratory for the Regeneration of a Marginalised Suburb in Milan: Towards the Creation of a Trading Zone. In A. Balducci & R. Mäntysalo (Eds.), *Urban Planning as a Trading Zone* (pp. 95–110). Springer Publishing.

Cambacédès, L.-P., & Bouissou, M. (2013). Cross-fertilization between safety and security engineering. *Reliability Engineering & System Safety*, *110*, 110–126. https://doi.org/10.1016/j.ress.2012.09.011

Cambacédès, L.-P., & Chaudet, C. (2010). The SEMA referential framework: Avoiding equivocations on security and safety issues. *Telecom ParisTech*, 14.

Carter, D. P., & May, P. J. (2020). Making sense of the U.S. COVID-19 pandemic response: A policy regime perspective. *Administrative Theory & Praxis*, *42*(2), 265–277. https://doi.org/10.1080/10841806.2020.1758991

CELINFO. (2010). *Explosion rue Léopold à Liège le 27 janvier 2010* [Power Point].

CESRB. (2009). *Code of Ethics for Scientific Research in Belgium*. http://www.enrio.eu/news-activities/resources/code-of-ethics-for-scientific-research-in-belgium/

Chen, C., Reniers, G. L. L., & Khakzad, N. (2019). Integrating safety and security resources to protect chemical industrial parks from man-made domino effects. A dynamic graph approach. *Reliability Engineering & System Safety*, *191*. https://doi.org/10.1016/j.ress.2019.04.023

Choudhry, R. M., Fang, D., & Mohamed, S. (2007). The nature of safety culture: A survey of the state-of-the-art. *Safety Science*, *45*, 993–1012.

Chrisman, N. (1999). Trading Zones or Boundary Objects: Understanding Incomplete Translations of Technical Expertise. *Social Studies of Science Annual Meeting*, 28–31.

Cidell, J. (2012). Just passing through: The risky mobility of hazardous materials transport. *Social Geography*, *7*(1), 13–22.

Cipollaro, A., & Lomonaco, G. (2016). Contributing to the nuclear 3S's via a methodology aiming at enhancing the synergies between nuclear security and safety. *Progress in Nuclear Energy*, *86*, 31–39. https://doi.org/10.1016/j.pnucene.2015.09.013

Claisse, F., Brunet, S., & Rogister, Y. (2002). des risques modernes à la société réflexive: Pour une autre approche du (bio) terrorisme. *Éthique Publique*, *4*(2), 115–131.

Clarke, A. E., & Star, S. L. (2008). The Social Worlds Framework: A theory/Method Package. In E. J. Hackett, O. Amstermsdka, M. Lynch, & J. Wajcman (Eds.), *The Handbook of Science and Tehcnology Studies* (3rd ed., pp. 113–137). The MIT Press.

Collins, H., Evans, R., & Gorman, M. (2007). Trading zones and interactional expertise. *Studies in History and Philosophy of Science*, *38*, 657–666.

Collins, H. M. (1981). Stages in the Empirical Programme of Relativism. *Social Studies of Science*, *11*(1), 3–10. https://doi.org/10.1177/030631278101100101

Collins, H. M., & Harrison, R. G. (1975). Building a TEA Laser: The Caprices of Communication. *Social Studies of Science*, *5*(4), 441–450. https://doi.org/10.1177/030631277500500404

Commission attentats. (2016). *Comptes rendus intégraux des auditons de la commission parlementaire sur les attentats de Bruxelles du 22 mars 2016*. (p. 625) [Comptes rendus intégraux]. Federal Parliament.

Cooper, J., Lewis, R., & Urquhart, C. (2004). Using participant or non-participant observation to explain information behaviour. *Information Research*, *9*(4), 1–16.

Cooper, M. D. (2000). Towards a model of safety culture. *Safety Science*, *36*, 111–136.

Cooper, M. D. (2016). Navigating the safety culture construct: A review of the evidence. *International Conference on Safety Culture*, 36.

Cooper, S. (2008). Regulating Hybrid Monsters? The limits of Latour and Actor Network Theory. *Arena Journal*, *28*(30), 306–331.

Cox, S., & Cox, T. (1991). The structure of employee attitudes to safety: An European example. *Work and Stress*, *5*(2), 93–106.

Cox, S., & Flin, R. (1998). Safety culture: Philosopher's stone or man of straw? *Work and Stress*, *12*(3), 189–201. https://doi.org/10.1080/02678379808256861

Creswell, J. W. (2006). *Qualitative Inquiry & Research Design. Choosing among five approaches* (2nd ed.). Sage Publications.

Cronbach, L. J. (1975). Beyond the two disciplines of scientific psychology. *American Psychologist*, *30*, 116–127.

Cusimano, J., & Byers, E. (2010). Safety and Security: Two Sides of the Same Coin. *Control Global*, 14–15.

Dandeker, C. (1990). *Surveillance, Power, and Modernity: Bureaucracy and Discipline from 1700 to the Present Day*. Cambridge Polity Press.

De Larrinaga, M., & Doucet, M. G. (2008). Sovereign Power and the Biopolitics of Human Security. *Security Dialogue*, *39*(5), 517–537.

De Munck, B. (2017). Re-assembling Actor-Network Theory and urban history. *Urban History*, *44*(1), 111–122. https://doi.org/10.1017/S0963926816000298

de Raymond, A. B., Israël, L., Jiminez, R., Mallard, G., & Revillard, A. (2004). Droit, réfléxivité et sciences sociales. Autour du livre de Bruno Latour: La Fabrique du droit (confrontations). *Travaux et Terrain*, *1*(6), 159–180.

de Roy van Zuijdewijn, J. (2016). Terrorism and Beyond: Exploring the Fallout of the European Foreign Fighter Phenomenon in Syria and Iraq. *Perspectives on Terrorism*, *10*(6), 82–96.

Dean, M. (2010). Introduction: Basic Concepts and Themes. In *Governmentality. Power and rule in modern society* (second edition). Sage Publications. https://www.schillingcts.com/wp-content/uploads/2017/09/Basic-Concepts-and-Themes-2010-Mitchell-Dean.pdf

Dekker, S. (2011). *Drift into failure. From hunting broken components to understanding complex systems*. Ashgate Publishing.

Deleuze, G. (1990). Post-scriptum sur les sociétés de contrôles. *L'autre Journal*, *1*, 242–246.

Denzin, N. K. (1989). *Interpretive interactionism*. Sage Publications.

Denzin, N. K., & Lincoln, Yvonna. S. (1994). *Handbook of qualitative research* (Vol. 1). Sage Publications.

Department of Homeland Security. (2007). *DHS Lexicon: Terms and Definitions* (p. 28) [Lexicon]. Department of Homeland Security. https://dhsonline.dhs.gov/portal/jhtml/dc/sf.jhtml?doid=52981

Diedrich, A., & Styhre, A. (2012). International expertise and local know-how in the trading zone. *Scandinavian Journal of Management*, *28*, 340–351.

Dillon, M. (2007). Governing Terror: The State of Emergency of Biopolitical Emergence. *International Political Sociology*, *1*(1), 7–28. https://doi.org/10.1111/j.1749-5687.2007.00002.x

Dillon, M., & Lobo-Guerrero, L. (2008). Biopolitics of security in the 21st century: An introduction. *Review of International Studies*, *34*, 265–292.

Dubois, M. (2016). « Cela nous a échappé… »: Théorie de l'acteur-réseau et le problème des générations scientifiques. *Social Science Information*, *56*(1), 107–141.

Dupont, I., & Reniers, G. L. L. (2010). Vergelijkende studie tussen veiligheid en beveiliging: Toepassen van proactieve beschermingsprogramma's bij kritieke infrastructuren. *Economics & Management*, 1–29.

Dwiartama, A., & Rosin, C. (2014). Exploring agency beyond humans: The compatibility of Actor-Network Theory (ANT) and resilience thinking. *Ecology and Society*, *19*(3). https://www.jstor.org/stable/26269633

Dykstra, E. H. (2003). *Toward an International System Model in Emergency Management*. Public Entity Risk Institute Symposium.

Edwards, J. R. D., Davey, J., & Armstrong, K. (2013). Returning to the roots of culture: A review and re-conceptualisation of safety culture. *Safety Science*, *55*, 70–80.

ENSREG. (2013). *What is nuclear safety?* [International Organization Web page]. https://www.ensreg.eu/nuclear-safety

Consolidated versions of the Treaty on European Union and the Treaty on the Functioning of the European Union, C 326, Official Journal PP. 1 (2007).

Directive 2012/18/EU of the European Parliament and of the Council of 4 July 2012 on the control of major-accident hazards involving dangerous substances, amending and subsequently repealing Council Directive 96/82/EC, Pub. L. No. L 197/1, Official Journal of the European Union 1 (2012).

Farazmand, A. (2007). Learning from the Katrina Crisis: A Global and International Perspective with Implications for Future Crisis Management. *Public Administration Review*, *67*(1), 149–159. https://doi.org/10.1111/j.1540-6210.2007.00824.x

Fenwick, T., & Richard, E. (2013). Performative ontologies. Sociomaterial approaches to researching adult education and lifelong learning. *European Journal for Research on the Education and Learning of Adults*, *4*(1), 49–63.

Fiss, P. C., & Zajac, E. J. (2006). The Symbolic Management of Strategic Change: Sensegiving via Framing and Decoupling. *Academy of Management Journal*, *49*(3), 1179–1193.

Flick, U. (Ed.). (2014). *The SAGE Handbook of Qualitative Data Analysis*. Sage Publications.

Flory, D. (2013). *Strengthening nuclear safety and security globally a continued international challenge*. 1–8.

Foucault, M. (1993). *Surveiller et punir: Naissance de la prison*. Gallimard. https://primo.lib.ulg.ac.be/primo_library/libweb/action/dlDisplay.do?vid=32ULG_VU1&afterPDS=true&docId=32ULG_ALMA2156427910002321

Foucault, M. (1997). *Language, counter-memory, practice: Selected essays and interviews* (D. F. Bouchard, Ed.; S. Simon, Trans.; 10. pr). Cornell Univ. Press.

Foucault, M. (2004). *Sécurité, Territoire, Population, cours au collège de France 1977-1978*. Editions Seuil. https://www.seuil.com/ouvrage/securite-territoire-population-michel-foucault/9782020307994

Fressoz, J.-B. (2012). *Apocalypse Joyeuse. Une histoire du risque technologique*. Editions Seuil.

Frost, R. (2004). Nuclear Terrorism Post-9/11: Assessing the Risks. *Global Society*, *18*(4), 397–422.

Fucks, I. (2004). *La culture de sûreté selon une démarche compréhensive. Une contribution à la gouvernance des risques dans des systèmes complexes.* [Doctoral Thesis]. Centre d'Etude de l'Energie Nucléaire.

Furnham, A., & Gunter, B. (2015). *Corporate Assessment*. Routledge.

Fusch, P., Fusch, G., & Ness, L. (2018). Denzin's Paradigm Shift: Revisiting Triangulation in Qualitative Research. *Journal of Social Change*, *10*(1), 19–32. https://doi.org/10.5590/JOSC.2018.10.1.02

Fusch, P. I., & Ness, L. R. (2015). *Are We There Yet? Data Saturation in Qualitative Research*. 9.

Galison, P. L. (1999). Reflections on Image and Logic: A Material Culture of Microphysics. *Perspectives on Science*, *7*(2), 255–284.

Galison, P. L. (2013). Trading Plans. In A. Balducci & R. Mäntysalo (Eds.), *Urban Planning as a Trading Zone* (pp. 95–110). Springer Publishing.

Gandhi, S., & Kang, J. (2013). Nuclear safety and nuclear security synergy. *Annals of Nuclear Energy*, *60*, 357–361.

Geertz, C. (1973). *The interpretation of cultures*. Basic Books.

Geertz, C. (1993). *The interpretation of cultures*. Basic Books.

Gherardi, S., & Nicolini, D. (2000). To Transfer is to Transform: The Circulation of Safety Knowledge. *Organization*, *7*(2), 329–348. https://doi.org/10.1177/135050840072008

Gieryn, T. F. (2002). What Buildings Do. *Theory and Society*, *31*(1), 35–74.

Gilbert, C., Journé, B., Laroche, H., & Bieder, C. (Eds.). (2018). *Safety cultures, Safety models. Taking stock and moving forward*. Springer Publishing.

Gilliom, J. (2001). *Overseers of the Poor: Surveillance, Resistance, and the Limits of Privacy*. University of Chicago Press.

Glendon, A. I., & Stanton, N. A. (2000). Perspectives on safety culture. *Safety Science*, *34*, 193–214.

Glesner, C. (2018). La gestion du risque sous tension! L'intelligence collective ou l'émulation sans ingérence. In S. Brunet, C. Fallon, P. Ozer, N. Schiffino, & A. Thiry (Eds.), *Risques, planification d'urgence et gestion de crise* (p. 324). La charte. https://dial.uclouvain.be/pr/boreal/object/boreal:212476

Glesner, C., Van Oudheusden, M., Fallon, C., & Turcanu, C. (2020). Bringing symmetry between and within safety and security cultures in high-risk organizations. *Safety Science*. https://doi.org/10.1016/j.ssci.2020.104950

Gomm, R., Hammersley, M., & Foster, P. (Eds.). (2000). *Case Study Method. Key Issues*. Sage Publications.

Goulet, F., & Vinck, D. (2012). L'innovation par retrait. Contribution à une sociologie du détachement. *Revue Française de Sociologie*, *53*(2), 195–224.

Gouvernement de Belgique. (1836). *Loi Communale du 30 Mars 1836*. Moniteur belge. https://unionisme.be/loi_communale.htm

Gouvernement de Belgique. (1963). *Loi du 31 décembre 1963 sur la protection civile*.

Gouvernement de Belgique. (2003a). *Arrêté royal portant fixation du plan d'urgence pour les événements et situations de crise nécessitant une coordination ou une gestion à l'échelon national*.

Gouvernement de Belgique. (2003b). *Loi sur la planification d'urgence du 28 mars 2003*.

Gouvernement de Belgique. (2006a). *Circulaire ministérielle NPU-1 relative aux plans d'urgence et d'intervention*.

Gouvernement de Belgique. (2006b). *Arrêté royal du 16 février 2006 relatif aux plans d'urgence et d'intervention*. 8.

Gouvernement de Belgique. (2009a). *Circulaire ministérielle NPU-2 relative au plan général d'urgence et d'intervention du Gouverneur de province*.

Gouvernement de Belgique. (2009b). *Circulaire ministérielle NPU-3 relative a l'approbation des plans d'urgence et d'intervention provinciaux*.

Gouvernement de Belgique. (2009c). *Circulaire ministérielle NPU-4 relative aux disciplines*.

Gouvernement de Belgique. (2011). *Arrêté royal du 17 octobre 2011 relatif à la protection physique des matières nucléaires et des installations nucléaires*. 10.

Gouvernement de Belgique. (2016). *Arrêté royal portant fixation du plan d'urgence national relatif à l'approche d'une prise d'otage terroriste ou d'un attentat terroriste* [Law].

Code du bien-être au travail, Federal parliament, Livre III (2017) (testimony of Gouvernement de Belgique).

Gouvernement de Belgique. (2020). *Arrêté royal portant fixation du plan d'urgence national relatif à l'approche d'une prise d'otage terroriste ou d'un attentat terroriste,*.

Graff Lambsdorff, J. (2015). *Preventing corruption by promoting trust: Insights from behavioral science* (p. 18) [Passauer Diskussionspapiere - Volkswirtschaftliche Reihe]. Universität Passau, Wirtschaftswissenschaftliche Fakultät.

Graham, S. (1998). *The end of geography or the explosion of place? Conceptualizing space, place and information technology. 22*(2), 165–185.

Grote, G., & Künzler, C. (2000). Diagnosis of safety culture in safety management audits. *Safety Science*, *34*, 131–150.

Guldenmund, F. . W. (2018). Understanding safety culture through models and metaphors. In *Safety cultures, Safety models: Taking stock and moving forward* (pp. 21–34). Springer Publishing.

Guldenmund, Frank. W. (2000). The nature of safety culture: A review of theory and research. *Safety Science*, *34*, 215–257.

Guldenmund, Frank. W. (2007). The use of questionnaires in safety culture research – an evaluation. *Safety Science*, *45*, 723–742.

Gutting, G. (1990). Foucault's Genealogical Method. *Midwest Studies in Philosophy*, *15*, 327–343. https://doi.org/10.1111/j.1475-4975.1990.tb00221.x

Haavik, T. K. (2011). On Components and Relations in Sociotechnical Systems. *Journal of Contingencies and Crisis Management*, *19*(2), 99–109.

Haddow, G. D., Bullock, J. A., & Coppola, D. P. (2017). *Introduction to emergency management* (Third Edition). Butterworth-Heinemann Books.

Haftendorn, H. (1991). The Security Puzzle: Theory-Building and Discipline-Building in International Security. *International Studies Quarterly*, *35*(1), 3–17. https://doi.org/10.2307/2600386

Hahn, C. (2011). *Intersection between nuclear safety and nuclear security*. Asan Plenum: Our nuclear future, Seoul South Korea.

Hansel, P. A. (1999). Mad Cow Disease—The OR Connection. *AORN Journal*, *70*(2), 224–238. https://doi.org/10.1016/S0001-2092(06)62237-0

Harsh, S. (2011). Purposeful sampling in qualitative research synthesis. *Qualitative Research Journal*, *11*(2), 63–75.

Harvey, J., Erdos, G., Bolam, H., Cox, M. A. A., Kennedy, J. N. P., & Gregory, D. T. (2002). An Analysis of Safety Culture Attitudes in a Highly Regulated Environment. *Work and Stress*, *16*(1), 18–36.

Hashim, W., & et. al. (2011). *Integration of Nuclear Safety, Security and Safeguards Systems*. GNEII Capstone project.

Haukelid, K. (2008). Theories of (safety) culture revisited—An anthropological approach. *Safety Science*, *46*, 413–426.

Healy, S. (2004). A 'post-foundational' interpretation of risk: Risk as 'performance.' *Journal of Risk Research*, *7*(3), 277–296. https://doi.org/10.1080/1366987042000176235

Heller, C. (2002). From Scientific Risk To Paysan Savoir-Faire: Peasant Expertise in the French and Global Debate over GM Crop. *Science as Culture*, *11*(1), 5–37.

Hennion, A. (2013). D'une sociologie de la médiation à une pragmatique des attachements. Retour sur un parcours sociologique au sein du CSI. *SociologieS*, 1–31.

Henriqson, E., Schuler, B., Van Winsen, R., & Dekker, S. W. A. (2014). The constitution and effects of safety culture as an object in the discourse of accident prevention: A Foucauldian approach. *Safety Science*, *70*, 465–476.

Hess, D. (2002). Ethnography of the Development of Science and Technology Studies. In P. A. Atkinson, A. J. Coffey, S. Delamont, J. Lofland, & L. H. Lofland (Eds.), *Handbook of Ethnography* (pp. 234–245).

Hessami, A. G. (2004). A systems framework for safety and security: The holistic paradigm. *Systems Engineering*, *7*(2), 99–112. https://doi.org/10.1002/sys.10060

Hofstede, G. (1994). *Cultures And Organizations, Intercultural cooperation and its importance for survival—Software of the Mind, the successful strategist series*. Harper Collins Business.

Hollnagel, E. (2014). *Safety I, safety II, The past and future of Safety Management.* Ashgate Publishing.

Holtrop, D., & Kretz, D. (2008). *Onderzoek security & safety: Een inventarisatie van beleid, wet- en regelgeving*. Arcadis.

Hood, C., Rothstein, H., Spackman, M., Rees, W. J., & Baldwin, R. (1999). Explaining risk regulation regimes: Exploring the 'minimal feasible response' hypothesis. *Health, Risk & Society*, *1*(2), 151–166. https://doi.org/10.1080/13698579908407015

Hopkins, A. (2016). *Quiet Outrage: The way of a sociologist*. Wolters Kluwers.

Howlett, M. (2009). Governance modes, policy regimes and operational plans: A multi-level nested model of policy instrument choice and policy design. *Policy Sciences*, *42*, 73–89.

Huang, D. T., Clermont, G., Sexton, J. B., Karlo, C. A., Miller, R. G., Weissfeld, L. A., Rowan, K. M., & Angus, D. C. (2007). Perceptions of safety culture vary across the intensive care units of a single institution. *Critical Care Medicine*, *35*, 165–176.

Huzzard, T., & Ostergren, K. (2002). When Norms Collide: Learning under Organizational Hypocrisy. *British Journal of Management*, *13*(2), 47–59.

IAEA. (1986). *INSAG-1: The Chernobyl Accident*. International Atomic Energy Agency.

IAEA. (1991). *Safety Culture (Safety Series No 75- INSAG-4)*. International Atomic Energy Agency.

IAEA. (1996). *INSAG-10. Defense in depth in nuclear safety* (INSAG, p. 48) [Report from the International Nuclear Safety Advisory Group]. International Atomic Energy Agency.

IAEA. (2001). *Measures to improve the security of nuclear materials and other radioactive materials. GOV/2001/41*. General Conference IAEA.

IAEA. (2004). *Code of conduct on the safety and security of radioactive sources*. International Atomic Energy Agency.

IAEA. (2008a). *Nuclear Security Culture*. International Atomic Energy Agency.

IAEA. (2008b). *SCART GUIDELINES. Reference report for IAEA Safety Culture Assessment Review Team (SCART)*. International Atomic Energy Agency.

IAEA. (2009). *Culture de sécurité nucléaire. Collection Sécurité nucléaire de l'AIEA N°7*. International Atomic Energy Agency.

IAEA. (2010). *The Interface Between Safety and Security at Nuclear Power Plants. INSAG-24*. International Atomic Energy Agency.

IAEA. (2016a). *IAEA Safety Glossary. Terminology used in nuclear safety and radiation protection*. International Atomic Energy Agency.

IAEA. (2016b). *Management of the interface between nuclear safety and security for research reactors*. International Atomic Energy Agency.

IAEA. (2017). *Culture For Safety. Nuclear Safety and Security Programme*. International Atomic Energy Agency.

IAEA. (2019). *Management of the Interface between Nuclear Safety and Security for Research Reactors*. International Atomic Energy Agency.

IAEA. (2020). *Design Basis threat* [International Organization Web page]. International Atomic Energy Agency. https://www.iaea.org/topics/security-of-nuclear-and-other-radioactive-material/design-basis-threat

Ihde, D. (1995). *Postphenomenology: Essays in the Postmodern Context*. Northwestern University Press.

IPCC. (2021). *AR6 Synthesis Report: Climate Change 2022 — IPCC* [International Organization Web page]. https://www.ipcc.ch/report/sixth-assessment-report-cycle/

Jasanoff, S. (1994). *Learning from Disaster: Risk Management After Bhopal*. University of Pennsylvania Press.

Jasanoff, S. (2004). *States of Knowledge: The Co-Production of Science and the Social Order*. Routledge.

Jasanoff, S. (2014). Vulnerability and Development-Bhopal's Lasting Legacy. In A. Hommels, J. Mesman, & W. E. Bijker, *Vulnerability in Technological Cultures: New Directions in Research and Governance* (pp. 89–108). The MIT Press.

Johnston, R. G. (2004). Adversarial safety analysis: Borrowing the methods of security vulnerability assessments. *Journal of Safety Research*, *35*, 245–248.

Joly, P.-B. (2015). Governing Emerging Technologies – The need to think out of the (black) box. In S. Hilgartner, C. A. Miller, & R. Hagendijk, *Science and Democracy—Making Knowledge and Making Power in the Biosciences and Beyond*. Routledge.

Jore, S. H. (2017a). Safety and security- Is there a need for an integrated approach? In L. Walls, M. Revie, & T. Bedford, *Risk, Reliability and Safety: Innovating Theory and Practice* (pp. 852–859). Taylor & Francis Group.

Jore, S. H. (2017b). Security culture—A sufficient explanation for a terrorist attack? In T. Bedford, M. Revie, & L. Walls, *Risk, Reliability and Safety: Innovating Theory and Practice Proceedings of ESREL 2016 (Glasgow, Scotland, 25-29 September 2016)* (pp. 467–474). Taylor & Francis Group.

Jore, S. H. (2019). The Conceptual and Scientific Demarcation of Security in Contrast to Safety. *European Journal for Security Research*, *4*, 157–174. https://doi.org/DOI 10.1007/s41125-017-0021-9

Jorgensen, D. L. (2015). Participant Observation. In R. A. Scott & S. M. Kosslyn, *Emerging Trends in the Social and Behavioral Sciences* (pp. 1–15). American Cancer Society. https://doi.org/10.1002/9781118900772.etrds0247

K. Smith, W., Erez, M., Jarvenpaa, S., Lewis, M. W., & Tracey, P. (2017). Adding Complexity to Theories of Paradox, Tensions, and Dualities of Innovation and Change: Introduction to Organization Studies Special Issue on Paradox, Tensions, and Dualities of Innovation and Change. *Organization Studies*, *38*(3–4), 303–317. https://doi.org/10.1177/0170840617693560

Kahila-Tanni, M. (2013). SoftGIS Development Process as a Trading Zone: Challenges in Implementing a Participatory Planning Support System. In A. Balducci & R. Mäntysalo (Eds.), *Urban Planning as a trading zone* (pp. 75–94). Springer Publishing.

Kassim, H., & Galès, P. L. (2010). Exploring Governance in a Multi-Level Polity: A Policy Instruments Approach. *West European Politics*, *33*(1), 1–21. https://doi.org/10.1080/01402380903354031

Kawulich, B. B. (2005). Participant Observation as a Data Collection Method. *Forum Qualitative Sozialforschung / Forum: Qualitative Social Research*, *6*(2), Article 2. https://doi.org/10.17169/fqs-6.2.466

Keesing, R. M. (1987). Anthropology as interpretive quest. *Current Anthropology*, *28*, 161–176.

Keesing, R. M. (1994). Theories of culture revisited. In R. Borofsky, *Assessing cultural anthropology: Vol. Vol. XIX* (p. 566s). McGraw-Hill.

Keller, L. W., Schaper, K. L., & Johnson, C. D. (1980). A hazardous materials identification system for the coatings and resins industry. *American Industrial Hygiene Association Journal*, *41*(12), 901–907.

Khripunov, I., & Kim, D. (2008). Time to think safety and security. *Korean Times*. http://www.koreatimes.co.kr/www/news/opinon/2011/08/137_92394.html

Kim, D., & Kang, J. (2012). Where nuclear safety and security meet. *Bulletin of the Atomic Scientists*, *68*(1), 86–93.

Kletz, T. A. (1999). The origins and history of loss prevention. *Institution of Chemical Engineers*, *77*(B), 108–115.

Koenick, S. (2011). *Safety and Security Interface*. International Atomic Energy Agency.

Komasová, S. (2021). Airport security as translation through division and movement. *Social Studies of Science*. https://doi.org/10.1177/03063127211037733

Kono, T. (1990). Corporate culture and long-range planning. *Long Range Planning*, *23*(4), 9–19. https://doi.org/10.1016/0024-6301(90)90148-W

Krackhardt, D., & Kilduff, M. (1990). Friendship patterns and culture: The control of organization diversity. *American Anthropologist*, *92*(1).

Kriaa, S., Pietre-Cambacedes, L., Bouissou, M., & Halgand, Y. (2015). A survey of approaches combining safety and security for industrial control systems. *Reliability Engineering and System Safety*, *139*, 156–178.

Kumar, N., Poonia, V., Gupta, B. B., & Goyal, M. K. (2021). A novel framework for risk assessment and resilience of critical infrastructure towards climate change. *Technological Forecasting and Social Change*, *165*, 120532. https://doi.org/10.1016/j.techfore.2020.120532

La chambre des représentants de Belgique. (2018). *Commission d'enquête- attentats Terroristes 22 Mars 2016. Résumé des travaux et recommandations* (p. 84) [Emergency management debriefing]. La chambre des représentants de Belgique.

La Porte, T. R. (2020). Doing safety... And then security: Mixing operational challenges—Preparing to be surprised. In C. Bieder & K. Pettersen Gould, *The coupling of safety and security. Exploring interrelations in theory and practice* (pp. 74–85). Springer International Publishing.

Laqueur, W. (2017). *A History of Terrorism*. Routledge. https://doi.org/10.4324/9781315083483

Lascoumes, P. (2007). *Les instruments d'action publique, traceurs de changement: L'exemple des transformations de la politique française de lutte contre la pollution atmosphérique (1961-2006)*. *26*(2–3), 73–89.

Lascoumes, P., & Le Gales, P. (2007). Introduction: Understanding Public Policy through Its Instruments—From the Nature of Instruments to the Sociology of Public Policy Instrumentation. *Governance: An International Journal of Policy, Administration, and Institutions , 20*(1), 1–21.

Latour, B. (1984a). *Les Microbes. Guerre et paix*. Pandore.

Latour, B. (1984b). The Powers of Association. *The Sociological Review*, *32*(1_suppl), 264–280. https://doi.org/10.1111/j.1467-954X.1984.tb00115.x

Latour, B. (1987). *Science in Action: How to Follow Scientists and Engineers through Society*. Harvard University Press.

Latour, B. (1990). Drawing Things Together. In M. Lynch & S. Woolgar, *Representation in Scientific Practice* (pp. 19–68). MIT Press.

Latour, B. (1992). Where are the Missing Masses? The Sociology of a Few Mundane Artifacts. In W. E. Bijker & J. Law, *Shaping Technology/Building Society: Studies in Sociotechnical Change* (pp. 225–258). MIT Press.

Latour, B. (1993a). *La clef de Berlin et autres leçons d'un amateur de sciences*. La découverte.

Latour, B. (1993b). *Petites leçons de sociologie des sciences*. La découverte.

Latour, B. (1994). On Technical Mediation. *Common Knowledge*, *3*(2), 29–64.

Latour, B. (2000a). La fin des moyens. *Réseaux*, *18*(100), 39–58.

Latour, B. (2000b). *Pandora's hope: Essays on the Reality of Science Studies* (1st ed.). Harvard University Press.

Latour, B. (2001). Réponse aux objections... *Revue Du MAUSS*, *1*(17), 137–152.

Latour, B. (2005). *Reassembling the Social: An introduction to Actor-Network Theory*. Oxford University Press.

Latour, B. (2007). Le fardeau moral d'un porte-clefs. *Sciences humaines et sociales*, 47–55.

Latour, B. (2010a). *Avoir ou ne pas avoir de réseau: That's the question In: Débordements: Mélanges offerts à Michel Callon*. Presses Des Mines. http://books.openedition.org/pressesmines/753

Latour, B. (2010b). *The Making of Law: An Ethnography of the Conseil D'Etat*. Polity.

Latzko-Toth, G. (2009). *L'étude de cas en sociologie des sciences et des techniques. Note de recherche*. Centre Interuniversitaire de recherche sur la science et la technologie.

Law, J. (1987). The Structure of Sociotechnical Engineering—A Review of the New Sociology of Technology. *The Sociological Review*, *35*(2), 404–425. https://doi.org/10.1111/j.1467-954X.1987.tb00015.x

Law, J. (1990). Introduction: Monsters, Machines and Sociotechnical Relations. *The Sociological Review*, *38*(1_suppl), 1–23. https://doi.org/10.1111/j.1467-954X.1990.tb03346.x

Law, J. (1992). Notes on the theory of the actor-network: Ordering, strategy, and heterogeneity. *Systems Practice*, *5*(4), 379–393. https://doi.org/10.1007/BF01059830

Law, J. (2004). *After Method: Mess in Social Science Research*. Routledge.

Le Coze, J. C. (2013). New models for new times. An anti-dualist move. *Safety Science*, *59*, 200–218.

Le Coze, J. C. (2019). How can safety culture can make us think. *Safety Science*, *118*, 221–229.

Lebailly, P. (2003). Sécurité alimentaire et crise de la dioxine en Belgique. *Sécurité Alimentaire et Crise de La Dioxine En Belgique*, 1000–1008. https://doi.org/10.1400/32711

Lee, T., & Harrison, K. (2000). Assessing Safety Culture in Nuclear Power Stations. *Safety Science*, *34*(1–3), 61–97. https://doi.org//10.1016/S0925-7535(00)00007-2

Leveson, N. (1993). *Safeware: System Safety and Computers*. Addison-Wesley.

Leveson, N. (2020). Safety and security are two sides of the same coin. In C. Bieder & K. Pettersen Gould, *The coupling of safety and security. Exploring the interrelations between theory and practice* (pp. 17–27). Springer International Publishing.

Levi, R., & Valverde, M. (2008). Studying Law by Association: Bruno Latour Goes to the Conseil d'État. *Law & Social Inquiry*, *33*(3), 805–825. https://doi.org/10.1111/j.1747-4469.2008.00122.x

Lewis, M. W. (2000). Exploring Paradox: Toward a More Comprehensive Guide. *Academy of Management Review*, *25*(4), 760–776.

Lillis, T. (2008). Ethnography as Method, Methodology, and "Deep Theorizing": Closing the Gap Between Text and Context in Academic Writing Research. *Written Communication*, *25*(3), 353–388. https://doi.org/10.1177/0741088308319229

Lundberg, C. C. (1990). Surfacing organisational culture. *Journal of Managerial Psychology*, *5*(4), 19–26.

Lupton, D. (1999). *Risk and Sociocultural Theory: New Directions and Perspectives*. Cambridge University Press.

Lyon, D. (2001). *Surveillance Society: Monitoring Everyday Life*. Open University Press.

MacMullin, K., Jerry, P., & Cook, K. (2020). Psychotherapist experiences with telepsychotherapy: Pre COVID-19 lessons for a post COVID-19 world. *Journal of Psychotherapy Integration*, *30*(2), 248–264. https://doi.org/10.1037/int0000213

Mainz, J. (2008). Relationalität und räumliche dynamik von risiken—Ein bioterroristisches szenario aus der perspektive der actor-network theory. In C. Felgentreff & Glade T., *Naturrisiken und Sozialkatastrophen* (pp. 411–419). Spektrum.

Malcolmson, J. (2009). *What is security culture? Does it differ in content from general organisational culture?* 361–367. https://doi.org/10.1109/CCST.2009.5335511

Manunta, G. (2007). Speculating on Security as a Field of Study and Practice. *Security Journal*, *20*(1), 19–22. https://doi.org/10.1057/palgrave.sj.8350039

May, P. J., & Jochim, A. E. (2013). Policy Regime Perspectives: Policies, Politics, and Governing. *Policy Studies Journal*, *41*(3), 426–452. https://doi.org/10.1111/psj.12024

Mbaye, S., Kouabenan, R., & Sarnin, P. (2009). Le Retour d'Expérience processus sociocognitifs dans l'explication des dysfonctionnements. *Fondation pour une culture de sécurité industrielle*, 43.

Metcalfe, A., & Ferguson, L. (2001). Half-opened being. In J. May & N. Thrift, *Timespace: Geographies of temporality* (pp. 240–261). Routledge.

Michaud, V. (2011). Proposition pour l'étude des tensions dans le mouvement, la sociomatérialité et le paradoxe. *Revue de communication sociale et publique*, *5*, 47–74.

Miron-Spektor, E., Ingram, A., Keller, J., Smith, W. K., & Lewis, M. W. (2018). Microfoundations of Organizational Paradox: The Problem Is How We Think about the Problem. *Academy of Management Journal*, *61*(1), 26–45. https://doi.org/10.5465/amj.2016.0594

Mol, A. (2002). *The body multiple. Ontology in Medical Practice*. Duke University Press.

Mountjoy, A. B. (2017). *Industrialization and Underdeveloped Countries* (2nd ed.). Routledge. https://doi.org/10.4324/9780203788646

Mumby, D. K. (2005). Theorizing Resistance in Organization Studies: A Dialectical Approach. *Management Communication Quarterly*, *19*(1), 19–44. https://doi.org/10.1177/0893318905276558

Munro, R. (2009). Actor-Network Theory. In S. R. Clegg & M. Haugaard (Eds.), *The SAGE Handbook of Power* (pp. 125–139). Sage Publications.

Murdoch, J. (1998). The spaces of actor-network theory. *Geoforum*, *4*, 357–374.

Mythen, G. (2006). *Ulrich Beck: A critical introduction to risk society*. Pluto Press.

Naevestad, T.-O. (2008). Safety Understandings among Crane Operators and Process Operators on a Norwegian Offshore Platform. *Safety Science*, *46*, 520–534.

Naevestad, T.-O. (2009). Mapping Research on culture and Safety in High-Risk Organizations: Arguments for a Sociotechnical Understanding of Safety Culture. *Journal of Contingencies and Crisis Management*, *7*(2), 126–136.

Neisser, F. M. (2014). "Riskscapes" and risk management—Review and synthesis of an actor-network theory approach. *Risk Management*, *16*(2), 88–120.

Neyland, D. (2008). *Organizational Ethnography*. Sage Publication.

Norman, D. A. (2000). *Design of everyday things*. Currency/Doubleday Publishers.

Nosengo, N. (2012). Italian court finds seismologists guilty of manslaughter. *Nature*. https://doi.org/10.1038/nature.2012.11640

NRC. (2018). *Safety Culture and Nuclear Security* [Nuclear USA Agency Website]. Safety Culture and Nuclear Security. https://www.nrc.gov/about-nrc/safety-culture/sc-nuclear-security.html

NTI. (2011). *How Sept. 11 Changed the Nuclear Industry | Analysis | NTI*. The Nuclear Threat Initiative. https://www.nti.org/gsn/article/how-sept-11-changed-the-nuclear-industry/

Nussio, E. (2020). Attitudinal and Emotional Consequences of Islamist Terrorism. Evidence from the Berlin Attack. *Political Psychology*, *41*(6), 1151–1171. https://doi.org/10.1111/pops.12679

OECD/NEA/FSC. (2013). *Stakeholder Confidence in Radioactive Waste Management – An Annotated Glossary of Key Terms*. OECD Nuclear Energy Agency.

OECD/NEA/RWMC. (2014). *"Foundations and guiding principles for the preservation of records, knowledge and memory across generations: A focus on the post-closure phase of geological repositories: A Collective Statement of the NEA Radioactive Waste Management Committee."* Organization for Economic Co-operation and Development.

Olsen, O. E., Kruke, B. I., & Hovden, J. (2007). Societal Safety: Concept, Borders and Dilemmas. *Journal of Contingencies and Crisis Management*, *15*(2), 69–79. https://doi.org/10.1111/j.1468-5973.2007.00509.x

Open Risk Manual. (2020). *Four eyes principle* [Collaborative website]. Open Risk Manual. https://www.openriskmanual.org/wiki/Four_Eyes_Principle

Osaci, M., Cristea, A. D., Ghuzan, D., & Berdie, D. A. (2018). SAP Authorization base on the four eyes principle. *International Journal of Engineering*, *26*, 43–46.

Perry, R. (2003). Emergency Operations Centers in an Era of Terrorism. *Journal of Contingencies and Crisis Management*, *11*, 151–159. https://doi.org/10.1111/j.0966-0879.2003.01104001.x

Pettersen Gould, K., & Bieder, C. (2020). Safety and Security: The Challenges of Bringing Them Together. In C. Bieder & K. Pettersen Gould, *The Coupling of Safety and Security: Exploring Interrelations in Theory and Practice* (pp. 1–9). Springer International Publishing.

Pettersen, K. A., & Bjornskau, T. (2015). Organizational contradictions between safety and security—Perceived challenges and ways of integrating critical infrastructure protection in civil aviation. *Safety Science*, *71*, 167–177. https://doi.org/10.1016/j.ssci.2014.04.018

Pidgeon, N. (1991). Safety culture and risk management in organizations. *Journal of Cross-Cultural Psychology*, *22*(1), 129–140.

Pidgeon, N. (1998). Safety culture: Key theoretical issues. *Work and Stress*, *12*, 202–216.

Piètre-Cambacédès, L. (2010). *Des relations entre sûreté et sécurité* [Doctoral Thesis]. Télécom ParisTech.

Pohler, W., & Schillmeier, M. (2010). Ein globales risikoereignis. In M. Holzinger, S. May, & W. Pohler, *Weltrisikkeggesellscheft als Ausnahmezustand* (pp. 121–151). Velbrück Wissenschaft.

Police de Liège. (2012). *AMOK 13 décembre 2011. Police de Liège* (p. 23) [Emergency management debriefing]. Police de Liège.

Poole, M. S., & Van de Ven, A. H. (1989). Using paradox to build management and organization theories. *Academy of Mangement Review*, *14*(4), 562–578.

Poole, M. S., & Van Den Ven, A. (2004). *Handbook of organizational change and innovation*. Oxford University Press.

Power, M. (2007). *Organized uncertainty: Designing a world of risk management*. Oxford University Press.

Quarantelli, E. L., Lagadec, P., & Boin, A. (2007). A Heuristic Approach to Future Disasters and Crises: New, Old, and In-Between Types. In *The Handbook on Disaster Research* (pp. 16–41). Springer International Publishing.

Razac, O. (2013). La gestion de la perméabilité. *L'Espace Politique. Revue en ligne de géographie politique et de géopolitique*, *20*, Article 20. https://doi.org/10.4000/espacepolitique.2711

Reason, J. (1998). Achieving a safe culture: Theory and practice. *Work and Stress*, *12*(3), 293–306.

Reichertz, J. (2014). Induction, Deduction, Abduction. In U. Flick, *The SAGE Handbook of Qualititative Data Analysis* (pp. 123–135). Sage Publications.

Reniers, G. L. L., Cremer, K., & Buytaert, J. (2011). Continuously and simultaneously optimizing an organization's safety and security culture and climate: The Improvement Diamond for Excellence Achievement and Leadership in Safety & Security (IDEAL S&S) model. *Journal of Cleaner Production*, *19*, 1239–1249. https://doi.org/10.1016/j.jclepro.2011.03.002

Reniers, G. L. L., & Dullaert, W. (2007). *Gaining and sustaining site-integrated safety and security in chemical clusters*. Nautulus Academic Book.

Richter, A., & Koch, C. (2004). Integration, differentiation and ambiguity in safety cultures. *Safety Science*, *42*, 703–722.

Rip, A. (2010). Process of entanglement. In *Débordements. Mélanges offerts à Michel Callon* (p. 408). Presses Des Mines.

Rochlin, G. I. (1999). Safe Operation as a Social Construct. *Ergonomics*, *42*(11), 1549–1560. https://doi.org/10.1080/001401399184884

Rodriguez, H., Quarantelli, E. L., & Dynes, R. R. (2007). *Handbook of disaster research*. Springer Publishing.

Rollenhagen, C. (2010). Can focus on safety culture become an excuse for not rethinking design of technology? *Safety Science*, *48*, 268–278.

Rose, N., & Miller, P. (2010). Political power beyond the State: Problematics of government. *The British Journal of Sociology*, *61*(1), 271–303.

Rosenberger, R. (2014). Multistability and the Agency of Mundane Artifacts: From Speed Bumps to Subway Benches. *Human Studies*, *37*(3), 369–392. https://doi.org/10.1007/s10746-014-9317-1

Ryle, G. (1949). *Concept of the mind*. Hutchinson and Company.

Schad, J., Lewis, M. W., Raisch, S., & Smith, W. K. (2016). Paradox Research in Management Science: Looking Back to Move Forward. *Academy of Management Annals*, *10*(1), 5–64. https://doi.org/10.5465/19416520.2016.1162422

Schein, E. H. (1985). *Organizational Culture and Leadership* (Vol. 14). Jossey-Bass Publishers. http://doi/10.1177/027046769401400247

Schikora, J. (2010). Bringing the Four-Eyes-Principle to the Lab. *Experimental Tests of Theories and Institutions*, *D13-V2*, 58.

Schnieder, L., Schnieder, E., & Ständer, T. (2009). *Railway Safety and Security – Two Sides of the Same Coin? !* International Railway Safety Council.

Schoch, C. (2011). *Rethinking climate change as a security threat*. https://www.osti.gov/etdeweb/biblio/22059792

Schulman, P. R. (2020). Safety and security: Managerial tensions and synergies. In C. Bieder & K. Pettersen Gould, *The coupling of safety and security. Exploring interrelations in theory and practice* (pp. 86–95). Springer International Publishing.

Scoles, J. (2018). Researching 'messy objects': How can boundary objects strengthen the analytical pursuit of an actor-network theory study? *Studies in Continuing Education*, *40*(3), 273–289. https://doi.org/10.1080/0158037X.2018.1456416

Seo, M.-G., Putnam, L. L., & Bartunek, J. M. (2004). Dualities and tensions of planned organizational change. In *Handbook of Organizational Change and Innovation* (pp. 73–107). Oxford University Press.

Shapin, S., & Barnes, B. (1977). Science, Nature and Control: Interpreting Mechanics' Institutes. *Social Studies of Science*, *7*(1), 31–74. https://doi.org/10.1177/030631277700700109

Shapin, S., & Schaffer, S. (1985). *Leviathan and the air-pump: Hobbes, Boyle, and the experimental life.* Princeton University Press.

Shokr, A. M. (2019). *Managing the interface between safety and security for research reactors* [Power Point]. International Conference on Research Reactors: Addressing Challenges and Opportunities to Ensure Effectiveness and Sustainability, Buenos Aires, Argentina.

Shughart, W. F. (2006). An analytical history of terrorism, 1945–2000. *Public Choice*, *128*(1–2), 7–39. https://doi.org/10.1007/s11127-006-9043-y

Simmel, G. (1994). Bridge and Door. *Theory, Culture & Society*, *11*(1), 5–10. https://doi.org/10.1177/026327694011001002

Slovic, P. (1992). Perception of risk: Reflections on the psychometric paradigm. In S. Krimsky & D. Golding, *Social theories of Risk* (pp. 117–152). Praeger Publishers.

Smith, D. E. (1987). *The Everyday World as a Problematic: A Feminist Sociology*. Northeastern University Press.

Smith, K. K., & Berg, D. N. (1987). *Paradoxes of group life*. Jossey-Bass Publishers.

Smith, W. K., & Lewis, M. W. (2011). Toward a theory of paradox: A dynamic equilibrium model of organizing. *Academy of Management Review*, *36*(2), 381–403.

Spieker, J. (2011). Foucault and Hobbes on Politics, Security, and War. *Alternatives: Global, Local, Political*, *36*(3), 187–199.

Stad van Hasselt. (2012). *Pukkelpop festival noodsituatie—18/08/2011* (p. 32) [Emergency management debriefing].

Star, S. L. (1999). The ethnography of Infrastructure. *American Behavioral Scientist*, *43*(3), 377–391.

Star, S. L., & Griesemer, J. R. (1989). Institutional Ecology, "Translation" and Boundary Objects: Amateurs and Professionals in Berkeley's Museum of Vertebrate Zoology, 1907-39. *Social Studies of Science*, *19*(3), 387–420.

Stohl, C., & Cheney, G. (2001). Participatory Processes/Paradoxical Practices: Communication and the Dilemmas of Organizational Democracy. *Management Communication Quarterly*, *14*(3), 349–407.

Strum, S., & Latour, B. (1987). Redefining the Social Link: From Baboons to Humans. *Social Science Information*, *26*, 783–802.

Su, T.-S., & Hsu, I.-Y. (2008). Perception towards chemical labeling for college students in Taiwan using Globally Harmonized System. *Safety Science*, *46*(9), 1385–1392.

Sullivan, C., & Forrester, M. A. (2018). *Doing Qualitative Research in Psychology: A Practical Guide*. SAGE.

The Hague Nuclear Security Summit. (2014). *Communiqué* (Communiqué de Presse No. 8193/14; p. 7). Council of the European Union. https://www.consilium.europa.eu/media/23823/141885.pdf

Thornberg, R., & Charmaz, K. (2014). Grounded Theory and theoretical Coding. In U. Flick, *The SAGE handbook of Qualitative Data Analysis* (pp. 153–169). Sage Publications.

Tierney, K. J. (2007). Recent Developments in U.S. Homeland Security Policies and Their Implications for the Management of Extreme Events. In H. Rodriguez, E. L. Quarantelli, & R. R. Dynes (Eds.), *Handbook on Disaster Research* (pp. 405–412). Springer International Publishing.

Tompson, P., & Mchugh, D. (2002). *Work Organisations*. Palgrave.

Valantin, J. M. (2017). *Géopolitique d'une planète déréglée—Le choc de l'Anthropocène*. Seuil. https://livre.fnac.com/a10837489/Jean-Michel-Valantin-Geopolitique-d-une-planete-dereglee-Le-choc-de-l-Anthropocene

Vaughan, D. (1996). *The Challenger Launch Decision. Risky Technology, Culture, and Deviance at NASA*. The University of Chicago Press.

Vitalis, R. E., Nor-Khaizura, M. A. R., & Son, R. (2016). Actor network theory in food safety. *International Food Research Journal*, *23*(6), 2319–2325.

Waltz, K. N. (2010). *Theory of International Politics*. Waveland Press.

Wang, A.-H., & Chi, C.-C. (2003). Effects of hazardous material symbol labeling and training on comprehension according to three types of educational specialization. *International Journal of Industrial Ergonomics*, *31*(5), 343–355.

Waugh, W. L. (2005). Terrorism and the all-hazards model. *Journal of Emergency Management*, *2*(1), 8–10.

Waugh, W. L., & Streib, G. (2006). Collaboration and Leadership for Effective Emergency Management—Waugh—2006—Public Administration Review—Wiley Online Library. *Public Administration Review*, *66*(1), 131–140.

Weilenmann, A., Normark, D., & Laurier, E. (2014). Managing Walking Together: The Challenge of Revolving Doors. *Space and Culture*, *17*(2), 122–136. https://doi.org/10.1177/1206331213508674

WENRA. (2019). *Interfaces between nuclear safety and nuclear security*. Western European Nuclear Regulators Association.

Whittle, A., & Spicer, A. (2008). Is Actor Network Theory Critique? *Organization Studies*, *29*(4), 611–629. https://doi.org/10.1177/0170840607082223

Willems, W. (2014). How to do things with knowledge: An interview with Sheila Jasanoff. *Krisis-Journal for Contemporary Philosophy*, *2*, 40–46.

Winner, L. (1980). Do artifacts have politics? *Daedalus*, *109*(1), 121–136.

Wipf, H. (2020). Safety and security in Aviation. In C. Bieder & K. Pettersen Gould, *The coupling of safety and security. Exploring interleations in theory and practice* (pp. 28–41). Springer International Publishing.

Wissink, B. (2013). Enclave urbanism in Mumbai: An Actor-Network-Theory analysis of urban (dis)connection. *Geoforum*, *47*, 1–11. https://doi.org/10.1016/j.geoforum.2013.02.009

Wolfers, A. (1952). "National Security" as an Ambiguous Symbol. *Political Science Quarterly*, *67*(4), 481–502. https://doi.org/10.2307/2145138

Woodman, R. W., Sawyer, J. E., & Griffin R. W. (1993). Toward a Theory of Organizational Creativity. *Academy of Management Review*, *18*(2), 293–321.

Woolgar, S. (1997). Science and technology Studies and the Renewal of Social Theory. In S. P. Turner (Ed.), *Social Theory and Sociology: The classics and beyond* (pp. 235–255). Blackwell Publishing.

World Bank. (2021). *D'ici à 2050, le changement climatique risque de contraindre 216 millions de personnes à migrer à l'intérieur de leur pays* [International Organization Web page]. World Bank. https://www.banquemondiale.org/fr/news/press-release/2021/09/13/climate-change-could-force-216-million-people-to-migrate-within-their-own-countries-by-2050

Yin, R. K. (2018). *Case Study Research and Applications: Design and Methods* (6th ed.). Sage Publications.

Yoo, H., & Lee, J.-H. (2015). Results of nuclear security culture survey on personnel at nuclear power plants. *Annals of Nuclear Energy*, *85*, 398–402.

Appendix

Appendix 1: Consent form

Title of Research Project: 'The interplay between safety, security and innovation: tensions and tradeoffs'

Name of Lead Researcher: Colin GLESNER

Participant Identification Number for this project:	**Please check box**
1. I confirm that I have received information about the project and I have had the opportunity to ask questions about the project.	☐
2. I understand that my participation is voluntary and that I am free to withdraw at any time without giving any reason and without there being any consequences. In addition, should I not wish to answer any particular question or questions, I am free to decline.	☐
3. I understand that my responses will be kept confidential. I understand that my name will not be linked with the research materials, and I will not be identified or identifiable in the reports that result from the research unless I give my consent.	☐
4. I agree for the data collected from me to be used in future research	☐

_____	_____	_____
Name of Participant	Date	Signature
_____	_____	_____
Interviewer: Colin GLESNER	Date	Signature

Copies:
Once this has been signed by relevant parties the participant will receive a copy, to keep with the information sheet and any other written information provided. A copy of the signed and dated consent form will be placed in the project's secure storage.

Appendix 2: List of scientific presentations

- GLESNER, C. (26-03-2018). "Coping with evolving risks and crises: Producing a REX framework for crisis management in the province of Liège". *Paper presented at SRA Benelux conference* 2018, SCK•CEN, Mol (Belgium). https://orbi.uliege.be/handle/2268/227918
- GLESNER, C. (30-05-2018). "Construction d'un cadre d'analyse de crise pour la province de Liège". *Project presented to the services of the governor of the Province of Liège*, Liège (Belgium). https://orbi.uliege.be/handle/2268/223780
- GLESNER, C. (18-06-2018). "Rearticulating Return of experience: Towards a participatory and flexible REX Information Infrastructure for safety and security management". *Paper presented at STS Italia Conference*, Padova (Italy). https://orbi.uliege.be/handle/2268/227919
- GLESNER, C. (28-07-2018). "Co-inventing a participatory "return of experience" digital platform for post-crisis management in Belgium". *Paper presented at EASST conference*, Lancaster (United Kingdom). https://orbi.uliege.be/handle/2268/227920
- GLESNER, C. (10-11-2018). "Safety and security: two cultures?". *Paper presented at SRA Nordic-Chapter conference*. Stavanger (Norway) https://orbi.uliege.be/handle/2268/227921
- GLESNER, C. (25-03-2019). "Safe and/or secure? Dealing with uncertainties in high-risk industries". *Paper presented at SRA Benelux conference*, Esch-Sur-Alzette (Luxembourg) https://orbi.uliege.be/handle/2268/234832
- GLESNER, C. (15/05/2019). "Safety or security: two cultures? rearticulating safety and security cultures in critical infrastructures through the lens of co-production". *Paper presented at TILTING Perspective conference*, Tilburg (Netherland). https://orbi.uliege.be/handle/2268/239326
- GLESNER, C. (25/07/2019). "Embracing tensions : Dealing with safety and security in High-risk organizations". *Paper presented at SRA Europe conference* Potsdam (Germany) https://orbi.uliege.be/handle/2268/239327

- GLESNER, C. (05/09/2019). "From safety first towards security first? Security culture and its impacts in high-risk organizations". *Paper presented at 4S conference*, New Orleans (United States of America). https://orbi.uliege.be/handle/2268/239328
- GLESNER, C. (07/09/2019) : "From safety first towards security first? An analysis of security and security sociotechnical imaginaries within one Belgian nuclear research center". *Paper presented at CPERI Workshop*. New Orleans (USA) https://orbi.uliege.be/handle/2268/239329