FOOD FOR THOUGHT

Articulation between compliance and initiative in safety management

Eric Marsden, Romuald Perinet and Jean Pariès

Coordination: Eric Marsden

n° 2024-09

TOPIC

Safety management

Les Cahiers de la sécurité industrielle

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www.FonCSI.org

6 allée Émile Monso – CS 22760
31077 Toulouse cedex 4
France

Twitter: @TheFonCSI
Email: contact@FonCSI.org

Abstract

Title	Articulation between compliance and initiative in safety management
Keywords	industrial safety, professional autonomy, initiative, compliance
Authors	Eric Marsden, Romuald Perinet and Jean Pariès
Publication date	August 2024

Safety in complex systems is produced by two complementary reservoirs: procedural compliance (the anticipation of potential hazards and implementation of procedures and other preventive barriers, also called "rule-based safety") and initiative (the actions of competent front-line workers who react appropriately to conditions in real-time, also called "managed safety"). This document analyses the articulation between these two sources of safety, and the way in which it may evolve given changes in the industrial world and in societal expectations. It suggests moving past a view of these two forms of safety as alternatives which could only develop one at the expense of the other, to explore more complex forms of interaction, such as co-development or mutual reinforcement between procedural compliance and initiative.

While the core of the debate on the relationship between compliance and initiative has so far focused on the work of frontline staff and the associated micro-centered compromises, this document also examines the decisions made across the **entire management line** up to the executive committee (the **macro-centered compromises** related to safety management and risk governance), as well as **inter-organizational dimensions** (impacts on relations with the safety authority, the judiciary, and civil society) and the resulting **systemic issues** (phenomena that emerge from the interaction between system components that are not visible when analyzing each component in isolation).

The original version of this document, in French, titled *Articulation des sphères réglées et gérées de la sécurité industrielle*, is available in the same collection with number 2024-06 (DOI: 10.57071/rgr871).

About the authors

This document is an output from the "strategic analysis" run by FonCSI on the articulation between compliance and initiative, which met around 15 times between 2021 and 2024. It is based on the academic and professional literature on this topic, as well as on the discussions during meetings of the strategic analysis group. The document was edited and primarily authored by Eric Marsden, a programme manager at FonCSI. Jean Pariès (FonCSI) and Romuald Perinet (GRTgaz) contributed sections of the text. The automated translation from French to English was reviewed by Eric Marsden.

To cite this document

Marsden et al (2024), *Articulation between compliance and initiative in safety management.* Number 2024-09 of the *Cahiers de la Sécurité Industrielle*, Foundation for an Industrial Safety Culture, Toulouse, France (ISSN 2100-3874). DOI: 10.57071/903aci. Available from FonCSI.org/en.

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Introduction

Context

In high-hazard industrial systems, safety is built upon two spheres: "rule-based safety" (preventing accidents through careful system design and adherence to safe work procedures) and "managed safety" (competent real-time responses by individuals who react appropriately to unforeseen situations and prevent loss of control). This document aims to examine the interplay between these two partly-complementary spheres, which are based respectively on compliance and proactivity, and to analyze how these interactions should evolve to account for societal and industrial changes.

This report is one output from a "strategic analysis", a research method developed by French research foundation FonCSI that brings together researchers and practitioners to reflect on and suggest improvements for a specific topic. FonCSI engaged members of the international research community using the term "*articulation between compliance and initiative in safety management*". This phrase represented our effort to translate into English a concept which is well known in the Francophone community working on organizational and human factors of safety as the tension between « sécurité réglée » and « sécurité gérée ». These concepts are not strongly present in the international (English-language) research literature on safety, and are non-trivial to translate as they encompass several characteristics: "rule-based safety" refers to a broad concept of compliance with a framework composed of regulations, directives, procedures, and professional rules and "managed safety" or "initiative-based safety" (the two translations exist in the literature) to the contribution of situated frontline expertise and professional autonomy.

Although well-known in France, both in academic and practitioner circles, this distinction is less familiar in the international community, and indeed it encompasses several dichotomies that are classically discussed in this field. The first dichotomy is between *proactivity* and *reactivity*, which differentiates between activities based on one hand on anticipation and prevention, and on the other hand on real-time reactions by people who interact dynamically (cognitively, emotionally, sensitively, etc.) with their environment. This dichotomy has been critiqued through the notions of **enaction** [Maturana and Varela 1987] and **situated cognition** [Hutchins 1995]. The second dichotomy, extensively analyzed by the field of activity ergonomics (which historically has been mostly developed by French-speaking researchers), distinguishes between prescribed work and real work, meaning the activity as anticipated during system design and constrained by adherence to planned procedures, versus the actual activity of the frontline worker, which always includes some adjustments to the planned activity. A different term for the same concept, the distinction between "work-as-imagined" and "work-as-done", has more recently been popularized by the "resilience engineering" community. The third dichotomy differentiates between risk management based on seeking and maintaining invariants, on one hand, and on the other hand risk management that recognizes disruptions and aims for resilience, following the pioneering work of A. Wildavsky, who highlighted the differing mindsets between these two strategies [Wildavsky 1988].

Our strategic analysis aimed to broaden the perspective on these dichotomies, which in existing research are mostly focused on the frontline operator, to the organizational level. This includes trade-offs associated with centralization and decentralization of decision-making processes related to safety management; the balance between the importance given to the situated expertise of frontline actors and the standardization of safety management activities; and more generally, between the pursuit of invariance and the pursuit of resilience.

The following paragraphs offer a succinct (and necessarily incomplete) description of the history and genealogy of research traditions that have analyzed various facets of this issue. It also serves as a case study of the circulation of ideas between scientific disciplines, national communities, and from academia to practice.

The narrative begins with **activity ergonomics** (also known as French-speaking ergonomics, as these ideas were primarily developed within this community **[Daniellou 2005]**), which has established a robust tradition of research-intervention grounded in ethnographic methods and a focus on the challenges faced by frontline workers. As early as the 1950s, this intellectual tradition highlighted the discrepancies between the work to be done and the manner of its execution **[Ombredane and Faverge 1955]**, and later between "task" (the formal, *de jure*, description of the work to be undertaken) and "activity" (the way the work is actually carried out, *de facto*, considering local constraints and worker expertise) **[Leplat and Cuny 1977; Leplat and Hoc 1983]**. These studies emphasized the active role played by frontline actors in compensating for the imperfections of equipment, procedures, and other aspects of system design. They assert the unavoidably incomplete nature of prescriptions in the face of real-world complexity, concluding that humans never work like mindless robots.

The related research tradition of **cognitive ergonomics** also analyzed the activities of frontline workers, focusing in particular on the operators of the increasingly complex and high-risk industrial production and transportation systems that were being designed and built in the 1960s. J. Rasmussen, leading a group of researchers at the Risø National Laboratory of the Danish Atomic Energy Commission, developed numerous influential concepts by integrating theories from control engineering and psychology. The group noted that the errors that led to accidents in nuclear reactors were most often associated with unanticipated situations that could not have been foreseen by system designers. They also found that experienced operators were frequently able to avoid accidents by compensating for system deficiencies. Rasmussen suggested that system interfaces should be based on an analysis of the future cognitive processes of the operator interacting with the system, rather than on the system designer's mental model. Subsequent work at Risø in cognitive engineering **[Hollnagel and Woods 1983]** on **error mechanisms** and recovery emphasized the importance of local context and the operator's professional history in understanding the system and managing disturbances. These researchers' distinction between the system's task description and the cognitive tasks of the system operator was similar to the task/activity distinction made by activity ergonomists.

Starting in the 1980s, significant work on **high-reliability organizations** (the "HRO" community) identified (among other factors) the importance for safe operation of recognizing the professional expertise of frontline workers and legitimizing their ability occasionally to move outside of predefined procedural frameworks. Sociologist M. Bourrier analyzed differences in the design and management of operational procedures and other prescriptions between four nuclear power plants in France and the United States. She demonstrated that differences in the level of involvement of target users in the process of defining procedures led to very different levels of appropriation and use of these prescriptions **[Bourrier 1996]**: when frontline actors can contribute to the definition of rules and procedures, they are more likely to adhere to them.

From the 1990s onward, the influential work of psychologist J. Reason unified the fields of cognitive ergonomics and **psychology** with the way these conceptual elements were applied by the human factors community in industry to analyze human error mechanisms and their prevention **[Reason 1990]**. In particular, Reason clarified the distinction between errors (involuntary deviations, slips and lapses), and violations (voluntary deviations, for example, due to imperfect procedures or to exploratory actions by experienced operators to develop their understanding of the system's constraints and limits).

During the same period, a body of work on **social regulation theory [Reynaud 1989; de Terssac 2003]**, poorly known outside France, described from a sociological perspective how collective regulation processes, organizational principles, and rules emerge through conflicts between different social groups within an organization. J.-D. Reynaud distinguished between control regulation, imposed from above, and self-regulation (informal "autonomous" rules produced by frontline actors to help them cope with certain limitations of externally imposed regulation). Reynaud and G. de Terssac analyzed the negotiation processes and organizational power issues that determine how top-down rules and self-regulation are combined, thereby linking the micro and meso levels of the organization to produce **joint regulation**. This perspective on organizational activity views organizations as the product of rules that are constantly updated through interactions and negotiations among individuals and collective groups within the organization.

In the early 2000s, researchers participating in a series of workshops sponsored by NATO on

human factors of safety, often strongly linked to the cognitive systems engineering work at Risø led by scholars such as E. Hollnagel, D. Woods, and S. Dekker, began using the term **resilience engineering** to describe a more systemic perspective on the interaction between system operators and system design, and more broadly between the local properties (such as operators' actions and decisions) and the global properties of the system. One stream, implicitly if not explicitly inspired by activity ergonomics, introduced terminology that distinguishes "work as actually done" and "work-as-imagined" **[Dekker 2006]**, and later between "work-as-done" and "work-as-imagined" **[Hollnagel 2012]**. A second stream (D. Woods, R. Cook), explicitly inspired by complexity sciences and particularly the work of the Santa Fe Institute (New Mexico, USA), focused on the stability of performance (including safety) of complex adaptive and autopoietic systems confronted with variability (including exceptional variability) of their internal and external contexts. They use the term organizational resilience to denote a system's dual capacity to adapt to past invariants (optimization and specialization when the environment does not impose disruptions) and to readapt when discontinuities occur. This group of researchers and industry experts was articulate and well-connected, and the associated ideas quickly spread within both the academic resilience engineering community and among practitioners.

A 2008 article in the journal *Safety Science* by G. Morel, R. Amalberti, and C. Chauvin contrasted the ways in which professional fisherman manage the trade-offs between production and safety, which significantly impact their livelihoods and safety, with how these issues are handled in "ultra-safe" industrial sectors such as nuclear energy and aviation, where proceduralization is used to attempt to exclude operating conditions that pose significant risks **[Morel et al. 2008]**. This article introduced the **equation** $S = S_R + S_M$, suggesting that safety is produced by a combination of "rule-based safety" (preventing accidents through careful system design and adherence to safe work procedures) and "managed safety", the presence of frontline expertise capable of effectively managing unforeseen situations and avoiding loss of control. The article presents a form of resilience where the control of high-risk situations relies on professional expertise. This equation was popularized in France by a widely-read technical report on human and organizational factors of safety written by F. Daniellou and published by FonCSI **[Daniellou et al. 2010]**, as well as by the use of the concept in safety training courses adopted by many French multinational companies.

FonCSI's recent work in this area attempts to integrate these research streams on organizational design, professional autonomy, violations of organizational rules, resilience, and adaptation to enhance our understanding of the articulation or hybridization between compliance and the "intelligent" application of rules and procedures. While most work on this topic concerns the compliance and adaptive behaviors of frontline workers, we have adopted in this work a **mesoscopic and macroscopic perspective**, examining in particular the work of managers and including **inter-organizational issues** in the scope, such as how this articulation is analyzed by the public and its representatives (legislators, regulatory authorities, the judiciary).

Objectives of this document

This document aims to explore the interplay between rule-based safety and managed safety in industries concerned by major accident hazards. It proposes to move beyond the notion of two "reservoirs" of safety connected like communicating vessels, where the development of one necessarily comes at the expense of the other, to explore more complex forms of articulation, such as co-development or mutual reinforcement.

While most of the debate on the articulation between compliance and initiative has so far concerned the work of frontline actors and the associated micro-centered trade-offs, this document also aims to explore the decisions made throughout the **entire hierarchical chain** up to the executive committee (the **macro-centered trade-offs** related to safety management and risk governance), as well as the **inter-organizational dimension** (impacts on the relationship with the safety authority, the legal system, and with civil society in the broadest sense) and **systemic issues** (phenomena emerging from the interaction between system components that are not visible when analyzing each component in isolation).

This document draws from the discussions during the strategic analysis on the interplay between rule-based safety and managed safety conducted by FonCSI during the period 2022–2024. It also incorporates elements from the academic literature on this topic (research on organizational and human factors of safety and "organization studies"), as well as work from various

expert organizations. It is a translation of the document originally published in French in the same collection, titled *Articulation des sphères réglées et gérées de la sécurité industrielle* [Marsden et al. 2024].

We analyze different **paradoxical tensions** that appear in the tension between compliance and initiative:

- Between the expectation of absolute compliance with rules and procedures and the encouragement to "show some initiative".
- Between standardization and the application of good practice and emphasizing the value of expertise and know-how.
- Between, on one hand, the right to make mistakes, and on the other, "getting it right the first time" (mixed in with "behaviour-based" ingredients such as techniques for improving human performance).
- The pursuit of ever-increasing control over the actions of frontline workers through increased proceduralization leads to an increase in the number of violations [Reason 1990], resulting in a phenomenon of normalization of violations, which diminishes the credibility of the rules.
- Procedures and rules aim to reduce uncertainty but cannot eliminate it; margins of interpretation are then used by workers as a resource [Crozier and Friedberg 1977]. The larger and more complex the body of rules, the more possible it becomes for people to exploit imperfections for personal gain [Sainsaulieu 1977].
- The tension between centralization, characterized by top-down rules and an infrastructure set up to ensure compliance, and decentralization, which relies on situated expertise and professionalism as well as adaptation to the local context. Following a procedure without adapting it to the local context can lead to ineffective or risky situations; some adaptations may lead to global system objectives or other macro-level constraints not being met.
- A tension between the risks of the extraordinary (catastrophes, accidents, visible problems that generate controversy) that the rules aim to prevent, and everyday safety, which is generated on a daily basis through operational decisions, compromises, adaptations, and other management acts, which is contextual and contingent, difficult to observe and debate. This gap makes it difficult to discuss and be accountable for work as it is actually carried out, rather than for work as presented in an investor brochure.

Document structure

Chapter 1 offers a description of **rule-based safety**, the normative approach to prevention based on compliance with a prescribed framework that anticipates various hazardous situations and aims to prevent their occurrence through the design of installations, operating rules, and safety procedures. This form of organization and control of work activity aims to specify both what needs to be done and how to do it: "prescribed work", which ergonomist A. Wisner called "fictitious work". We analyze the main **criticisms** directed at this way of thinking about safety, particularly the limited credit it tends to give to the expertise, autonomy, and proactivity of frontline actors.

Chapter 2 describes the notion of **managed safety** or initiative-based safety, that is, how safety is ensured in actual work, as well as the skills and expertise that produce safety outside of, or in addition to, the rule-based approach. The concepts of *seamanship* and *airmanship* are described, and the complex issue of professional autonomy and the delegation of authority is analyzed.

Chapter 3 proposes different ways to approach the **co-development**, or the necessary **articulation**, between these two approaches to safety. It discusses three ways of conceptualizing this hybridization: (1) a static adjustment at the system design stage, (2) two strategies that can coexist if certain organizational conditions for "high reliability" are met, and (3) expert improvisation based on an investigative logic, in the sense of pragmatist philosophy. We describe the equation $S = S_R + S_M$ used in some educational materials on the tension between compliance and initiative, decoding the contributions and limitations of this simple model for the understanding of people responsible for managing safety within companies. The theme

of actor autonomy, related to local expertise and initiative, is addressed, followed by a brief description of some organizational mechanisms that enable articulation or hybridization.

Chapter 4 examines various research works that have addressed the compliance-initiative articulation adopting an **organizational approach**, focusing on the meso level (the hierarchical chain leading to the CEO and board) and the macroscopic level of the system and its inter-organizational dimensions. At the meso level, we discuss the phenomena of "managerialization" of organizations, the role of middle managers, the consequences of the development of audit practices on the ability of professionals to deploy their expertise, the development of the compliance function within large companies, and the significant impact of digital management tools on work control and monitoring. At the macro level, we discuss the role of public perception of initiative-based safety which is based on improvisation, the consequences for organizations that tend to develop facades, myths, and fantasy plans to create an acceptable — though hypocritical – presentation of safety management. The chapter also describes how the co-development of the rule-based and managed spheres of safety can be approached **systemically**, analyzing the emergent phenomena produced by the interactions between different components at different scales. The contributions of organizational resilience theories are briefly mentioned.

The document provides **numerous illustrations** of the discussed concepts, drawn from various industrial sectors (processes, energy, transportation, etc.). These framed examples sometimes concern problems encountered, and sometimes positive practices that might be applicable elsewhere. However, it is important to keep in mind that the practices of articulation between rule-based and managed safety, between compliance and proactivity, vary significantly between industry sectors and risk categories; they are largely dependent on the safety model adopted and the organizational culture. Thus, the highly rule-based approach to safety that historically characterizes the railway sector (which has been described as "prescripto-repressive") differs significantly from the more managed approach used in medical surgery, which is largely dependent on the surgeon's expertise and experience. Likewise, a deviation from the procedures implemented to respect the obligations imposed by occupational safety regulations (which are generally very deterministic and legalistic) will generally be perceived differently from an initiative taken by an aircraft pilot to deal with an unforeseen event.

Acknowledgements

FonCSI, a public-interest research foundation, thanks its sponsors and partners, as well as the following people who have contributed to the strategic analysis on the tension between compliance and initiative in safety management:

- René Amalberti, FonCSI
- Olivier At, EPSF (French railway safety authority)
- Frédéric Hénon, UIC (International union of railways)
- Florence-Marie Jegoux, DSAC-DGAC
- Benoît Journé, Nantes Université
- Julien Kahn, EDF R&D
- Alexandre Largier, IRSN (French Institute for Radiation Protection and Nuclear Safety)
- Cécile Laugier, EDF DPN
- Jean-Christophe Le Coze, Ineris
- Philippe Loche, SNCF, retired
- Bertrand Mangin, IRSN (French Institute for Radiation Protection and Nuclear Safety)
- Tania Navarro, IRSN (French Institute for Radiation Protection and Nuclear Safety)
- Philippe Noël, TotalEnergies
- Olivier Omnes, EPSF (French railway safety authority)
- Jean Pariès, FonCSI
- Romuald Perinet, GRTgaz
- Olivier Rolland, EPSF (French railway safety authority)
- Valérie Vassent, IRSN (French Institute for Radiation Protection and Nuclear Safety)
- Nicolas Wolff, Eurovia-Groupe Vinci

We also thank the researchers and experts who participated in the academic seminar organized at the end of 2022, as well as the researchers who were interviewed by the strategic analysis group:

- Paul Almond, University of Leicester Law School, UK
- Moshe Farjoun, Schulich School of Business, York University, Canada
- Gudela Grote, Dept. of Management, Technology and Economics, ETH Zürich, Switzerland
- Ruthanne Huising, EM Lyon, France
- Ranga Ramanujam, Owen Graduate School of Management, Vanderbilt University, USA
- Kristine Størkersen, Sintef, Norway
- David Woods, Dept. Integrated System Engineering, Ohio State University, USA

The contributions of these researchers have been published in a collective volume in the open access *SpringerBriefs in Safety Management* collection managed by FonCSI, titled *Compliance and Initiative in the Production of Safety: A Systems Perspective on Managing Tensions and Building Complementarity* **[Le Coze and Journé 2024]**.

Finally, the document was improved by very useful comments from Prof. François Daniellou, who was responsible for many contributions on articulation-compliance tradeoffs, both in the academic domain and in its link with professional practices, and who was scientific director of FonCSI between 2015 and 2019. It was also enriched by a contribution from Claude Gilbert, emeritus research director at the CNRS, a specialist of collective risks who presided the Scientific Committee of the FonCSI, then its strategic analysis group, between 2007 and 2018.

1

The rule-based approach to safety

Safety management involves identifying work situations and sequences of interactions that could lead to a hazardous situation, and establishing barriers to prevent these hazardous situations, avoid their escalation into accidents, or mitigate their consequences. Among these barriers are the rules and procedures established by system designers to guide the activities of frontline workers.

What is a rule?

Definition

We use the term "rule" in this document to refer to a broad set of normative prescriptions, including work methods described in operation manuals, standard operating procedures, instructions, "life-saving" rules, regulations, specific legislation, obligations mandated by industry, national, or international standards, incentives or obligations imposed by a management system or computerized user interface. This term also encompasses the social norms governing behaviors deemed appropriate in a specific professional context.

The term "rule-based safety" refers to the contribution to safety constituted by the existence of a reference framework of rules and the strict application of this framework. The term "normative approach to safety" refers to a safety approach based solely on compliance with the prescribed framework; it equates obedience, compliance, and safety.

The normative approach to safety is related to what the eminent sociologist M. Weber (1864–1920) calls rationalization, a process that has structured modern societies, whose archetypal social form is the **bureaucracy**: a formal organization characterized by a hierarchical authority structure, a well-established division of labor, written standards and procedures, an impersonal approach to tasks, and a strong emphasis on technical competence. It is also closely associated with the scientific management of work advocated by F. Taylor, described in the box below.

1.1 Why put in place rules and procedures?

Rules and procedures are implemented to achieve several objectives:

- **Organizational control**: Following the principles of scientific management (*cf.* the box below), they allow central actors to design activities as tasks and control, in a top-down approach, the activities performed at the frontline. Thus, rules define the boundaries of expected operation and describe the levers that operators can use to keep the system within this safe operating envelope. The goal is to increase the likelihood that the organization produces the desired outcomes (quality, safety, costs, deadlines).

  This approach to work relies on the planning and standardization of tasks. The design of work activities is structurally separated from their execution, and the people executing the tasks are subjected to numerous controls (work permits, supervision, audits, peer cross-checks, and other reliability practices) to ensure compliance with the reference framework.

Scientific management

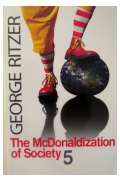
Definition

Scientific management, also known as "Taylorism" after one of its main developers, the American engineer F. Taylor, is a method of organizing and rationalizing production that developed during the second industrial revolution at the end of the 19th century. It involves recursively breaking down the task to be accomplished into elementary sub-tasks, seeking the most efficient movements for each sub-task, and specifying them as precisely as possible, eliminating any nuance and factor related to the local context or the worker's specific skills. Work is then conceived as the mechanical execution of the specification, the repeated implementation of the optimal work procedure (the "quickest and best way"). It relies on the distinction between those who design the procedures and those who execute them, on specialization and subordination, and on assembly line work. This method was popularized in France by the mining engineer H. Fayol.

This approach to work organization has enabled productivity gains in many industrial sectors, including the automotive industry. However, it is criticized for its naivety[1]. Many analysts (particularly in activity ergonomics) note that it is unrealistic to imagine developing optimal work plans that are adapted to all work situations encountered in a realistic work environment subject to various sources of uncertainty. In systems least exposed to variability, the limited latitude this way of organizing work leaves to frontline actors to develop and deploy their professional expertise is not very respectful of their health.

While the principles of scientific management, associated with scenes from Chaplin's film *Modern Times* (1936) and with dominant-subordinate political relations, may seem outdated today, this conception of work organization persists in certain situations and organizational configurations. For example, the distance between "those who design and control" and "those who do" is exacerbated in subcontracting situations, where the contractor specifies the work objectives as precisely as possible and sets up a supervisory function to monitor compliance. At the core of popular management approaches such as operational excellence and *lean management*, there is typically — although multiple interpretations of these approaches exist — an emphasis on compliance with a prescribed reference framework which is adapted to the activity. In another domain, the success of multinational fast-food chains testifies to the attractiveness for some consumers of standardized food that leaves little room for the creativity of the cooks.

McDonaldization of society



Example

American sociologist G. Ritzer suggests that the renowned fast-food multinational is today a better illustration of M. Weber's analyses on scientific rationality than are bureaucracies[2] **[Ritzer 1993]**. These companies are characterized by (1) a managerial focus on efficiency aimed at optimizing task performance and eliminating downtime; (2) extensive use of quantifiable rather than qualitative objectives (focusing on the quantity of food sold or on revenue rather than a subjective appreciation of taste); (3) predictability of the customer experience through process standardization; and (4) activity control through the management line up to the company headquarters, facilitated by the use of robotics.

The author suggests that these organizational principles have spread to Western societies, affecting our values, preferences, objectives, and worldviews, leading to a certain global uniformity, today reinforced by the standardized experience of online commerce.

▷ **Coordination mechanism**: Rules and organizational routines also enable coordination among individuals and groups by making explicit the activities performed to allow alignment and by clarifying the responsibilities of each actor.

[1] While these criticisms have been widely developed among social science researchers since the 1970s, as early as 1916, the economist R. Hoxie wrote, "*[scientific management] is a reversion to industrial autocracy which forces the workers to depend upon the employers' conception of fairness and limits the democratic safeguards of the workers. It is unscientific and unfair in the setting of the task and in the fixing of wage rates; in spirit and essence it is a cunningly devised speeding-up and sweating system; it intensifies the modern tendency toward specialization of the work and the task; it condemns the worker to a monotonous routine and tends to deprive him of thought, initiative and joy in his work and to destroy his individuality and inventive genius; it lessens the continuity and certainty of employment.*" **[Hoxie 1916, p. 65]**.

[2] Weber had already observed this: the efficiency of bureaucracies diminishes over time: rules and procedures accumulate without limits, quantitative objectives are achieved at the expense of work quality, and bureaucrats resist any reform that would reduce their power.

As an illustration, the highly developed rule-based framework[3] is one of the main factors that has enabled the development of commercial aviation internationally, despite significant differences between countries **[Haavik et al. 2017; Pélegrin 2013]**.

- ▷ Tool for **codification** and **knowledge management**: Rules and procedures act as an "organizational memory" **[Walsh and Ungson 1991]**, describing the functioning of equipment and processes and identifying gaps that may pose problems. Rules are essential for preserving organizational knowledge during personnel transitions and facilitate the training of new staff, while promoting the interchangeability of individuals in the workplace.

  However, it should be noted that these learnings, traditions, and bureaucratic bodies embedded within organizations do not only have positive effects, as they can maintain outdated beliefs and hinder adaptation to a dynamic environment. According to **[Nystrom and Starbuck 1984b]**, "*Institutionalized knowledge leads to narrow vision and rigidity, which can result in major crises.*"
- ▷ Crystallization of a number of **predefined trade-offs** between different issues, such as between efficiency and safety. The construction of rules is based on invariants and past experience.

Example

Contingency fuel rules in civil aviation

The framework of civil aviation rules stipulates that the captain must ensure before any flight that the fuel quantities allow for the planned flight with an "acceptable safety margin". This margin is defined in France by the Civil Aviation Code — and similarly in other countries' national regulations — incorporating various criteria such as 10% of the estimated quantity to reach the destination, plus an additional 20 minutes of flight time. The fuel reserve, usually unused, represents an economic and environmental cost that airlines might wish to reduce; the regulation provides an illustration of a trade-off between cost and safety which is predetermined by the profession.

- ▷ Reference used by the **legal system** to help establish **responsibilities in case of an accident**. Judges tend to consider any deviation from the rule-based framework as a sign of guilt (*cf.* the discussion in § 4.2.4).
- ▷ **Facade** enabling company leaders to demonstrate that safety issues are addressed formally, thereby preserving the **legitimacy** of the organization **[Nystrom and Starbuck 1984a]**. The framework of rules can be shown to regulatory authorities or members of the public to attest to the thorough consideration of possible threats and the efforts undertaken to prevent them (*cf.* the discussion in § 4.2.3). When an accident or incident occurs, the framework of rules can be used to establish a distance between the organization and the deviant behavior that most often preceded the accident. Since the accident is perceived as the result of a "hole in the net" constituted by the fabric of rules, enriching the framework allows for a quick and inexpensive[4] change to the system to prevent the recurrence of the undesired event, showing that the accident did not go "unaddressed". Thus, rules proliferate primarily to provide legal protection to the organization and/or the regulatory authority ("cover your ass" phenomenon **[Barabas 1993]**).

Key issue

This multiplicity and diversity of objectives that the rule-based framework addresses does not always facilitate management conducive to the production of safety.

[3] The prescribed framework in civil aviation covers numerous aspects of the design, production, maintenance, and operation of aircraft, aerodromes, and air traffic control infrastructures. Examples include aircraft flight manuals, equipment maintenance procedures, "standard operating procedures" established by airlines, and the attention given to using standardized phraseology for communications between pilots and air traffic controllers.

[4] J. Leplat notes that "*Instead of changing the working conditions, which are the source of the accidents, the rules are changed, or one is added, so as to allow the transfer of the responsibility for a similar accident to the operator, without concern for the coherence of this rule with others or for its relevance to other concrete situations.*" **[Leplat 1998]**. Furthermore, the direct and indirect costs (in terms of impacts on future productivity) of modifying procedures are generally much lower than those of a technical modification or redesign of the installation, even if procedural modification is significantly less effective in terms of safety.

1.2 Rule types

Rules and procedures can encompass a wide range of objects, from detailed and precise prescriptions for performing a task to general descriptions of priorities; they can be very context-specific or, conversely, abstract. They may target the activity of the frontline actor, or — more rarely — the executive committee. **[Bieder and Bourrier 2013]** note in their introduction to the book *Trapping Safety into Rules. How Desirable or Avoidable is Proceduralization?* that:

> *A striking result of these debates on the proceduralization of safety is the extreme diversity of what is called a rule or a procedure. Indeed, the words "rule" and "procedure" are used to designate a wide range of documents with very varied statuses and target users.*

[Hale and Swuste 1998] propose a classification of safety rules that includes three categories:

1. **Action rules**, which define actions to be performed and prohibitions, step by step, allowing little room for freedom of interpretation and adaptation to the local context. These are the rules that provide the least freedom to the executor but also offer the greatest support. For example: "*smoking is prohibited*" and "*all pressurized equipment must be equipped with two independent relief valves*".
2. **Goal rules**, which define concrete actions or system states that must be achieved, but do not prescribe how to achieve the goal. For example, "*the annual average concentration of NO_2 must not exceed 40 $\mu g/m^3$*" or "*as low as reasonably practicable*".
3. **Process rules**, which define how to make decisions about actions to take or how to organize these actions. These rules constrain the executor the least but also provide the least support. For example: "*the employer must consult with employees or their representatives to set work schedules*" and "*when general operating rules cannot be applied, the action to be taken will be decided jointly by the production team foreman and the maintenance team foreman*". Project management milestone meetings, which require discussion and validation by all trades involved at each phase of the project, are another example.

The choice of rule form should, according to these authors, be made based on various factors such as the level of uncertainty associated with task performance, and the level of competence of the people performing the work:

- To what extent is the system closed and predictable? The greater the local variability, the more the rules will need to be adapted to the micro-contextual situation.
- How rapid is innovation in the system? The faster the technological evolution, the more rules should be written close to the local context.
- What is the degree of interaction among individuals in the field, and what are the risks if they do not follow the same framework? The greater the need for homogeneity (or equality), the more rules should be written at a central level. The global civil aviation system provides an illustration of this notion.
- To what extent are the participants likely to pursue their own goals despite possible conflicts with those of the system level? The stronger this self-centered tendency, the more the rules will need to be written at a higher level than where this conflict appears.
- What is the degree of knowledge and expertise at the micro level? The greater this professionalism, the more the drafting of the framework can be entrusted to the local level.

Indeed, different work environments use varying proportions of these categories of rules: for example, the work of pilots in aviation is framed by more action rules than process rules, while the work of anesthetists in hospitals is framed by fewer action rules and by a higher proportion of process rules **[Grote et al. 2004]**.

1.2.1 Degree of detail in a rule

Rules can be drafted in varying levels of detail, depending on the level of experience of the people they address[5], and depending on whether they are designed more as a guide for the user's action (allowing room for interpretation or adaptation to the local context) or as a very precise sequence of actions to be performed. Historian L. Daston, who published a historical analysis of the use of rules in the West since antiquity **[Daston 2022]**, discusses the distinction between "thick" and "thin" rules:

- **Thick rules** (also known as models or paradigms) are flexible and general rules that apply to a wide variety of situations. They come with examples, remarks, adjustment margins, and a list of exceptions. They allow for bridging the gap between the universal and the particular. Using these rules requires cognitive work, judgment, and analogical reasoning to choose which rule is applicable in a particular context and how it can best be applied[6].
- **Thin rules**, also known as algorithms, are explicit, context-independent, unqualified, and unambiguous. These rules have no exceptions and apply without experience, expertise, or reflection. They only work in a standardized and predictable world.

Daston suggests that the modern world (since the 19th century), characterized by the progressive reduction of uncertainty resulting from industrial development and standardization, has seen a development of thin rules (adapted to the bureaucratic world) at the expense of thick rules. This evolution has partly been motivated, she writes, by "a growing mistrust of discretionary power, which has been called arbitrary, capricious, inconsistent, unpredictable, unjust, opaque, self-interested, and even tyrannical" (p. 270).

Rules are resources for action but do not completely determine action. Thus, the user of a rule does not act mechanically but makes various choices (first of all, of the rule or rules that best suit the situation they are facing) and trade-offs between what is essential and what is less so, what applies given the local context and what is less relevant, what presents a risk to their person or their ethics, and what corresponds to the best practices of their profession.

Example

The monastic rule of Saint Benedict

The Rule of Saint Benedict is a normative text referenced by certain monastic orders such as the Benedictines or the Cistercians, describing the life of monks in 73 chapters. It was written around the year 530 and is still used by some monasteries today.

The text describes various guidelines for the daily life of monks, but especially the discretionary conditions that allow for adaptation of the rule. For example, Chapter 42 states that "the monks should maintain continuous and absolute silence", but immediately adds "unless the charity to be shown to guests requires it, or the Abbot orders something to be said". The Abbot, who must have "all the discernment and moderation necessary", is cited 120 times as having the authority to violate a rule. This formulation of the rule, both precise and flexible, is cited as one of the factors contributing to its exceptional longevity **[Daston 2022, p. 45]**.

[5] A practical problem encountered: during the Trump presidency in the USA, some refineries experienced significant turnover, with the mass departure of experienced operators. This type of situation necessarily impacts the compliance-initiative articulation; the framework that had been gradually developed based on the experience of frontline actors who knew the installations well was less suited to a population of operators with less developed experience.

[6] An illustration of the difficulty in formulating clear and unambiguous rules is given by the moderation of hateful content online, where the boundaries between acceptable and unacceptable are subjective and fractal. An online game that shows the complexity of interpreting rules, even when expressed in simple terms, is "No vehicles in the park".

1.2.2 Degree of formalism of a rule

The rule-based framework comprises various elements with different levels of formalization. Hence, management literature distinguishes between rules (formal, written artifacts) and **organizational routines**, which are patterns of collective action ("repetitive, recognizable patterns of inter-dependent actions, carried out by multiple actors") **[Feldman and Pentland 2003]**. The academic literature on knowledge management differentiates formal rules from **tacit rules** (customs, habits, and traditions); this distinction is related to the one established between explicit and tacit knowledge **[Polanyi 1966; Collins 2010]**. Tacit (or implicit, or informal) knowledge is tied to an individual and can hardly be codified and transferred to another person; it is context-dependent. Conversely, explicit knowledge is formalized, codified, documented, and can be articulated and transmitted to others.

Certain forms of tacit knowledge and tacit rules are particularly important for performance, including safety performance, in high-risk activities, as will be discussed in § 2.1.

1.3 Critiques of the rule-based approach

The rule-based approach to safety has been the subject of several criticisms over many years, the main ones of which are outlined below:

- The limitations of the scientific approach to work: in complex systems, it is in practice impossible to develop a prescribed framework that anticipates all potential contingencies, local peculiarities, and degraded situations. Frontline actors will inevitably need to supplement or deviate from the prescribed elements to complete their tasks.

> *Those who want to virtually eliminate man-made risks are constructing a Maginot Line, creating a false sense of security by pouring resources into combating a few risks that will likely never materialize, all the while becoming less able to cope with whatever dangers actually do occur.* **[Wildavsky 1988, p. 90]**

Rules cannot cope with the inevitable variability of work situations. It is generally not possible to anticipate at the design stage all malfunctions and combinations of contingencies that may arise, and therefore all the degraded conditions the operator will face.

Example

The limits of military plans

A famous military analogy comes from Prussian Field Marshal von Moltke (1800–1891), who developed a new way of directing armies by imagining several options rather than a single plan. He is known for the quote "*No plan survives contact with the enemy*". Note, however, the reformulation by W. Churchill, "*Plans are of little importance, but planning is essential*".

It is thus necessary to acknowledge the existence of a gap between the task and the activity[7], or between prescribed work and actual work, or "work-as-imagined" and "work-as-done" in the more recent terminology adopted by English-speaking human factors researchers.

Key issue

A doctoral thesis that studied the perception of safety rules among railway professionals in the Netherlands in the 1990s, cited in **[Hale and Borys 2013]**, found that only 3% of employees surveyed reported frequently using the prescribed framework, and nearly half indicated they never used it. 47% sometimes found it unrealistic, 29% believed it was used only to blame an operator, 95% believed that work could never be completed on time if procedures were followed, 79% thought there were too many rules, 70% thought they were too complicated, and 77% thought they sometimes contradicted each other. Other studies conducted at the same period found similar attitudes in the UK railway sector and in other sectors such as the chemical industry.

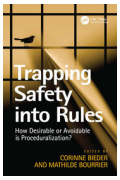
7 Activity ergonomics uses the term *task* to designate both the prescribed (what is to be done and how to do it) and the technical, environmental, social, and organizational conditions in which this prescribed must be realized. The term *activity* refers to how the subject mobilizes to achieve this prescribed.

Behaviors that contribute to industrial safety are not only those of rule compliance **[Andriessen 1978; Marchand et al. 1998]**: they are also **initiative behaviors**, which promote careful exploration of the system state, enable a critical view of the applicability of procedures, allow alertness to dangerous situations, and encourage collaboration among actors who can contribute to safety.

The critique of the scientific (Taylorist) approach to work has long been championed by activity ergonomics, which has introduced important concepts such as the difference between prescribed work and actual work, social regulation within a group of workers, the cognitive dimension of any work activity, the necessity of incorporating margins of maneuver in work design, and the role of experience.

▷ The limitations of a safety model based on the ideal of a fixed normative framework that does not account for the erosion of the designed safety margins caused by the **adaptive behaviors** of individuals, collectives, and systems. As early as the 1990s, researcher J. Rasmussen criticized the sophist trap of defense in depth ("**defence in depth fallacy**"), explaining that technical and organizational defense barriers, even if intended to be independent, are rarely so in practice due to the adaptive practices of individuals working within systems[8] **[Rasmussen 1990]**. This idea was later adopted by S. Snook with the term "practical drift" in his analysis of a friendly fire incident during the Iraq war **[Snook 2000]**. It is closely related to the concept of **normalization of deviance** developed by D. Vaughan.

▷ The rule-based approach to safety, which involves progressively accumulating new rules and requirements based on experience feedback, leads to **excessive complexity** due to the accumulation of sometimes incoherent rules. This phenomenon of over-prescription or "hyper-proceduralization" **[Amalberti 2001]** occurs while the volume of rules has already reached problematic levels in many industrial sectors[9]. Safety then becomes "trapped in rules", as noted by **[Bieder and Bourrier 2013]**. Over-prescription contributes to the phenomenon of normalization of deviance mentioned above, as well as the bureaucratization of safety (the increasing focus on "accountability" and responsibility **[Dekker 2014]**, a point developed in § 4.2.4).



▷ The excessive development of prescriptions leads to reduced professional autonomy and **weakens the expertise** of operational actors, potentially causing them to stop reflecting on the meaning of the activities they perform, infantilizing them **[Dekker 2017]** (*cf.* the discussion in § 2.1 on professionalism and the concepts of "seamanship" and "airmanship"). The reduction of frontline actors' autonomy diminishes their ability to develop their skills, as the objective of work shifts from performing a task safely to "*executing the rules and respecting the prescribed barriers*" **[Leplat 1998]**. The focus on compliance with the prescribed framework weakens the questioning attitude and engagement of frontline workers. This phenomenon of demotivation and loss of meaning is reinforced when managerial control tools, implemented in the name of compliance, rely heavily on quantitative indicators, as shown by observations in the nuclear energy sector in a doctoral thesis **[Krasnopevtseva 2022]**.

On a more macro level, the development of a regulatory framework based on detailed prescriptions (rather than outcome objectives) reduces the **capacity for innovation** of industrial actors and tends to infantilize them, reducing their intrinsic motivation to improve the safety of their activities **[Marsden et al. 2023]**.

▷ This evolution also leads to the **demotivation** of employees: in his book *The Utopia of Rules*, the anarchist anthropologist D. Graeber describes rules as "*instruments by which hu-*

[8] A classic illustration of this lack of independence: a process whose deviation is monitored by both a human operator and an automatic alarm. Human monitoring and the alarm device might be designed as independent safety barriers, with a very low probability of simultaneous failure. However, in practice, the human operator tends to rely on the presence of the alarm and does not maintain as high a level of vigilance as if it were not present.

[9] The "ratchet effect" of proceduralization (it is easier to add a rule than to remove one) and the risks of over-prescription have long been known. Montaigne, for instance, wrote that "*The most desirable laws are the rarest, simplest, and most general*" (*Essays*, book 3, chapter 13). Portalis, in his preliminary speech on the draft French Civil Code presented a few years after the French Revolution, assured that "*We have avoided the dangerous ambition of wanting to regulate and foresee everything*".

man imagination is broken" [Graeber 2015]. Work psychologist Y. Clot shows that "blocked activity", the desire to do one's job well which is frustrated by an overly restrictive organizational framework, is a source of work-related suffering and psychosocial risks for workers [Clot 2010]. It contributes to **disempowering** frontline actors, reducing them to mere "button pushers", as well as frontline supervisors, whose main role becomes verifying compliance with the prescribed framework.

- This disengagement in the task also leads to the **automation paradox** [Bainbridge 1983]. Indeed, when everything goes well, the operator of an automated system is seldom required to act on the system's controls, which tends to decrease their attention, reduce their accurate mental representation of the system's state, and degrade their piloting skills. When an unforeseen or critical situation arises, the operator must quickly take control and will struggle to react appropriately.

- Procedures and rules are **static tools** that must be used in a **dynamic environment**, as indicated by the Danish Maritime Accident Investigation Board [DMAIB 2016, p. 4]:

> *When deviation from procedure is stated as the cause of an accident and future accidents are countered by new or more procedures, it pertains to the idea of procedures functioning as barriers between accident and normal operation. Thinking of procedure as a safety barrier is based on a belief that safety is embedded in the procedures and formalisation of the operations on board ships. However, it is rarely questioned why people deviate from procedures and whether procedure equals safety. And what is the nature of procedure in the first place?*

- Excessive effort spent on producing rules and ensuring that frontline actors appear to comply with them leaves less time available for boots-on-the-ground management activities that involve listening and resolving problems.

The expertise valued in a rule-based approach is that of people who — often far removed from the frontline — construct and teach the rules, rather than that of frontline operators, who are seen more as executors trained to apply the rules.

1.4 Compliance, initiative, violation, and transgression

Compliance with rules by organizational actors has historically been seen as one of the main characteristics distinguishing modern bureaucratic organizations from most earlier political institutions, where leaders' instructions were transmitted in person by their representatives.

[Dalton 1959, p. 268], discussing compliance, explains that:

> *The individual is a product of groups. In his development from infancy, he conforms to major demands of his group, or seems to when he cannot. If he fails he is punished. Over the years he is shaped by conformity to ever mounting expectations. As a responsible adult he continues to be punished for nonconformity.*

Definition

Different approaches to the notion of compliance

Compliance with rules and regulations is a more nuanced concept than one might think [Parker and Nielsen 2011]. It can be analyzed in an **objectivist** manner (why and how individuals and firms comply with the prescribed rules) or in an **interpretive** manner (how the meaning of the rule is transformed through interpretation, negotiation, and implementation by individuals and companies [Edelman and Talesh 2011]).

As an illustration, federal legislation in the USA prohibits discrimination in hiring, without clearly defining the behaviors that constitute discrimination or the specific obligations of companies to prevent such phenomena. In this context, compliance with the prescribed rules largely depends on the interpretation by decision-makers within companies, particularly concerning concepts such as discrimination, which are based on general principles of morality and their societal interpretation at a given time. Thus, from an interpretive perspective, compliance is socially constructed and can vary depending on the viewpoint adopted.

The academic literature on compliance distinguishes between:

- **Substantive compliance**, which implies that the objective of the rule or prescribed framework is achieved;
- **Regulated compliance**, which implies that explicit obligations are met, without necessarily achieving the objective;
- **Creative compliance**, in which an individual or company complies with the letter of the rule but in a manner that contradicts the spirit of the rule [McBarnet and Whelan 1991].

Transgression refers to actions within an organization that contradict the rules (laws, internal regulations, orders from superiors) or norms (often tacit "meta-rules") [Girin and Grosjean 1996]. In the industrial world, transgression is mostly negatively connoted as a source of accidents. In academia, the concept is treated in different ways depending on the discipline and author, as noted by [Gofen 2014]. Some researchers discuss deviations or divergences, others refer to shirking or sabotage [Brehm and Gates 1997], others talk about "responsible subversion" ([Hutchinson 1990] referring to nursing work) or "creative insubordination" (regarding school principals [Haynes and Licata 1995]), as a manifestation of negotiation among organizational actors that allows contradictory constraints to coexist [Babeau and Chanlat 2008], or as a sign of inventiveness and autonomy with respect to the task that characterizes professionalism (particularly in processes that enable innovation [Alter 1993]).

Contrary to popular wisdom, violations of frontline workers do not, in general, generate safety risks. This is particularly true for experienced staff. In aviation, published results from the LOSA[10] audit mechanism show that there is no flight without deviations from the reference specified by handbooks and procedures, that "violations" (conscious and deliberate deviations) constitute the majority (54%) of observed deviations, that more than 60% of deviations are not detected by the crew, and 30% are detected and corrected by the crew. Only 2% of voluntary deviations are considered risky for flight safety, compared to 69% of knowledge errors (those related to a lack of expertise). As J. Pariès writes [Pariès 2021a]:

> *These results invalidate the thesis that "deviances" necessarily carry additional risks. On the contrary, they show that when expertise is adequate, and the safety culture is well-tuned, the risk associated with adjustments necessary for the fluidity of activity is well managed. The "good" violinist does not make more mistakes because they add their vibrato. (Safety) risk primarily comes from a lack of expertise.*

The academic literature in sociology and organization studies offers several complementary explanations for the presence of violations and transgressions:

- Since the prescribed framework is sometimes inapplicable or unsuitable, violations are sometimes necessary to ensure system performance. They can be considered as **indicators of the necessary compromises** that allow frontline actors to manage the **sometimes contradictory injunctions** arising from the rule-based framework while fulfilling their mission [Amalberti 2013]. Violations may even be necessary for the safety of those working within the system. One often-cited example from the Piper Alpha disaster is described below; another example mentioned by K. Weick is that of firefighters responding to a major forest fire at Mann Gulch in the USA, who died because they followed the rule that required them always to carry their (heavy) equipment with them [Weick 1993]. Other examples from aviation are discussed by S. Dekker in a provocatively titled article *Follow the procedure or survive* [Dekker 2001].

[10] The LOSA (Line Operation Safety Audit) mechanism, managed by ICAO, is a program of observations of pilots' and other crew members' activities in normal work situations. Observations are conducted by experienced peers, with confidentiality guarantees for observed teams. Observers note potential safety threats, crew responses, procedural errors or violations, and other reactions. The mechanism has existed since 2001.

Deadly compliance at Piper Alpha

Example

The Piper Alpha oil platform in the North Sea suffered a fire and explosions in 1988, killing 167 people. Some of those who died on the platform could have been saved if they had not followed safety procedures. For example, these procedures instructed people not to jump into the sea from the platform, but to shelter in the living quarters (which had fire protection) and wait for rescue helicopters. Unfortunately, the smoke from the fires was so dense that helicopters could not land, the living quarters were filled with smoke and carbon monoxide, causing the deaths of many people sheltering there. The platform eventually collapsed into the sea, taking those who had followed the procedures with it. The only survivors (61 out of the 226 people on board) were those who decided that the procedures would not work in this situation and who jumped into the sea to reach the nearby firefighting boats **[Cullen 1990]**.

▷ The necessity of "expert transgression" is also highlighted by the phenomenon of **work-to-rule**, which involves applying the rule to the letter in a way that hampers the system's operation. The academic literature uses terms like "malicious compliance" and "uncivil obedience" **[Bulman-Pozen and Pozen 2015]**.

Renfe driver abandoning post following procedure

Example

In 2016, a train driver from the Spanish railway company Renfe abandoned his train, and the 109 passengers on board, at Osorno station. The driver was supposed to be replaced at this station (regulations state that a driver cannot perform a continuous service for more than 6 hours, to avoid fatigue), but the replacement driver was not present. In its official response to the incident, Renfe indicated that the majority of drivers had "common sense" and would not have followed the rules to the letter.

There is literature on "pro-social rule violations", the intentional non-compliance with a rule or organizational policy, where the main intent is to benefit the organization or one of its stakeholders. **[Morrison 2006]** proposes three categories of pro-social violations:

- ensuring professional responsibilities are carried out more effectively;
- helping a subordinate or colleague;
- improving service provided to a customer.

▷ **[Reynaud 1989]** argues that deviations often reflect "a form of zeal in the service of the company" rather than acts intended to harm its interests. Thus, the frontline actor "makes do", **improvises**, uses raw materials that do not exactly conform to prescribed specifications, skips certain steps in an equipment startup procedure, overlooks certain anomalies that are deemed non-critical, repairs their machine without waiting for an authorized technician, or agrees to take off despite forecasted poor weather at the destination.

▷ **[Dodier 1996]** notes that some infractions or deviations are signs that frontline actors seek to **demonstrate their expertise**:

> *"The operator seeks to show that they do not belong to the ordinary or lower categories of employees in terms of skills but that they possess superior abilities.*

Thus, **[Dodier 1995]** discusses **arenas of technical skills**: places where individuals test their abilities and face the judgments of their peers.

▷ Deviations and violations sometimes stem from the processes involved in **defensive professional ideologies**[11], such as virile displays among some construction workers, where hazards and are choreographed as a risk to be controlled and overcome by skilled professionals in an "act" performed in front of other members of the work collective **[Dejours 1987; Cru 2014]**.

▷ Some non-conformities observed within companies can be seen as employees' reactions to a negative perception of **power relations** within organizations, a sense of loss of autonomy and identity. These **perceived injustices** can cause frustration, which can then motivate deviant behavior **[Lawrence and Robinson 2007]**.

[11] The notion of defensive professional ideology, according to D. Cru, refers to a set of beliefs, values, and representations shared within a profession or professional community. These beliefs and values are developed in response to perceived threats or external challenges to the profession and aim to justify and legitimize existing professional practices and norms.

Various studies have identified multiple factors that influence the **degree of compliance** with prescribed standards:

- ▷ Structurally incomplete rules;
- ▷ Variability in processes and individuals: violations become more likely when performance deviates from objectives **[Lehman and Ramanujam 2009]**;
- ▷ Poorly defined conditions for rule application (certain operational situations do not allow the use of the rule or work procedure);
- ▷ Precise wording: the more vaguely the rules are written, the more likely unintentional violations will occur[12];
- ▷ Incompatibility between the ideal technical/organizational situation described in the rules or procedures (e.g., no faulty sensors) and the actual situation of the installation **[Bourrier 1999]**. As F. Bastiat wrote in *La Loi*: "The surest way for laws to be respected is to make them respectable". Referring to the Three Mile Island nuclear accident, **[Llory 1999]** highlights the optimism that allows procedure authors to indicate that frontline actors must ensure they are "not stressed" when a serious nuclear accident occurs;
- ▷ Adequacy between task demands and available resources **[Hansez and Chmiel 2010]**;
- ▷ The level of autonomy in one's work **[Parker et al. 2001]** (see also the discussion in § 2.3), with more autonomy being associated with more deviation;
- ▷ The behavior of colleagues (especially their tendency to violate rules);
- ▷ Individual propensity to take risks.

[12] According to civil rights professor H. Silverglate (Harvard University), the legislative corpus in the United States is so vast and imprecisely written that an average professional violates three federal criminal laws per day **[Silverglate 2009]**. This lack of clarity is exploited by federal prosecutors to pursue individuals whose behavior they disapprove of, even when other laws indicate that the actions in question should be legal. This mechanism is used to target whistleblowers (Snowden, Assange), doctors who prescribe painkillers to terminally ill patients, individuals accused of financing terrorism (defense of the Kurds, "ecoterrorism"), as well as actions as mundane as collecting rainwater on their own property. Let us remember that Beria (working for Stalin) said, "Show me the man and I'll find you the crime", and Richelieu wrote, "Give me six lines written by the most honest man, and I will find something in them to hang him".

2

The "managed" approach to producing safety

The rule-based approach to safety, described in the previous chapter, relies on compliance with rules and procedures that prepare the system for generally anticipated situations and aim to develop its capacity to handle them. As noted in the previous chapter, this approach to safety has limitations, which become more apparent as the system becomes complex and subject to hazards and uncertainties[1]. Thus, the rule-based approach and the procedural framework exist alongside a **managed approach to safety** (also referred to as "initiative-based safety"), which [Daniellou et al. 2010] define as the

> *capacity to anticipate, perceive, and respond to unforeseen failures by the organization. It relies on human expertise, the quality of initiatives, the functioning of collectives and organizations, and management attentive to the reality of situations and fostering the integration of various types of knowledge useful for safety.*

Managed safety does not depend on compliance and procedures but rather on the strategies, initiatives, improvisations, and ingenuity deployed by frontline actors — individually or in groups — to cope with contingencies and the variability of real work, drawing on a plurality of normative sources. Thus, it is produced (with safety thought of as something the system *does*, rather than a quality it *has* or not) through the expert knowledge of actors, their ability to make sense of events, and the real-time implementation of **individual and collective skills**. To highlight some differences between these two approaches:

- Rule-based safety is essentially a **top-down** approach, in which management, the design office, and method experts plan and control the work of frontline actors; managed safety in contrast is essentially a bottom-up approach, where the experience, expertise, and know-how of actors closest to the hazards shape the organization's response to risks.
- Rule-based safety is essentially a **static** approach, relying on anticipation and the development of a reference framework at the design stage, whereas managed safety is dynamic and adaptive.
- Rule-based safety relies on **compliance**, whereas managed safety relies on proactivity and reactivity, autonomy, initiative, adaptation (and therefore resilience, though this term is used with a wide variety of meanings).

Figure 2.1 summarizes the differences between these two approaches to safety.

[1] As [Reason et al. 1998] states, "*there will always be situations where no rule is available or where variations in local circumstances challenge the applicability of the available rules*".

Normative-Rationalist Model

Classical approach that equates obedience, compliance, and safety. Rules are seen as constraints on the behavior of frontline actors, reducing the number of errors they commit. Rules are designed and imposed by experts higher up in the hierarchy and distant from the field; frontline actors do not have the necessary skills to create a safe reference framework. Compliance is the best way to work in all anticipated situations. Deviations are negative and should be discouraged, or at least serve as learning opportunities.

The academic literature adopting this view mainly comes from technical disciplines and psychology; it primarily considers relatively simple work activities.

Adaptive-Constructivist Model

Rules are socially constructed action patterns, derived from experience combined with the diversity of frontline reality. Rules are local, situated, and include exceptions and nuances. It is the frontline actors who have the necessary expertise to produce safety in a dynamic context. Formal rules are necessarily simplified abstractions, to be used as general indications, but must be adapted to each concrete situation. The imposition of external rules is perceived by expert operators as an unwelcome limitation of their professionalism and ability to deploy their skills. Violations are inevitable; knowing when a violation is necessary is seen as a marker of expertise.

The academic literature adopting this view comes from sociology, ethnography, and management, focusing on cases mainly in complex systems with a strong technological component.

Figure 2.1 Two models of the role of rules and procedures in the creation of safety, according to **[Hale and Borys 2013]**.

Various empirical studies suggest that the adaptive-constructivist model is more relevant in complex systems. For example, **[Boskeljon-Horst et al. 2022]** examine how military personnel resolve conflicts between objectives in an operational context, relying on ingenuity and innovation that are not communicated to the hierarchy due to the organizational culture's lack of support for adaptations.

2.1 Tradecraft, professionalism and resilience

As **[Morel et al. 2008]** state, "*it is professionalism, not the rule, that should dictate action*". Morel proposes the term "enhanced competence" to describe

> *a deep and broad competence capable of largely replacing the numerous rules and procedures governing an activity, thus avoiding their accompanying perverse effects and gaps. It is not about eliminating all rules, but about placing competence at the heart of activities.*

Different terms are used to denote this professional expertise or professionalism. For instance, in the maritime transport sector, the term "**seamanship**" refers to the practical application of skills related to the safe operation of a vessel, derived from the combination of professional experience and technical knowledge **[Kongsvik et al. 2020]**. This notion is reflected in certain regulations, such as Rule 8 of the International Regulations for Preventing Collisions at Sea[2], which states that

> *Any action taken to avoid collision shall, if the circumstances of the case admit, be positive, made in ample time and with due regard to the observance of good seamanship.*

It is noteworthy that this excerpt illustrates that the rule-based and managed spheres of safety do not exist in isolation from one another; effective use of the rule-based framework is an act of management. This observation will be revisited in the following chapter, which addresses the articulation between these two ways of producing safety.

Over the past twenty years, the international maritime sector has experienced significant growth of its rule-based sphere, particularly through the implementation of the International Safety Management Code (ISM). Studies on the impact of this trend (development of safety management systems, procedures, formalized risk analyses and checklists, increasing use of audits to verify compliance) identify generally hostile attitudes among experienced professionals towards this new way of framing their activity. Procedural requirements are perceived

[2] This regulation, "Colreg 1972" (from "Collision Regulations"), is one of the regulations of the International Maritime Organization.

as being drafted by individuals who neither know nor understand the maritime profession. They believe that this evolution tends to delegitimize experience and weaken specialized safety expertise (specific to the profession) **[Almklov and Antonsen 2014]**, in favor of generic and standardized expertise carried by risk management experts. Thus, in a study conducted in the maritime sector, **[Almklov et al. 2014]** collect the following testimony:

> *You know, good seamanship, it is tragic, it is about to disappear completely. That expression, 'good seamanship', it doesn't exist anymore, because everything that is to be done, has to be written on a list. You are not supposed to use good seamanship and common sense, you are supposed to use check lists, procedures and maintenance lists. That's what it's all about. And I know this is a source of great annoyance to the guys on the deck.*

Professionals also feel that this process infantilizes them and reduces them to a bureaucratic role. For example, some sailors say "*The captain today is no longer a sailor; he is a secretary*" **[Knudsen 2009]**. **[Størkersen et al. 2020]** collect testimonies from experienced sailors such as "*You give apples to the teacher/auditor, but it doesn't make your work safer*" and "*We answer what we want our 'parents' to hear*". The hypertrophy of the rule-based safety sphere forces operational staff to perform additional tasks to document their activity. They must ensure the translation between the local and situated context of their activity and the generic boxes provided by the system implemented for traceability and auditability. The dimensions of the work that operational staff consider most important often occur in the "shadow" of the auditability mechanism.

This old notion of seamanship has been adopted in aviation using the term "**airmanship**", which denotes "*the ability to act with discernment and use relevant skills and behaviors, as well as in-depth knowledge to achieve flight objectives*"[3].

Various incidents in the commercial aviation sector have illustrated the ability of certain pilots to go far beyond the prescribed recovery actions. Notably, the remarkable landing on the Hudson River in 2009 following the loss of both engines on an Airbus A320 (US Airways Flight 1549, an event depicted in the film *Sully*), and Qantas Flight 32 in 2010, where despite the uncontained failure of one of the engines on an Airbus A380 causing significant damage to various systems, the pilots managed to land without casualties by using piloting strategies far removed from merely following checklists. Other accidents, where a lack of airmanship was highlighted — particularly the 2009 crash of AF 447 between Rio and Paris — underscore the crucial importance of this capability for safety.

Though not specific to safety issues, several commentators mention the lack of meaning and autonomy in work, the proliferation of processes, and the lack of flexibility as the main sources of job dissatisfaction **[Dejours 1993; Bouzou and De Funès 2018]**, potentially leading to workplace suffering and burnout.

It should be noted that operator expertise is sometimes perceived as a **source of danger**: some expert "cowboys" take more risks than less experienced operators and have a higher accident rate. R. Amalberti uses the term "self-proclaimed super-experts" **[Amalberti 2021]**:

> *This is not a category of expertise in the proper sense but more a typology of psychological profiles that spans the three levels of expertise. They willingly expose themselves to the system's less well-known and more risky areas, to demonstrate their know-how and ability to resolve non-standard situations (which they sometimes provoke). The pleasure and search for personal validation of their successes are important drivers of these professionals' behaviors. They like to show off their tricks, may become rare experts of tomorrow, but many of them will instead be the authors of incidents and accidents that shatter their dreams. Their number varies greatly depending on the industry. Few in number and generating high concern when they are identified in ultra-safe systems, they can be the norm in artisanal systems.*

[3] This definition is provided by EASA in the Part-FCL document, the "Flight Crew Licences" component of the regulations.

Key issue

"Ultra-safe" systems[4] bet that, statistically, deviation from rule-based competence is negative for safety. This leads to safe systems that lack resilience ("robust yet fragile"). Is this the "price to pay"?

2.2 Fuzzy rules

Rules and procedures never cover everything. **[Rasmussen 1997]** proposed explicitly describing the boundaries of what is permitted and developing skills as these limits are approached, rather than attempting to describe all the rules of a system and exhausting oneself in the hunt for deviations. Rules that would be suitable in this context are those that clarify the boundaries and provide recommendations and assistance as these limits are approached. Responsibility for the definition of these boundary rules would lie with central management for high-level rules, which involve a global vision of possible interactions, and with local teams for rules involving significant expertise related to the local context **[Hale and Swuste 1998]**.

Vague or flexible rules are drafted to allow the operator some flexibility in their interpretation, according to the specific circumstances of implementation and their context of application. Phrases such as "should" rather than "must"; "if applicable, work under nitrogen"; "according to good seamanship"; "as deemed necessary" are used. This small syntactical change profoundly alters the use of the rule. The purpose of this flexibility is to provide the front-line operator with discretionary space in which they can apply their **judgment**. **[Grote 2009]** indicate that "flexible routines" permitted by such rules allow for a good balance between the general need for standardization of activities within an organization[5], and the necessity to allow for adaptation, thus promoting organizational resilience.

It is useful to distinguish degrees of adaptation (intensity of management):

- Interpreting the rule and implementing it depending on the operational context of the day (e.g., the force to use when implementing "tighten the bolt").
- Adapting the rule to respect its spirit and intended objective: the prescription is designed based on a number of assumptions about the context in which it will be applied, and these assumptions are sometimes only partially valid in the operational context, necessitating certain modifications to respect the intended spirit of the rule. This form of adaptation raises the question of the threshold in level of modification where one should start speaking of *deviation* (or violation) by the operator.

[4] According to R. Amalberti's definition, ultra-safe systems are those where the annual probability of an accident is less than 10^{-6} (civil aviation in Western countries, the nuclear industry, for example). These are over-regulated, over-protected systems, whose adaptive capacity is neutered by the accumulation of norms, precautions, and protective barriers **[Amalberti 2001]**. A paradox affects these sociotechnical systems: the safer the system becomes in the anticipated domain, the more fragile it becomes outside this envelope.

[5] A basic assumption in management is that standardization and the implementation of organizational routines improve performance by reducing uncertainty about the actions to be taken, facilitating coordination, and increasing stability, managerial control of activities, and their legitimacy.

Concept of red and yellow lines

Example

A project to reform the prescribed framework used by intervention teams on high-pressure gas pipelines was undertaken by French company GRTgaz. This project developed the concepts of "yellow lines" and "red lines", providing a new framework for the necessary "agility" on construction sites.

Yellow lines are rules that can be deviated from under certain conditions. Red lines are non-negotiable (mandatory) rules referring to key safety parameters of interventions (in particular, the pressure and flow rate in the pipeline). A few verbatim statements illustrate how these concepts are interpreted by the concerned teams:

> *Red lines are conditions that we will never allow ourselves to exceed. Under no circumstances, in no conditions. And yellow lines: these are conditions that we consider in certain cases, with a specific study, taking into account the operators' experience for example, we will be able to, by anticipating a bit and thinking about how we can organize, we will be able to cross them in certain cases.*

> *An example of a yellow line: we set a limit of 55 bars under normal circumstances for working. But it happens that on certain projects, there is a need to exceed this pressure. So, we conduct a feasibility study of that project, to see if the personnel and equipment can carry out the project safely. And then there are the red lines, which, when we reach these red lines, we cannot carry out the project safely.*

These new benchmarks structure discussions, negotiations, and arbitration around any compensatory measures to be defined during activity preparation or incident management. They also serve to revise operating procedures and guide the choice of scenarios for field inspections and training. They enable more open and constructive dialogue on real work, particularly during supervisory visits or annual experience feedback meetings.

A more complete description of the context and results of the intervention, with graphic excerpts illustrating how the framework is presented, is provided in appendix A.

2.3 Worker autonomy

The concept of autonomy at work has been extensively studied in management, sociology, ergonomics, and psychology. **[de Terssac 2012]** defines it as follows (our translation):

> *Autonomy is a human disposition manifested in work either through resistance, strikes, implicit or negotiated internal arrangements, or unprecedented procedural inventions, in order to exercise one's capacity to influence work norms or the order of production.*

As early as the 1920s, management theorist M. P. Follett advocated thinking in terms of "power with" (cooperation, emancipation, and autonomy) rather than the "power over" that characterized Taylorist management. The notion of *empowerment* of frontline actors promotes voluntary compliance rather than enforced compliance **[Wilkinson 1998]**. This notion has seen various interpretations, including leftist ideological approaches emphasizing industrial democracy and workers' rights, and liberal discourses seeing it as an opportunity for entrepreneurial workers to free themselves from bureaucratic constraints and union power. It has also been used as a directive for survival in the face of corporate downsizing and outsourcing in the 1990s-2000s, or even as a way of abandoning frontline workers by depriving them of organizational support in the face of uncertainties **[Adler 1999]**[6].

[6] More recently, the directive for resilience has been used similarly by some elected officials to positively frame their disengagement from responsibility for preventing damage related to natural risks, or even those caused by armed conflicts.

Definition

Semi-autonomous teams according to the Tavistock Institute

Following World War II, a group of researchers from the Tavistock Institute of Human Relations in London studied work organization in certain coal mines in Scotland. In the post-war period, the mining industry was rapidly mechanized to meet growing demand. The researchers compared work organization and its links with mechanization in two mines, where the social climate, turnover, and consequently productivity differed greatly.

The poorly performing mine relied on top-down control, a strong division of labor, and task specialization. The well-performing mine was organized around small semi-autonomous groups, in which versatile employees regularly changed roles, developed a variety of skills, and regulated their activity with little hierarchical control. The groups cooperated with each other, employee engagement was evident, absenteeism was low, and accidents were infrequent. This work organization resembled that which prevailed before the introduction of mechanization in the mines, an organization that had allowed for strong team cohesion **[Trist et al. 1963]**. The researchers concluded that social interactions within collectives were important both to avoid feelings of alienation and to enable effective collective functioning.

The emphasis of this group of researchers on the importance of designing the technical-economic and social components of the system as an interacting whole explains the term "sociotechnical" given to this school of thought, which contrasts with a purely mechanistic approach to work organization.

Surveys such as those conducted by the European Foundation for the Improvement of Living and Working Conditions (Eurofound) find that[7] the

> *"form of organization that combines high latitude in task execution with strong employee participation is the most beneficial, as employees develop their skills, have better quality of life at work, greater motivation, etc. But it is also positive for companies, as they face fewer recruitment difficulties, less absenteeism, more motivation, creativity, and innovation.*

Autonomy and the delegation of authority are the opposite of the centralization of decisions and the establishment of a homogeneous rule-based framework[8]. This tension and its impact on safety are difficult to arbitrate, as autonomy promotes the engagement of frontline actors and allows situated expertise to be expressed, but it can also be the source of deviations that pose risks:

- Benefits of autonomy: a higher level of autonomy is associated with both **better organizational performance** and benefits for individuals (ability to develop professional skills, individuals' trust in the organization, their engagement in their activity, and generally better **quality of life at work**), as indicated by numerous studies in "work design" **[Cummings 1978; Parker 2014]**. Deference to expertise, which allows a frontline actor to make significant decisions, such as halting production, without referring to their hierarchical chain[9], is one of the dimensions identified by researchers from the HRO school as enabling safe operation even in the presence of disruptions **[Weick et al. 2008]**.
- Risks associated with autonomy: organizations fear accidents that could be caused by experienced frontline actors who develop **excessive confidence** in their knowledge and control of the system (the "cowboy" effect mentioned by R. Amalberti **[Amalberti et al. 2009; Amalberti 2021]**).

  Furthermore, significant autonomy can lead to a low level of cohesion and adherence to the organization's objectives. **[Weick 1976]** discusses the case of universities, where the regulatory framework is minimally restrictive, performance—both overall and individual—is difficult to evaluate, different faculties operate largely independently, and frontline teacher-researchers are highly qualified, subject to little hierarchical control, and act with great professional autonomy. He popularized the notion of **loose coupling** as a mechanism that reconciles autonomy and dependence within the organization. Loose coupling

7 Source: Interview in the magazine Travail & Sécurité with A. Parent-Thirion, research director at Eurofound.

8 The etymology of the word autonomy is explicit: the word is derived from the Greek *autonomos* and the parts *auto* (self) and *nomos* (rule, law). A direct definition is "the fact of governing oneself according to one's own laws".

9 A frequently cited example of this high autonomy granted to frontline actors concerns the "organized chaos" of landing or taking off on an aircraft carrier at sea. The lowest-ranked sailor on the ship, working on the deck, has the authority to stop takeoffs if they detect, for example, debris on the deck **[Roberts 1990]**.

allows the organization to implement local adaptations and innovations when the external environment evolves rapidly, tolerates subsystem malfunctions, reduces coordination costs, and permits decentralization, self-determination, and actor autonomy. Regarding universities, Weick suggests that strict control over the accreditation of academics is a significant constraint that allows the system to "hold together", maintaining a minimum of cohesion and integration within institutions. In later works, Weick highlighted the role of organizational culture in coordinating and integrating members of an organization, reconciling decentralization and frontline actor autonomy with the centralization of values and norms as a binding force **[Weick 1987]**.

Finally, high levels of autonomy and liberation can lead to clannish modes of operation, with segregation **[Ughetto 2018]**, or even with savagery, as illustrated by W. Golding's novel *Lord of the Flies*.

The dichotomy presented above is naturally reductive; thus, **[Ughetto and Haradji 2023]** write (our translation):

> *The problem of autonomy presents itself less in terms of an opposition between autonomy and the effort of a priori control, and more in terms of the various arrangements of autonomy and control, as well as the management of issues, possible contributions, and constraints introduced with regard to these arrangements by taking activity into account.*

Adding to the complexity of this tension and these arrangements, delegation, autonomy, and control form **fractal boundaries** in the workplace, with each hierarchical level demanding greater freedom of action[10]. The centralization-decentralization trade-off may be established differently depending on the hierarchical level concerned or based on an evaluation of each work collective's level of expertise.

New management paradigms and leadership models emphasize employee autonomy and network-based work rather than managerial control and hierarchy. Notable examples include (*cf.* figure 2.2) G. Hamel's book *The End of Management: Inventing Tomorrow's Rules* (Vuibert, 2008), I. Getz's concept of the "liberated company"[11], and the older Theory Y by D. McGregor (humans enjoy working and should be trusted to organize their work). These authors advocate against overly detailed prescriptions of activities, allowing "a hundred flowers to bloom[12]."

Figure 2.2 *Books by management gurus on popular themes such as the liberated company, agile organization from the software development world, and new leadership models like facilitator managers and humble managers.*

[10] For example, in the past decade, there has been a trend in several large companies to consolidate the management of safety-related issues (industrial, environmental, health, and psychosocial risks) within a single entity, "One Safety". This strong centralization impacts the leeway of those ensuring the link with frontline activities.

[11] Getz defines liberated companies as "*organizational forms that allow employees complete freedom and responsibility to take the initiatives they believe are best.*"

[12] It should be noted that Mao Zedong's campaign, which encouraged intellectuals to express themselves freely and criticize the Chinese Communist Party, was swiftly followed by a period of violent repression of those who had criticized the regime.

Example

Self-organization at Bayer

In 2024, the pharmaceutical company Bayer announced it would eliminate 99% of its internal reference documents and reduce the number of management layers. The CEO stated, "We hire highly educated and skilled employees, then place them in constrained environments with an abundance of rules and procedures and eight levels of hierarchy. Then we wonder why large companies function so poorly most of the time." The company plans to restructure around 5000 to 6000 "self-directed teams" that collaborate on projects they choose together for 90-day periods before forming new teams for the next period.

Generally, companies emphasizing the autonomy of frontline employees (often using terms like "liberated company") are involved in service activities where creativity and innovation are paramount, as opposed to concerns of safety, reliability, and planning. This terminology is more common in advertising agencies than in nuclear power plant operations.

Safety through the elimination of rule-based frameworks. In connection with the principles of liberation, the concept of "shared space" aims to improve road safety in city centers by removing a significant portion of the regulatory framework (road markings separating the sidewalk from the roadway, traffic signs, traffic lights, traffic rules). The hypothesis advanced by the Dutchman H. Monderman is that traffic regulation and road sharing are left to politeness, common sense, and social interaction among users. Some elements of this philosophy have been adopted in France in "meeting zones" (though with very stringent regulations for motorists).

The rule-based/managed articulation must be studied as a **dynamic** rather than a static phenomenon, which includes the constant production of rules (an inflationary approach that does not necessarily contribute to the overall quality of the corpus — as evidenced by the phenomenon of working to rule[13]). The progressive complexity of control mechanisms[14] (internal and external) concerns both organizational structures within companies and their relationship with regulatory authorities.

2.4 Related concepts

Managed safety is a very general notion, which is influenced by or encompassing numerous qualities or concepts studied by social science researchers for decades. These include:

- **Recovery work** [Faverge 1970], which involves "*getting a process that tends to derail back on track to eliminate dysfunctions, disruptions, or deviations.*" As noted by J.-M. Faverge, it is often the recovery initiatives of frontline actors that allow the system to function, but these recovery situations are also the most prone to accidents.
- **Arrangements** and **power games**, which refer to the strategic use of rule ambiguity for the benefit of actors [Crozier and Friedberg 1977]. Operational staff find that their ability to make the system work and ensure production despite the uncertainties and limitations of the prescribed framework gives them a certain organizational power, particularly over the hierarchy. They can use this power to ensure their activity is valued. This phenomenon also implies that these tacit and local knowledge, despite their importance for safe operation, will not be spontaneously transmitted between individuals or organizational groups.
- **Autonomy at work** [de Terssac 1992] and the issues of *empowerment* of frontline actors (*cf.* the discussion in § 2.3).
- The **ingenuity** deployed by frontline actors to find adjustments between people and between people and machines [Dodier 1995]. [Bourrier 2001] speaks of ingenious bypassing and invention to describe actors' ability to circumvent the prescribed framework to account for local contingencies, thereby creating "*margins of autonomy, pockets of private information, in short, power.*"

[13] Also known as "malicious compliance" and "uncivil obedience" [Bulman-Pozen and Pozen 2015].

[14] [Reason et al. 1998] notes that "*Safe operating procedures are continually being amended to prohibit actions that have been implicated in some recent accident or incident. Over time, these additions become increasingly restrictive, often reducing the range of permitted actions to far less than those necessary to get the job done under anything but optimal conditions.*"

- ▷ The **adaptive capacities** of frontline actors to cope with uncertainty and unexpected events **[Amalberti 1996]**, which constitute their main contribution in a highly automated system.
- ▷ The concept of work activity has been developed to account for the fact that work mobilizes the worker's intelligence in performing their task, and that the term "executor" is often unsuitable in many work situations. The task-activity distinction highlights the adaptive capacity of the frontline operator **[Daniellou and Rabardel 2005; Cuvelier 2016]**. It encourages better thinking about the rule to make it more achievable and requires reflection on preserving the operator's "management skills" (can they retain their competence if they do not use it?).
- ▷ **Instrumental theory**, located at the intersection of ergonomics and professional didactics, studies how professionals use rules and procedures. These rules begin their life as symbolic artifacts developed by designers to influence the activity of operational staff. They become instruments shaped and used by frontline actors, who, on the one hand, assign them functions sometimes unforeseen by the designers (a process called *instrumentalization*), and on the other hand, appropriate the rules and adapt their ways of doing things to make the best use of them for their own objectives (a process known as *instrumental genesis*) **[Rabardel 1995]**.
- ▷ "Safety in action" is "*the way subjects go about acting safely in the face of disruptions and managing their own actions, which are not always optimal in terms of the rules*" **[de Terssac et al. 2009]**.
- ▷ The "constructed safety" proposed by a working group of the COFSOH of the ASN, which extends the notions of safety in action and constructive ergonomics **[Falzon 2013]** to focus on the availability of resources (including rules, expertise, and initiative) and the ability to construct effective trade-offs between partially contradictory constraints and objectives.

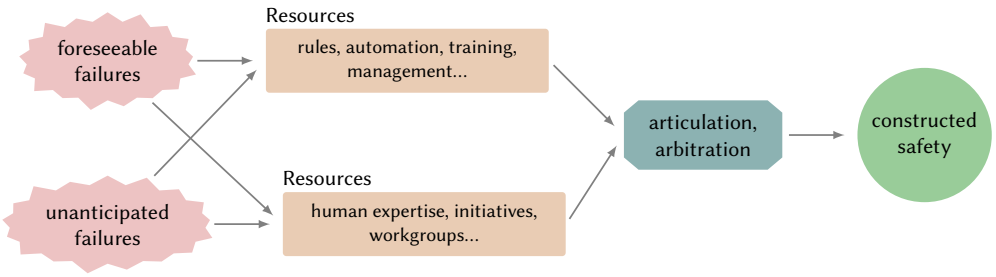


Figure 2.3 *The role of trade-offs in the articulation between resources, constraints, and objectives that enables the production of constructed safety, according to the report of COFSOH Working Group D* **[COFSOH 2017]**.

This reflection criticizes the often-evoked dichotomy "rules are for nominal situations and management is for the unexpected", instead seeing an interpenetration between the rule-based and managed to respond to a continuum of disruption levels. Periods and mechanisms of improvisation do not free themselves from rules but rely (as in a jazz orchestra) on a mixture of resources, both pre-written and spontaneous (*cf.* figure 2.3).

- ▷ **Resilience**, which in social sciences refers to a system's ability to maintain or redefine the dynamic equilibria that allow it to exist as something stable in a variable environment. This concept, developed particularly within the school of resilience engineering, covers in English-language literature part of the concepts related to the ability to articulate the ruled and managed forms of safety production. The contributions of this school are discussed in § 4.3.

3

Articulating compliance and initiative

As explained in the previous two chapters, the rule-based and managed dimensions of safety production — expert knowledge and frontline actors' field experience — are both necessary for the safe operation of complex systems. The challenge lies in their **co-development** or **hybridization**. This is not a simple and static articulation, but rather a mechanism with multiple facets, manifesting in different forms depending on the nature of the organizations and risks involved [Nascimento et al. 2013]. The modes of articulation can evolve over time, influenced by the contingencies faced by the organization and individuals, as well as by changes in context and workforce demographics.

Here, we aim to avoid certain **conceptual traps** or caricatural approaches:

- "*Compliance-based safety is when the operator follows the rules, and managed safety is when the operator no longer follows them*". Management also fundamentally involves the operator interpreting the situation to determine which rule applies, or acting when no rule applies. Furthermore, this focus on the frontline operator overlooks the numerous judgments made by the hierarchical line, which contribute to managed safety. The analysis of autonomy concerning the rule should also incorporate the roles of managers, prescribers, and safety authorities.
- "*Rules are for the expected, management and initiative are for the unexpected*". A significant part of managing the unexpected is based on rules: precautionary rules, such as the fuel carriage rule for airplanes already mentioned; generic rules, such as "always do" or "never do"; emergency stop rules, etc. Moreover, the improvisational mechanisms used in situations are more nuanced than this expected-unexpected dichotomy [Weick 1998]. An analogy used by some authors is the jazz group, which relies on a mixture of pre-written and improvised elements [Meyer et al. 1998; Moorman and Miner 1998]; as for organizational performance, the harmonious nature of this improvisation depends on deep experience and a degree of discipline that are not immediately visible.

- "*Compliance and initiative are like communicating vessels, disjoint registers, which must be appropriately balanced*". In fact, these are not disjoint registers; quite the contrary: in the literal sense, "management" includes rule compliance. Just as financial management relies on management rules, the safety rule framework is a tool for safety management, which tends to become dominant over time. However, for consistency with the vocabulary widely used in industry (in particular in France) today, we will retain the meaning of the term "managed safety" as centered on "what happens outside the rule".

3.1 Different forms of articulation: tradeoffs, equilibria, dialogue

B. Journé, a management professor and contributor to FonCSI's strategic analysis, summarized different academic perspectives on the notion of the articulation between rule-based safety and managed safety, distinguishing three main approaches described below.

3.1.1 A static adjustment decided at design time

The first approach to the articulation between rule-based and managed safety is to consider them as two **alternative modes** of safety management. In this approach, one can develop either one or the other to the maximum, but it will be very difficult to develop both simultaneously. This is the approach proposed by economist A. Wildavsky, particularly in his excellent book *Searching for Safety* **[Wildavsky 1988]**:

- The anticipation strategy aims to eliminate all forms of the unexpected, covering possible situations with rules and procedures. This approach involves bureaucratic rationalization of the organization, relying on a managerial logic and the expectations of external stakeholders. The rule expresses rationality and its function is to eliminate the unexpected; safety resides in rule compliance; audit and reporting mechanisms allow for monitoring proper functioning (which is functioning in conformity).
- The resilience strategy (Wildavsky uses this term to characterize organizations differently from its later usage) aims to develop the system's capacity to adjust to the unexpected, relying on expertise, professional skills, and situational intelligence.

According to Wildavsky, the articulation between the anticipation strategy and the resilience strategy involves an exclusive choice between them at the system's design. These two modes are of opposing natures and cannot coexist. Relying more on anticipation weakens and delegitimizes the resilient capacity; resorting to management will be seen as a failure of the dominant strategy). Conversely, an organization relying on a resilience strategy (startup spirit valuing innovation, or an organization with a strong professional culture) will tend to view any form of proceduralization as abandoning the ambition to be resilient, fluid, and adaptive. This choice made at the design stage can subsequently evolve over time.

Anticipation and resilience rely on very different resources (the former on uniformity, bureaucracy, and compliance; the latter on expertise, variability, and the self-regulation of frontline actors[1]).

It should be noted that this was of thinking of the articulation between initiative and compliance as a slider adjustment, where one can only develop at the expense of the other, holds a significant "market share" in France, and it is promoted by Icsi[2] (*cf.* figure 3.1).

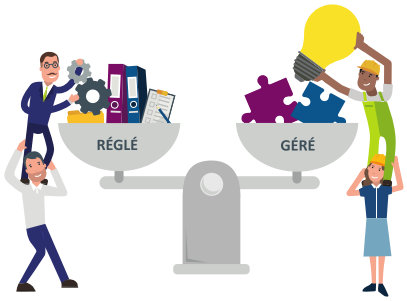


Figure 3.1 *Graphical representation associated with the explanation "Finding the right balance between rule-based and managed safety", document "The Essentials of Safety Culture", Icsi, 2017. The term « réglé » translates as "rule-based", and « géré » "managed". The symbol of the balance explicitly illustrates the hypothesis that these two forms of safety can only develop one at the expense of each other.*

[1] A. Wildavsky, cited in the dissertation manuscript of J. Eydieux, wrote in 1985, "*Anticipation emphasizes uniformity: the less fluctuation, the better. Resilience stresses variability: one does not do so well in good times but learns to persist in the bad.*".

[2] The Institute for an Industrial Safety Culture (Icsi) is a French organization that offers training and support services on topics related to industrial safety and shares a common history with FonCSI.

3.1.2 Compatible strategies if certain organizational conditions are met

The "simultaneously, provided that" approach posits that rule-based and managed strategies can coexist and be mutually reinforcing, provided that certain organizational conditions — which are quite demanding in practice — are met. This is the "HRO" approach from the school of researchers who have theorized the existence of highly reliable organizations, particularly following K. Sutcliffe and K. Weick.

- ▷ Anticipation and resilience are dual approaches, possessing opposite characteristics, but they can function together if the organization exhibits certain traits (particularly: the ability to maintain organizational slack[3] despite managerial pressures to eliminate unused resources in normal times; the existence of work collectives that can self-organize and are regularly exposed to situations requiring initiative and autonomous functioning).
- ▷ Highly reliable organizations are characterized by powerful oppositions, such as between technocratic rationalization and professional expertise mentioned above, and between centralization (to ensure the coherence of safety management methods) and decentralization (to address the complexity of the field and to identify threats early, with action and decision-making capabilities granted to local experts). These organizations' expertise lies in finding compromises between these different factors, relying on very specific roles and functions within the collectives as well as a strong capacity for local and temporary self-organization in crisis situations. The HRO literature discusses episodes or **bubbles of improvisation** that appear within an otherwise largely rule-based framework. Potential transition points between rule-based and managed operations are typically identified in advance and are the subject of training. Lessons learned from managed episodes are used to improve the rule-based framework through capitalization and feedback.
- ▷ Both the anticipation strategy and the resilience strategy must gain true political legitimacy (respect for both the technostructure that produces the rules and the professions that embody the professional know-how of adaptation and adjustment), and it is necessary to act to maintain the self-organization capacities of work collectives. For example, in the cases studied by the researchers at UC Berkeley who initiated the HRO school (the bridge of an aircraft carrier, a nuclear power plant control room), the collectives know and respect the prescribed framework but are capable of quickly switching to high-resilience functioning when the situation demands it.

3.1.3 Articulation as expert improvisation

Finally, some pragmatist researchers[4], propose viewing articulation as **expert improvisation**, a "making do".

- ▷ Anticipation constitutes the foundation of "resilient control". In risk situations, operators conduct an "inquiry" (a quest for meaning, an exploration and research activity): the situation is not fully understood, but it is known that one cannot act as usual; it is necessary to assess the situation, act to better understand and control it, relying on rules and procedures but also taking initiatives by deviating from the standard. The pragmatist logic posits that action and reflection are inseparable and are articulated by inquiry. One cannot understand the problem without simultaneously considering available resources and possible actions. The problem informs the reflection on solutions, but anticipation and knowledge of possible solutions also inform understanding of the problem.
- ▷ During this inquiry process, actors use available resources, found in both rule-based and managed safety spheres. What allows the articulation of rule-based and managed is the logic of inquiry, that is, the search, here and now, for a solution to an identified problem, relying on different forms of resources to maintain system control. Unlike the HRO approach, which focuses on macro-organizational articulation, the pragmatist approach focuses on locally constructed meaning, even if an inquiry can mobilize the

[3] Organizational slack is an excess of resources within the organization that contributes to its resilience.

[4] The pragmatist approach in social sciences, following the work of American philosophers C. Peirce and J. Dewey, aims better to understand what experience is and how it is constructed. According to these researchers, knowledge does not exist in isolation from the real world but is produced in and by action through an empirical inquiry process that people undertake to reduce their doubts. Therefore, it is a school of thought that opposes the rationalist current.

broader organization (work collective, national support services, possibly a crisis unit, subcontractors and partners, the safety authority).

- ▷ The expert knowledge mobilized by the managed sphere naturally relies on the rule-based framework, and the rule-based framework only has practical meaning in light of a local situation analyzed by professional experts. Thus, the rule-based is the background of the managed, and conversely, the managed is the background of the rule-based, with a fluid relationship between the two.
- ▷ Inquiry is a form of improvisation that relies on substantial know-how and a mix of pre-written and spontaneous actions. Safety in action is arbitrated by professionals themselves based on the situation, adding to or deviating from formal rules. Their expertise allows the rules to transition from an "abstract status of 'norm' or 'prescription' to a tangible resource for action, which can be interpreted, discussed, or diverted", as noted by **[Denis 2007]** (our translation).

It should be noted that the ability to implement managed safety depends on the background, skills, and expertise levels of individuals working within the system. This expertise tends to be more significant in those with long experience within the system, but it is not merely the number of working years; rather, regular exposure to situations requiring autonomy and initiative development is crucial. This competence may atrophy in "veterans", including those with excellent technical knowledge, if their exposure to these situations, in operation or training, is not maintained and legitimized by organizational practices.

3.2 The $S = S_R + S_M$ "equation"

The debate on the articulation between rule-based safety and managed safety is rooted in long-standing theoretical notions, particularly those that have permeated activity ergonomics since the 1960s, as discussed in chapter 1. However, the use of the terms "rule-based" and "managed", especially their mathematical formulation $S = S_R + S_M$, is more recent, originating from an article published by G. Morel, R. Amalberti, and C. Chauvin in 2008 **[Morel et al. 2008]**. The article, based on G. Morel's doctoral dissertation, analyzes how professional fishermen balance the risk of accidents due to poor weather conditions against the risk of production loss (income loss resulting from the decision to remain in port, which, in the long run, could jeopardize the economic survival of the activity).

Example

Artisanal approach to safety among professional fishermen

Professional fishing is an activity exposed to significant risks of fatal accidents. Fishing captains must make high-stakes trade-offs between production and safety, between the survival of the fishermen and the survival of their enterprise. Analysis in a simulation context of decisions to go to sea despite degraded weather conditions indicates that professionals rely much more on their expertise, experience, and know-how than on a regulatory context to make these decisions, knowing that each operational team is responsible for its own safety. This "artisanal" approach to safety, based on strong expertise and adaptability, is far removed from a regulation-based approach.

These studies highlight the fact that a resilient system (in the sense that it is based on strong adaptation by expert professionals) is not necessarily a safe system (despite some confusion between these terms in certain works).

This equation formulation, along with its graphical representation illustrated in Figure 3.2, was popularized in France by a training course on human and organizational factors of safety sold by the Icsi, developed in particular by F. Daniellou, a professor of ergonomics and author of an influential guide on this topic **[Daniellou et al. 2010]**.

This equation is a simple mini-model with all the inherent advantages (providing a basis for reflecting and exchanging on issues related to the rule-based/managed articulation) and disadvantages (overly simplistic framing that obviously does not represent all factors contributing

5 The presence of this bidirectional arrow in this graphical formulation is due in particular to discussions with G. de Terssac.

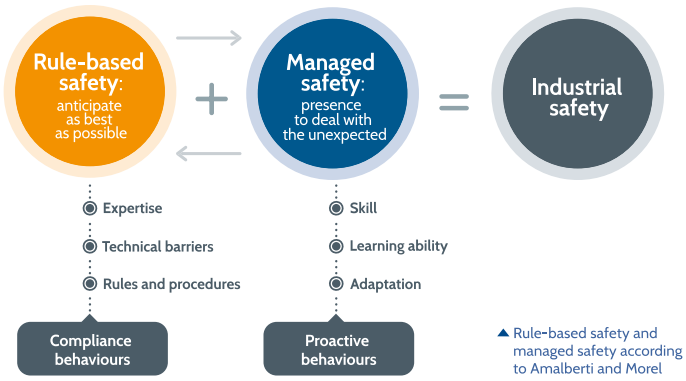


Figure 3.2 *Graphical representation of the $S_R + S_M$ "equation" proposed by the Icsi in its document "The Essentials of Safety Culture", 2017. Note the presence of arrows suggesting a form of interaction between rule-based and managed spheres: managed safety operates within a rule-based framework (actors do not act arbitrarily), and managed safety can and should be analyzed to ensure continuous improvement of the rule-based framework[5].*

to safety in complex work situations) of such an object. Among the **benefits** and **limitations** of this formulation, we can cite:

- ▷ Its ability to convey in a basic but understandable way an observation derived from activity ergonomics (*cf.* the discussion in § 1.3):
  - compliance with rules is not sufficient to ensure safety;
  - it is necessary — sometimes, in the presence of unforeseen events — to add a component of local expert interpretation;
  - constantly expanding the rule-based sphere and body of procedures to react to unforeseen events produces more undesirable effects than progress.
- ▷ Its slightly subversive role in making decision-makers aware that the "noble" work of management (making trade-offs, using expertise) is not only present at the highest hierarchical levels but also on the front lines, among the "executor staff". This management activity includes choosing the right rule to apply in a given situation, interpreting this rule, and reflecting on the activity's purpose, the objectives sought, the main risks associated with the task, and the context.
- ▷ Its ability to serve as an effective entry point for discussions with managers when they start to consider compliance issues, helping them, for example, to address the articulation between central directives and field specifics. Managers often seek guidance on the conditions enabling this articulation.
- ▷ The risk of being interpreted too simplistically by industry managers, who may see "rule-based" as referring to obedience and compliance with a rule, and "managed" as the whims and vagaries of frontline staff. These initiatives are sometimes successful, but — particularly when they become visible to the managerial line, thus leading to a hindsight bias — sometimes unsuccessful.
- ▷ Criticism from some that it "adds" together items that are not expressed in the same units. Work activity is always "managed"; activity is a management of constraints and objectives (including safety). Rule-based safety is a forcing function for the activity, in the sense of a constraint on the user's actions that prevents them from performing actions that could cause an undesired result. Among the resources and tools implemented to respond to this need for tradeoffs are rules (pre-developed trade-offs based on invariants and past experiences) that simplify the arbitration decision-making.
- ▷ The term "rule-based" is sometimes criticized because the rule framework traditionally comes from the management world.
- ▷ Also criticized because the equation does not highlight different important issues, such as organizational dimensions, relationships, communication, and bureaucratization.

It is useful to add some clarifications to better appreciate certain subtleties of the model:

- The R in this equation covers procedures, but also professional rules, formal and informal professional practices.
- The + should not necessarily be interpreted as implying that S_R and S_M are communicating vessels: one might think that S_R and S_M can be jointly developed, and their interactions can be examined. To manage, certain resources are needed, including rules; conversely, what gives meaning to the rules is the managed component (expertise). These interactions are partially determined by organizational culture, national culture, etc.

Key issue

Let's dare an analogy: does the music produced by an orchestra result from a simple addition between the score and a management activity? Clearly not: the music also results from the talent of the musicians, their competence. The score is written assuming that the musicians will know how to interpret it. Each musician interprets the score according to their instrument, their position in the orchestra, their experience. Conformity is important to avoid cacophony, but the value of a musical concert lies in the specificity of a performance, including elements of personalization.

- Nothing in the model indicates that S_M is present only when S_R is inapplicable. There is always (a bit of) S_M. A good procedure applied by an experienced operator is not the same as when applied by a temporary worker: the former's experience has allowed them to develop the skills to judge if the procedure is applicable that day.
- The two spheres do not mobilize the same type of knowledge: S_R relies on formalized, explicable knowledge, while S_M largely relies on embodied knowledge, which is not easily expressed. Hence, the difficult dialogue between the two and the challenge it represents.

3.3 The design and management of a corpus of rules

The implementation and management of a framework of rules and associated derogation mechanisms is a broad topic that encompasses psychological, linguistic, technological, organizational, social, and political dimensions.

The application of procedures is a **cognitive task** in its own right, as noted by **[Dekker 2003]**, requiring subtle judgments about the sequencing and timing of sub-tasks, their relative importance, and their prioritization, taking into account the local context. This observation implies that:

- Rules are resources for action. They do not specify all the circumstances in which they apply, and therefore cannot dictate their own application. They cannot, by themselves, ensure safety.
- Correct application of procedures in situ requires both substantive and skillful competence.
- Safety results from the operators' ability to judge when and how to adapt (or not) the procedures to local circumstances.
- To progress in safety, organizations must control and understand the underlying reasons for the gap between procedures and practice, and improve the capacity of front-line actors to judge when and how to adapt.

The academic and technical literature provides numerous insights on the proper drafting of a rule and the management of a corpus of rules and procedures, addressing questions such as:

- How to draft the procedure (ease of understanding, absence of conflict with other rules, prioritization based on their safety impact);
- The degree of detail that should be included;
- Incorporating an explanation of the objective sought, to help the user of the procedure adapt it optimally to an application context that might not be exactly as envisioned by the designer;
- Adaptation to the targeted audience, particularly according to their level of experience;

- ▷ Drafting in close association with front-line actors (co-production) **[Reason et al. 1998]**. Some researchers go further and suggest "*starting from safety practices to establish relevant rules rather than the reverse*" **[de Terssac et al. 2009, p. 14]**. This does not mean turning away from existing safety rules, but understanding how operators "*combine them in action, decide to use them or not, and above all [how they] invent others to 'act safely'*".
- ▷ The informational support on which it is presented to users and the associated navigation and search modalities. This simple issue is the source of many practical problems. In some companies, for example, the documentation associated with the safety management system is carefully maintained in a locked room, to be available when the auditor comes to perform a compliance check, thus ensuring a complete disconnection between the system's objective and the activity associated with its maintenance. In other cases, the rule-based framework is maintained on a modern computer system to which front-line actors do not have access. When significant investments are made to provide modern digital tools (connected tablets, etc.) to operational staff allowing them to consult different elements of the framework, careful observation of work in situ shows that the sophisticated equipment is much less usable than the paper documentation it often replaced: front-line actors cannot open multiple views simultaneously, cannot make annotations, do not have access to a bookmark function, and the search functions are hardly usable.
- ▷ The regular evaluation and revision of rules, and the integration of feedback (*cf.* § 3.5.4). The cost of this activity should not be underestimated.

Example

State-Based Operation in the nuclear sector

After the Three Mile Island nuclear accident[6], EDF and Framatome developed a new approach to incident and accident management of nuclear reactors, called «conduite par état» in French, variously translated as "state-based" or "symptom-based" approaches (in the following, SBA). This approach aims to propose management strategies adapted to each physical state of a reactor. Indeed, while incidental or accidental events and their developments can be very varied, the possible states of reactivity, cooling, and confinement of the reactor can be enumerated from normal operating conditions to accidental conditions **[Couturier 2020]**. Thus, the SBA differs from the event-based management approach previously used, which requires identifying the cause(s) of the encountered problem in abnormal situations to select the most appropriate procedure to apply.

The strictly event-based approach is insufficient because experience in plants shows that reality does not always conform to anomalies studied during the design phase: conditions encountered are different from envelope assumptions, and unforeseen failures can overlap with the initiating event, complicating the diagnosis (which is generally valid only at the accident's origin) and disrupting the course of the anomaly. Improvements have been made to broaden the validity domain of event-based procedures, but it fundamentally appears impossible within this approach to account for all conceivable (simultaneous or not) combinations of physical and human failures.

The SBA allows adapting the management strategy to apply by regularly checking the six state functions of the installation, which are:

- ▷ The core sub-criticality or the level of nuclear power;
- ▷ The primary circuit water inventory;
- ▷ The removal of residual power from the primary circuit;
- ▷ The integrity of the steam generators;
- ▷ The water inventory of the steam generators;
- ▷ The integrity of the containment structure.

More concretely, in the event of an incident or accident requiring the application of incident or accident procedures, the management team applies a procedure called the Orientation and Stabilization Document (DOS) whose objective is to determine the appropriate management strategy for the event being faced. The adequacy of the strategy chosen following the application of the DOS is regularly reassessed in light of these six state functions. This allows management teams to change the procedure to apply in case of deterioration of the installation and thus ensure the transition to a safe state.

Operators apply Incident and Accident Management instructions by doing what is explicitly requested in the documents (following a rule-based approach); these procedures, developed based on the installation's design studies, help minimize the consequences of the incident or accident. However, an adaptation of the procedures is possible (a managed approach) respecting

an established organization: derogation from the instruction is subject to consultation between operators and their hierarchy. Depending on the nature of the derogation analyzed, different actors participate in this consultation (which leaves space for the managed sphere of safety).

The SBA, supported by the management organization, allows adapting the diagnosis according to the evolution of the installation's state. It is the combination of the SBA and the established organization that constitutes a proposal for articulating compliance and initiative and helps reduce the risk of inappropriate actions, which could lead to a secondary accident. Similar modifications to management procedures in the USA are referred to using the terms "symptom-based", "state-based", and "scenario-independent".

This form of support for safe operation despite uncertainty about the system's state is also found in the medical sector, which establishes an analogous distinction between **symptomatic treatment** (targeting a manifestation of the disease, such as reducing a fever or inflammation) and **etiological** or "root cause" treatment (targeting the cause, such as administering an antibiotic to treat bacterial tonsillitis). Etiological management generally requires diagnostic tests that cannot be performed urgently; symptomatic treatments help maintain the patient in a satisfactory state while awaiting test results.

[6] The Three Mile Island accident (1979) revealed deficiencies in the operators' understanding of the reactor's state due to weaknesses in the HMI. Numerous alarms were triggered, creating a "Christmas tree" phenomenon that overwhelmed the operator team with information. During this accident, the operators applied procedures unsuitable for the situation due to their incorrect understanding of it. These actions led to a worsening of the situation.

It is interesting to establish a connection with J. Rasmussen's **functional abstraction hierarchy** means-ends model, graphically represented in figure 3.3. Managing rules involves navigating the means-ends axis of this hierarchy: when a rule regarding the means to be implemented is not feasible in a given situation, it is necessary to move up the hierarchy until a more generic rule, expressed in terms of objectives to be achieved and general principles, is found. This generic rule will help arbitrate between possible actions[7]. Moving up the abstraction hierarchy implies seeking a more general resource that allows for the determination of the appropriate action, which may require the use of a derogation mechanism or an appeal to a higher level ("n+1").

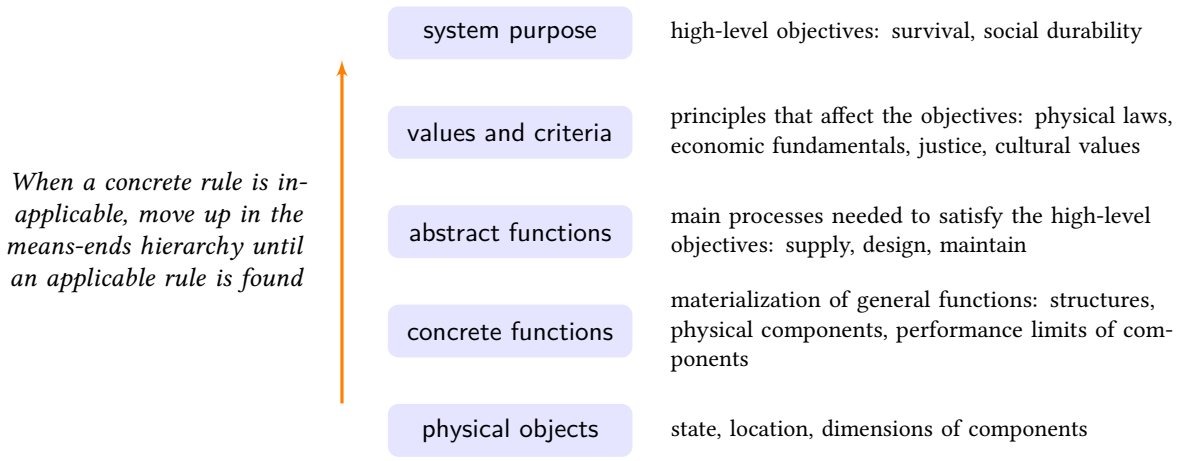


Figure 3.3 *Abstraction hierarchy (means-ends) from* [Rasmussen 1985]. *This represents a functional decomposition of the work environment in complex sociotechnical systems, ranging from the system's purpose (its goals, the high-level principles governing its operation) to the physical equipment composing it. Moving from top to bottom on this means-ends axis corresponds to analyzing* ***how*** *different system elements are implemented to meet objectives. Moving from bottom to top reveals* ***why*** *different physical objects exist.*

Key issue

Should we move towards fewer rules and more explicit principles? Napoleon already wrote that "*the commander in chief should only indicate the general direction, simply determining the goals to be achieved; as for the means to be employed to achieve them, they must be left to the free choice of the executive bodies, otherwise success is impossible*". This practical suggestion seems relevant in most large modern sociotechnical systems, where the rule-based framework is generally more extensive than desirable.

One could imagine the usefulness of a **rule-writing policy**, which would depend on various contextual factors such as the author and the target of the rule (who is speaking to whom), the level of authority, and the level in Rasmussen's functional abstraction hierarchy. This policy should allow for the integration of the interpretative dimension of rules. An illustration of contextual writing is provided by the hierarchy of norms in the civil aviation sector (*cf.* figure 3.4).

[7] This way of conceptualizing the use of a framework of rules written at different levels of abstraction, advocated by J. Pariès in the FonCSI strategic analysis group, is not widely known but is not new. For instance, J. Leplat, writing about safety rules, states, "*As work becomes more discretionary, rules must take different forms and must be more meta-rules which prescribe not so much the safe behavior to adopt as the properties required from the behavior and the criteria it must satisfy. Then the operators' responsibility is no longer to be judged in terms of deviations from prescribed rules or standard safe behavior, but in assessing if, in the specific situation, these meta-rules are implemented as they should be by a skilled operator.*" [Leplat 1998].

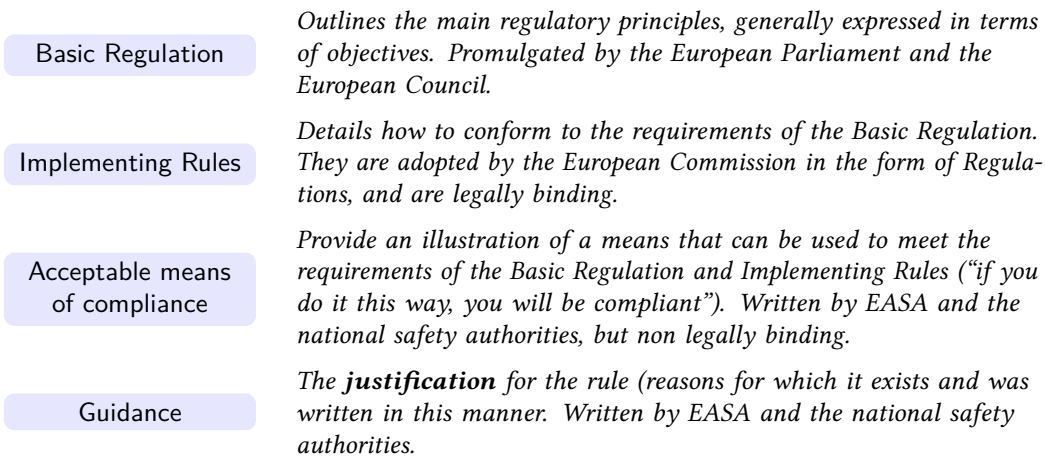


Figure 3.4 *The hierarchy of rules and regulatory instruments used in aviation in Europe.*

Example

Usage of the Quick Reference Handbook by aircraft pilots

[Wright et al. 1998] studied the annotations made by an airline pilot in their personal copy of the *Quick Reference Handbook* (a manual provided by the aircraft manufacturer, containing all emergency procedures and checklists for the aircraft in a practical, abbreviated format). 38% of the 323 annotations made by the pilot concerned justifications of the procedure structure (the reasons for specific actions, such as "disable the auxiliary fuel pump"). This finding highlights the importance for experienced users to understand the reasoning behind a rule, allowing them to interpret and apply it while considering contingencies (26% of the annotations in the mentioned study concerned possible adaptations of the procedure).

This observation supports the idea that procedures are used as a *resource for action*, allowing for a certain degree of flexibility, rather than as exact prescriptions of the actions to be taken.

3.4 Participatory construction of the prescribed framework

A participatory approach to creating and revising work rules (involving frontline actors in the creation of procedures and safety rules, as well as in review sessions) leads to several positive outcomes:

- better applicability of the rules, leading to better adherence;
- a smaller number of rules;
- better ownership of rules and safety practices by frontline actors.

This approach moves away from the "Bonapartist" management style (over-proceduralization, low trust in individuals) that persists in some companies (particularly in France, known for "management by circulars"[8]), and towards more contemporary organizational modes such as liberated, agile, empowering, and self-managed companies. These forms of organization help reduce disengagement from work ("quiet quitting"), absenteeism, and turnover[9].

[8] Compared to other democracies, France has particularly centralized, vertical, and authoritarian political institutions **[Ory 2023]**, and these tendencies are reflected in the corporate world. A 2018 Ifop survey *Les salariés et la transformation managériale* indicates that 43% of the employees and 44% of the managers (in private companies with more than 50 employees) believe that their company's management trusts them to make decisions on important issues. Respondents also felt that the trend was towards more hierarchy, employee obedience, opacity in decision-making processes, and bureaucracy. Recall also that during the Covid-19 pandemic in 2019, even leaving one's home in France required filling out a declaration of honor.

[9] In France, only 7% of employees reported being engaged in their work in 2023, compared to 23% worldwide, according to the annual Gallup survey *State of the Global Workplace*, 2023 edition. The categories other than *engaged* are *not engaged*, "not psychologically attached to their work and company" and *actively disengaged*, "unhappy at work, resentful towards the company for not meeting their needs, and vocal about their dissatisfaction." Furthermore, the proportion of employees who consider work to be "very important" in their lives has plummeted over just over thirty years, from 60% in 1990 to 21% in 2022 (and 25% among managers), as indicated by a note from the Jean-Jaurès Foundation.

In the following paragraphs, we propose some illustrations of this principle and its importance for safety.

Example

Participative review of the rule framework (railways, USA)

An analysis of the impact of a participative revision approach to the procedural framework in the railway sector in the USA found that the intervention led to more usable safety rules, a higher compliance rate, and improvements in safety culture (particularly less conflict between hierarchical levels). The intervention also resulted in a reduction in the rate of workplace accidents and their severity, measured by the damages paid to victims [Ranney and Nelson 2004, 2007].

Example

Participative review of the rule framework (gas transport, France)

GRTgaz, a high-pressure gas transport operator within the Engie group, occasionally requires **hot tapping** operations on high-pressure gas pipelines to allow for pipeline deviations without interrupting gas supply. These operations require significant preparation (including the installation of heavy intervention equipment), precision, and vigilance. They involve high operational variability and are sometimes performed in emergency situations. The necessary skills are mainly acquired through training, mentoring, and practical experience. The challenge is to learn to "feel the machine" and know "how far one can go."

In the context of structural changes (decentralization of the risk management function ensured by the expertise pole) and a renewal of staff, recurring observations of variability in professional practices between teams, and a higher number of incidents in the past year, management and teams expressed concerns about practice compliance, with feared consequences in the form of errors and incidents. GRTgaz's Industrial Performance and Safety Unit was asked to support teams in updating the procedural framework better to reconcile the need for high compliance and rigor with the necessary autonomy of actors in often highly constrained and specific projects.

An intervention approach based on interviews, field observations, and various types of workshops aimed at exploring possible improvement paths (on risk analysis, feedback, collective vigilance, and prescription), identified 20 improvement items for the procedural framework and safety management system.

The intervention seemed to have enabled the actors to better understand and recognize each other in their roles, positions, legitimacy, and power, and more generally allowed the organization to better negotiate with itself a partial renunciation of a more "traditional" safety approach, based on rule-based safety, centralization, and control, in favor of a more adaptive and resilient model, more aligned with the real (decentralized) organization, (complex) activity, and (variable) environment.

A more detailed description of the context and results of the intervention is provided in Appendix A.

Other studies that we find interesting to mention briefly:

- A comparison of maintenance activities in four nuclear power plants in the USA and France found that in two of these plants, where engineers responsible for preparing the rules communicated with the intervention team about the content of the prescriptions, or where team leaders were authorized to change the procedures, the number of rule bypasses was lower [Bourrier 1996].
- A study on construction sites highlights the benefit of collective work preparation. Setting up collective discussions, involving site management, before the most difficult phases of the project, brings benefits in terms of work quality and accident prevention. [Six 1999] refers to this as the "social space in which the procedural framework is built."

The following example illustrates the risks that may arise when frontline actors feel that the organization is not sensitive to discussions about work conditions and possible adjustments to the prescribed framework.

Example

Risks of concealed compromises within a profession

C. Murie's doctoral research on the work of aviation maintenance mechanics [Murie 2022] highlights the safety risks that occur when frontline staff prefer to make micro-centered compromises (arrangements within a small work group) when the prescribed framework is not compatible with their perception of safe work, rather than making the effort to produce a macro-centered compromise (involving equipment designers, managers, etc.). Frontline staff are encouraged to prefer the former option when the organization is perceived as not open to discussing the difficulties of applying the framework and seeking acceptable modifications.

3.5 Organizational features facilitating effective articulation

In this section, we briefly describe a number of organizational devices used in various sectors to foster a relevant interplay between rule-based and managed safety. These include structures managed by trades, CRM-type training, feedback mechanisms, work discussion spaces, and deviation mechanisms. This list is not exhaustive and should not be considered a catalog; we aim merely to highlight the role these organizational devices can play, if operated in a favorable organizational context, in improving the articulation between rule-based and managed spheres.

3.5.1 The trade

The trade is a forum for reflecting on high-stakes situations that can be a source of rules and regulations to frame individual behaviors while leveraging relevant initiatives [Daniellou 2012]. It helps develop a shared view of quality work, "work well done", as well as **prudence-related know-how**.

Definition

Prudence-related know-how

This term ("savoirs-faire de prudence" in French) encompasses a set of attitudes and behaviors, informal practices, aimed at ensuring workplace safety and health. In a slaughterhouse, for example, this may involve specific details of the cutting technique related to how to position a piece of carcass and the types of cuts to make, which help avoid injuries and fatigue caused by an excessive number of movements. This know-how, specific to each trade and type of activity, is passed on by experienced workers to apprentices when they work together over long periods, using a pedagogy based on demonstration and observation. These skills are typically difficult for workers to formalize, for instance, in the form of a rule.

This concept was highlighted by D. Cru and C. Dejours following observations of construction workers' activities: these skills were detectable by an expert observer watching the work activity but were not found in the rule-based framework regarding the activity [Cru and Dejours 1983].

The culture of the trade also significantly impacts the perception of rules and the acceptability of expert deviations. [McDonald et al. 2005], based on a study in an English hospital, note that doctors reject written rules, preferring to rely on unwritten rules concerning acceptable behavior for their profession. In contrast, nurses view compliance with the prescribed framework and the standardization of behaviors as synonymous with professionalism and criticize the violations by doctors.

Technological innovation and robotization have led, over the past few decades, to a reduction in the number of employees for whom the notion of trade plays a structuring role.

3.5.2 Work debate spaces

Numerous research studies highlight the value of work debate spaces, **discussion spaces** concerning issues encountered in the workplace, which according to [Detchessahar 2013], constitute a medium (our translation)

> *through which all the adjustments, compromises, and makeshifts implied by the incompleteness of prescriptions and the irreducibly erratic nature of concrete activity are realized.*

Such work debate spaces have been experimented in an electricity distribution company (see the box below).

Work debate spaces at RTE

Example

An experiment implementing work debate spaces was conducted by R. Rocha as part of his doctoral thesis at RTE, a French electricity distribution company. RTE aimed to update its safety management policy, characterized by a heavyweight oversight system (numerous rules and procedures, rigid sanctions and penalties when non-compliances were detected, etc.), yet still experiencing more or less visible field anomalies. The action-research aimed to develop spaces where potentially delicate work situations could be collectively debated among employees, and also between employees and managers, to influence the organization **[Rocha 2014; Rocha et al. 2015]**.

These discussion spaces must adhere to the **principle of subsidiarity [Rocha et al. 2017]**, often necessitating a change in how power and autonomy are approached within collectives.

The principle of subsidiarity

Definition

The principle of subsidiarity holds that responsibility for an action within an organization should be taken at the closest hierarchical level competent to solve the problem. Thus, a central authority should not perform tasks or make decisions that could be handled at a lower level. Politically, this principle is defined in the Treaty of the European Union: *Under the principle of subsidiarity, in areas that do not fall within its exclusive competence, the Union shall act only if and insofar as the objectives of the proposed action cannot be sufficiently achieved by the Member States, whether at central, regional, or local level, but can rather, by reason of the scale or effects of the proposed action, be better achieved at Union level.*

The principle of subsidiarity proposes reversing the notion of delegation: it is no longer the leaders who delegate certain decisions to the base, but rather when a situation exceeds an entity's capacity to act, it is escalated to a higher hierarchical level. The Latin etymology of this word, *subsidiarius* (reserve troops), reflects the tension between the idea of *non-intervention* (under normal conditions) and that of *capacity to intervene* (if necessary).

In practice, this principle is seldom respected, whether politically or in workplace organization within companies and administrations. Frontline actors generally have little leeway to adapt injunctions from the rule-based sphere of safety to the constraints of the "here and now" **[Dugué and Petit 2022]**.

C. Masson's doctoral thesis observed teams operating nuclear submarines, analyzing their response to an accidental situation with ambiguous elements **[Masson 2013]**. She compared the reactions of teams working on two generations of submarines, which differ in design, consideration of human factors in safety, and the approach to the prescribed framework (one using a state-based control approach, the other not). She found that both teams managed to handle the accidental situation by bringing the reactor to a safe state, concluding that (while noting the difficulty of generalizing from a small number of cases):

> *An adaptive system that allows for debate spaces on practices is not necessarily less safe than a normative system. [...] Top-down standardization is not the only path to achieving an acceptable level of safety. (p. 192)*

It is noteworthy that the sometimes difficult state of social debate in France has hindered the success of various historical experiments, such as the worker self-expression groups put in place by the Auroux law of 1982 and quality circles[10]. The importation of approaches such as *lean management* in France, which in Japan includes debate spaces to exchange ideas for production improvements, has often seen these formal discussion spaces gradually become empty shells **[Bertrand and Stimec 2011]**. Informal exchange spaces allowing for "autonomous regulation" in the sense of Reynaud (see the box below) sometimes function better than formal

[10] "Self-expression groups" were provided for in France by the Auroux law of 1982 on workers' right to self-expression. J. Auroux, Minister of Labor, wanted companies to not be "the place of machine noise and human silence" and aimed to establish a culture of social negotiation. Later, quality management introduced "quality circles" to promote continuous improvement. The implementation of these participatory mechanisms within French companies has been criticized by some authors who see it more as an adjustment of Taylorism rather than as a challenge to its fundamental principles. **[Linhart 1991]** refers to the *ostrich's stiff neck* to evoke the suspicion that persisted, according to the author, within company management towards the working class. Linhart feared that these mandatory participatory mechanisms, which rarely lead to changes in work organization, could weaken the informal exchange networks present within trades and workshops.

mechanisms in large companies, but tend to be viewed as non-productive time by management, a waste to be eliminated by following lean principles.

J.-D. Reynaud's social regulation theory

Example

The theory of **social regulation** (or joint regulation) put forward by J.-D. Reynaud analyzes the process by which rules (both explicit and implicit rules existing in any social structure)[11] are established. He suggests that this process of rule production, regulation, is more important to study than the rules themselves, which (considering all the context in which the rules are interpreted and used) constantly evolve. Rules are seen as a collective construct reflecting the opposition between several social groups with divergent values. Reynaud indicates that "rules are hardly separable from the activity that creates and maintains them, that is, the regulation activity."

Reynaud distinguishes between *control regulation* (top-down imposition of formal/explicit rules to control execution work) and *autonomous regulation* (production by frontline actors of informal/implicit rules to resist imposed control or to compensate for certain limits of formal rules), where the term *regulation* denotes the process of negotiating and maintaining social rules. In Reynaud's analysis, conflicts between actors are normal as they reflect their desire to seek new rules allowing collective action: conflict and negotiation produce order.

G. de Terssac applied this analytical framework to the modalities of rule production in industries at risk of major accidents **[de Terssac 2003]**, developing the concepts of "constructed safety" **[de Terssac and Mignard 2011]** and usage rules **[de Terssac 2013]**.

The notion of **dialogism** by philosopher E. Morin refers to the idea that different logics or principles can form a whole without losing their duality in this unity. While Hegel's dialectic aims to find coherence between two logics through exchange and communication, highlighting their contradictions and seeking to transcend them through synthesis, dialogics (or "double logic") aims to integrate them within the same system through the cooperation of both logics. The distance between the rule-based and managed spheres of safety can be seen as a "fertile gap to be cultivated", as proposed by **[Cuvelier and Woods 2019]**, rather than as a risk to be eliminated or reduced.

Key issue

When conducted in constructive organizational conditions, debate can be seen as a means to transcend the opposition between the rule-based and managed spheres of safety, conceiving them as reservoirs that can nourish each other.

3.5.3 CRM-type training and proactive exercises

Training actions aimed at improving "crew resource management" (CRM)[12] are implemented in sectors such as aviation and healthcare. One of the objectives is to regulate individual risk-taking and potential deviations.

According to **[Haller and Stoelwinder 2013]**, CRM training in hospitals creates spaces and opportunities for the entire team involved in an operating room to discuss risks and safety procedures, facilitating a shared vision of their importance and relative priorities. This consensus includes elements that need to be formally documented, whereas previously, these decisions were left to individual discretion.

Experiments have been conducted by researchers working with FonCSI on forms of "resilience-based" training/intervention, which aim to develop professionals' ability to interpret ambiguous situations, act, and cooperate in unforeseen or critical situations. Two families of training/intervention methods are studied, always in a "non-curricular" spirit, i.e., deviating from traditional "classroom" training modes **[Flandin et al. 2021]**:

[11] Reynaud defines rules as: "A rule is an organizing principle. It can take the form of an injunction or prohibition aimed at strictly determining behavior. But it is more often a guide for action, a standard that allows judgment, a model that guides action" **[Reynaud 1989]**.

[12] CRM: Crew Resource Management, a set of training procedures focusing on communication and interpersonal relationships, leadership, and decision-making among crew members. These types of training courses were implemented following lessons learned from the Tenerife accident in 1977.

- Those that develop **proactivity in ordinary situations**, i.e., daily activities that create favorable conditions for proper functioning. These involve various forms of exchanges between professionals aimed at a better shared understanding of goal conflicts, decisions made, difficulties encountered (e.g., procedures not well adapted to certain situations), and improvement possibilities.

  For example, training/intervention methods designed to train attentive and caring professionals include: (1) debriefing forms using photographic traces to collectively reconstruct a common understanding of what happened during the intervention, the important points for different professions and services involved, and sources of friction between professional cultures; (2) "scenario-investigations" where trainees follow procedures, construct and interpret clues, solve technical problems, and locate equipment in a virtual environment replicating a nuclear reactor building **[Drakos et al. 2017]**.

- Those that enhance **reactivity in extraordinary and critical situations**, i.e., the ability to recover from critical organizational destabilization. These are mainly simulation-based approaches, such as crisis exercises, used to improve professionals' ability to produce managed safety rather than to verify the proper execution of plans (improvement of the rule-based safety sphere).

While these new training-intervention approaches seem promising for enhancing organizations' capacity to cope with contingencies, there is relatively little experience on the generalization of such systems **[Ketelaars et al. 2024]**.

3.5.4 Operational experience feedback and organizational learning systems

Certain industry sectors have ensured a **qualitative improvement of their procedural system**, thanks to experience feedback systems that allow workers to report difficulties encountered in using a rule or procedure. This involves collecting information on situations where the procedure was not suitable given the local context, analyzing them, and improving the procedures and rules. These feedback systems contribute to building compromises and capitalizing on lessons learned to update the rule-based framework and the equipment.

3.5.5 Debriefing meetings

Debriefings are meetings organized following a phase of work (intervention, mission, project-related activity) where participants exchange orally to establish a critical account and assessment of the work done. One useful topic during these meetings is the difficulties in applying the procedural framework, the decisions made given the local context, and possible modifications to the procedure, rule, equipment, or work organization. Debriefings allow the transition from an experience to a narrative, thus transforming private knowledge into public knowledge, which can create general and shared knowledge about the system's operation **[Pastré 1999]**.

C. Masson's study on nuclear reactor operation in two generations of submarines, cited above, identifies different uses of debriefings (particularly "debate-oriented" debriefings) to improve the articulation between rule-based and managed dimensions of safety (our translation):

> *In this study, it is possible to observe debriefing situations where trainers adopt a normative approach. The objective here is to measure the gap between what operators did and what the prescription expected of them. There is a significant reminder of the prescription, and trainers position themselves as "knowers" vis-à-vis "learners". This study also observed more "debate-oriented" debriefings inspired by the adaptive safety approach that tends to reconcile rule-based and managed dimensions of safety. Indeed, they allow the formal rules to be debated and informal rules to be reworked in concert with trainers and operators. Trainers use debriefings to broaden operators' possibilities, creating an envelope of acceptable good practices for each situation. In doing so, trainers move away from the idea that there is only one way to do things, which would be the procedural way. Debriefings are an opportunity for trainers to measure the evolution of practices and to propagate a good practice observed one day in a simulator to another team. Finally, trainers adopt a "positive" attitude (Rudolph et al., 2007). All these elements show that these debriefings tend to promote the development of operators' autonomy and skills. Therefore, these are constructive debriefings. (p. 195)*

3.5.6 Exemptions and derogation mechanisms

Regardless of the thoroughness of activity preparation, certain situations cannot be anticipated. Therefore, in any complex system, it is essential to have mechanisms that allow for exemptions, under various conditions and following appropriate approval procedures, from the established rules. These exemption mechanisms are highly variable in nature, ranging from informal procedures (such as oral validation by a team leader) to highly formalized processes involving an internal analysis by a dedicated committee, which is subsequently validated by the safety authority.

4

Systemic approach to the link between compliance and initiative

In this chapter, we briefly describe various research efforts that have explored the articulation between rule-based and managed spheres from an **organizational perspective**, focusing on mesoscopic scales (incorporating the hierarchical chain leading to general management in enterprises) and the macroscopic scale of the system, which includes inter-organizational dimensions and connections with civil society (*cf.* figure 4.1). These meso and macro scales are critical in determining the choice of safety doctrine and the strategy selected to manage system instability: the extent to which the system's functioning is based on predictive capability and predetermined operations versus other strategies related to reactivity and creativity.

Finally, we conduct a **systemic analysis** of the articulation between rule-based and managed spheres in the production of security, focusing on the emergent characteristics produced by the interactions between the different components and scales of the system. This analysis is based on the theory of organizational resilience.

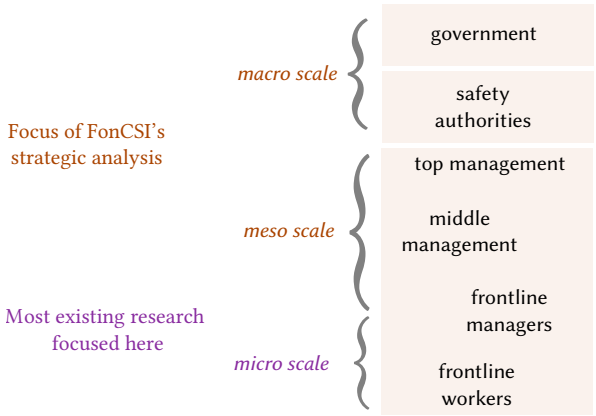


Figure 4.1 *Meso and macro scales of a sociotechnical system, according to a graphical representation popularized by J. Rasmussen. A systemic approach to the rule-based/managed articulation involves studying this interaction at different scales of the system, taking into account the interactions between organizational levels, the role of the public, and various institutions that structure society (regulatory authorities, judiciary, media). It also involves analyzing the emergent characteristics produced by these interactions, rather than those resulting from the properties of each component considered in isolation.*

4.1 Rule-base and managed spheres at the meso scale

As discussed in the previous chapter, most research on the compliance-initiative articulation has focused on the work of frontline actors and the micro scale of the system. However, as indicated by **[Dien 2011]**, the entire organization — including higher hierarchical levels — is concerned with these issues (our translation):

> *Finally, the relevance of deviations from procedures will be greater if the contradictions between official directives (e.g., strict adherence to procedures) and the implicit and real (!) messages conveyed (e.g., providing "outdated" procedures that do not correspond to the evolution of the installation) are minimal. In other words, it is necessary to ensure that the means and resources required for the effective implementation of the decided policies are present. Moreover, it seems necessary that everyone, within the* ***entire*** *organization, assumes responsibility for their actions (or inactions), whether their effects were immediate or delayed.*

In the same vein, **[Hayes and Maslen 2021, p. 187]** note that,

> *the disconnect between the current positioning of theory and research practice is so distinct that safety science research could be characterized as seeking answers in easily accessible places rather than in those most likely to lead to improvements.*

This viewpoint is also shared by J. Pariès, scientific director of FonCSI, who explains in an *Industrial Safety Tribune* titled *À propos du réglé et du géré* **[Pariès 2021b]** that

> *managed safety is simply, by definition, the management of safety. This means much more than the residual activity not yet addressed by rules, or the initiative or inconsistency of basic actors. Fundamentally, safety results from management, that is, trade-offs between risks and various dimensions of performance (efficiency, safety, health, comfort, etc.). And this occurs at all levels of the organization, especially at the highest. Managed safety is therefore not reserved for basic operators. It is often the lack of "management" and high-level trade-offs that creates the need to "manage" at the sharp end.*

The existing qualitative studies on the link between managerial activities and industrial safety mainly concern the first level of supervision and, more rarely, middle management, with few studies focusing on senior management (an exception being the literature on "upper echelon theory", described in the box below, which focuses more on economic risks than safety risks). For instance, a systematic meta-review of the academic literature on safety leadership **[Pilbeam et al. 2016]** found that none of the 25 articles studied concerned the work of senior managers. This relative absence of studies is likely due to the difficulty of accessing these decision-making environments for social science researchers.

Definition

Upper Echelon Theory

"Upper echelon theory" analyzes the impact of personal characteristics (psychological factors, age, education) of leaders on their perception of the organization's situation, their evaluation of possible actions, and their strategic decisions. Empirical studies show, for example, that younger leaders are statistically more inclined to take strategic risks, that female leaders are — in Western countries — statistically more risk-averse than male leaders, and that companies led by individuals with initial management training are more likely to go bankrupt than those led by individuals with initial technical training **[Cannella et al. 2008]**. More recent studies show that the characteristics of the executive committee better predict firms' strategic decisions than the characteristics of the CEO alone.

In the context of the strategic analysis led by FonCSI, **[Ramanujam 2024]** draws on studies in healthcare safety to show that this "orientation" of decision-makers can also influence the extent to which staff within an organization feel free to use their initiative by deviating from rule-based norms.

4.1.1 Managerialism and managerialization

We designate the term "meso scale" to refer to functions within the organization ranging from middle management to corporate leadership. These functions are referred to as "management" roles, where management, as suggested by G. de Terssac, involves both **defining the boundaries** for work activities and **maintaining** activities **within the planned boundaries**[1]. Historically, this managerial function (and the establishment of the rule-based framework) within companies has primarily been ensured by the hierarchical management line. However, the rise of managerialism[2] in large firms has led to the emergence of other functions responsible for specific aspects of the rule-based framework, such as the design office that designs products and selects or designs the necessary equipment for production, the methods office that develops work schedules and procedures, and the purchasing department that establishes guidelines concerning relationships with suppliers.

The number of these functions contributing to the development of the rule-based framework has increased with the phenomenon of "managerialization" of organizations. Functions such as "planners" **[Dujarier 2015]** — consultants, auditors, organizers, project managers, quality and methods experts, management controllers, financial officers, IT specialists, tax experts, buyers, merger and acquisition specialists, and corporate service providers — have multiplied. These planners (specimens of the species *homo dispositivus*) design work situations while being distant from the workplace and being perceived as unfeeling and even inhuman. Based on a survey conducted in various companies, as well as her own professional experience, M.-A. Dujarier observes that actual work disappears behind this "disembodied" management carried out at a great organizational, physical, and temporal distance from frontline activity.

Managerialization is also expressed through the increase in **reporting obligations** within companies, with each organizational level having to feed an ever-wider array of indicators (on production levels, costs, incidents, and anomalies affecting quality or safety, but also extra-financial dimensions such as environmental impacts, diversity of employee profiles at various levels of responsibility, and other "ESG" dimensions). This obligation extends beyond the scope of the company itself, as managers must also provide various indicators concerning their clients and suppliers (e.g., child labor throughout the supply chain as part of the duty of vigilance of major contractors[3], greenhouse gas emissions of clients as part of "scope 3" evaluations).

The massive development of mechanisms that establish a framework and controls on managerial activity reduces managers' ability to act as **translators** between top-down directives from corporate leadership and bottom-up constraints from the frontline. This adjustment and translation activity, illustrated in figure 4.2, which supports the **principle of subsidiarity** within organizations, is one of the important activities of managers, as indicated by F. Daniellou **[Daniellou et al. 2010]**:

> *Management (frontline supervision, service, and site management) plays a major role in these adjustments that allow the organization to function:*
>
> - *managers contribute to the preliminary definition of the structure, including formal rules (they "define the framework");*
> - *they ensure the daily adjustments necessary between formal rules and other sources of knowledge and rules, particularly professional practices (they "make things fit");*
> - *they participate in the periodic renegotiation of formal rules when necessary.*

[1] The French term for managing in the workplace (« encadrer ») has the double meaning of supervising and of establishing boundaries.

[2] We use this term to denote the adoption of a scientific approach to management and the associated process of professionalizing managerial work.

[3] The French law on corporate duty of vigilance, enacted in 2017, establishes a legally binding obligation for large companies operating in France to identify and prevent adverse human rights and environmental impacts resulting from their own activities, from activities of companies they control, and from activities of their subcontractors and suppliers, or companies with whom they have an established commercial relationship.

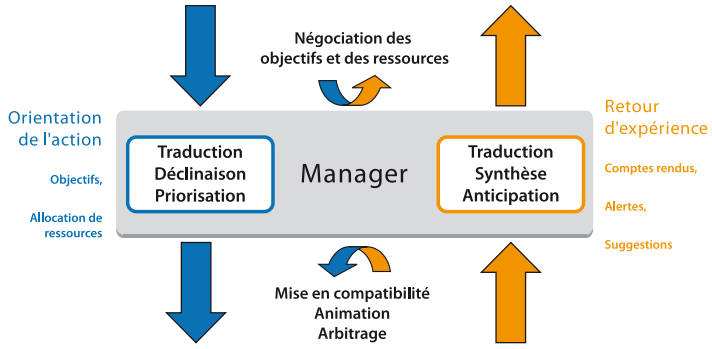


Figure 4.2 *The role of the manager, according to* **[Daniellou et al. 2010, p. 94]***: defining the context and boundaries in which work activities take place, adjusting, translating, making things fit, renegotiating.*

Key issue

Reducing these possibilities for translation results in inevitable adaptations falling on frontline actors (operational staff and frontline management), who have few resources to help them make decisions. It also leads to increased **organizational silence** and weakens **organizational lucidity** (the ability to have a reliable understanding of the human cost at which safe performance is achieved **[Pariès 2023]**).

Nevertheless, some researchers advocate for this restriction of managerial leeway regarding safety issues. For instance, A. Hopkins writes **[Hopkins 2011]**:

> *There is, in addition, a whole set of what might be described as non-operational decisions that impact on safety, for example, planning, design, and investment decisions. I shall argue that it can be dangerous to allow those who make these decisions to carry out their own risk assessments, because these assessments are likely to be biased in the direction of allowing decision-makers to do what they are already predisposed to do—a confirmation bias of sorts. In particular, there are constant pressures on these decision-makers to minimize cost and hence to understate the risks of the lowest cost option. [...] First, investment and planning decisions are likely to have a greater impact on company profit than many operational decisions. Second, the decision-makers are likely to be more powerful, and hence more resistant to limitations on their decision-making freedom and more able to point to the inevitable inconsistencies and inefficiencies in all blanket restrictions. Third, the rules concerned are more likely to be externally imposed rules and thus in conflict with prevailing presumption in favour of self-regulation.*

This "managerialization" — the development of management through setting performance objectives, resorting to "benchmarking", and the proliferation of computerized management tools — particularly affects the work of **frontline managers**. Various studies observe reduced interest for this function, perceived as difficult, subject to tensions, and having to arbitrate the contradictions between the difficulties experienced by operational teams ("patching up the procedures", as **[Martin 2013]** writes) and top-down corporate objectives, all while having very limited leeway. Frontline managers must ensure the "coexistence of professional rules and performance objectives, or in other words, horizontal professionalism and the injunction to professionalism", as **[Martin 2013]** writes. These managers know that they will be held accountable in the event of an incident or accident, especially if the actual work performed proves to be different from what was prescribed.

Various focus group studies organized in France note statements such as "The only residual responsibility in the role is in the job title", "Our role has been emptied of its substance" **[Colin et al. 2009]**. According to an Opinion Way study cited in **[Lanoë 2019]**, 41% of managers consider their role to be useless in today's working world, and 62% of non-managers would not want to become managers if given the opportunity.

4.1.2 Designed-in auditability and "safety bullshit"

The doctoral thesis of C. Stoessel **[Stoessel 2010]**, which addresses workplace autonomy and social recognition based on observations in the nuclear sector, includes an excerpt from a conversation with a technical manager who explains the evolution of practices (our translation):

> *If you notice vibrations in a motor, you request a written opinion from maintenance to determine if your equipment is available. In the past, the guy would say "It's fine", and that was it. Now, you need a document. If the Safety Authority shows up and asks, "How can you be sure your equipment is available?", you can't respond, "Well, maintenance told me". No, you need a document; written records remain. And it's not just the Safety Authority, but also the hierarchy, the Nuclear Inspection…*[4]

Over the past few decades, there has been a development of the principle of control based on the "**designed-in auditability**". Rather than conducting these inspections "directly" on operators in a regulated sector, the authority can require the operator to ensure the traceability and auditability of its activity by implementing quality assurance mechanisms, audits, and internal controls to detect deviations from the standard. The authority can then rely more on indirect control mechanisms, which consist of verifying that the audit system is functioning in a satisfactory manner. This control approach, initiated in the financial sector, is expanding into other sectors of activity **[Blewett and O'Keeffe 2011; Marsden et al. 2023]**. It leads to a rule-based framework designed not only to improve performance but also to ensure a certain uniformity in the execution of work, following a quality approach that allows the detection of deviations, traceability, and auditing.

Some researchers denounce an "audit explosion" **[Power 1994]** which leads to "**rituals of verification**" associated with the excessive growth of the rule-based framework. This evolution has several consequences:

- The delegitimization of the expertise of front-line actors, already mentioned in § 2.1 regarding the concepts of seamanship and airmanship;
- The development of "**safety bullshit**" **[Størkersen and Fyhn 2024]** (a deliberately provocative term used by researchers who contributed to FonCSI's strategic analysis on the articulation between initiative and compliance behaviours, inspired by the anthropologist Graeber's notion of "bullshit jobs"), bureaucratic tasks that serve to document and trace real activity to ensure its auditability, performed in the name of safety but producing nothing in terms of actual safety. **[Blewett and O'Keeffe 2011]** mention the effort deployed to maintain up-to-date "*documentation that has little impact on the actions necessary to ensure the safety and health of workers, and may even hinder the production of safety by over-prescribing tasks and producing inapplicable rules, limiting the adaptation margins of operators*".
- The phenomenon of "**auditism**" **[Størkersen et al. 2020]**, in which the anticipation that the activity must be auditable shapes the very way of performing the work (one can no longer imagine performing a task that relies solely on professionalism for its safe completion without its compliant performance being auditable by a third party and the activity being certified according to an ISO-type standard);
- A loss of **functional redundancy** due to the diversity of task execution forms by different expert operators. This functional redundancy is a source of resilience in the system; the development of standardization (and the confrontation between sheriffs tracking "cowboys" with somewhat unconventional methods) impoverishes the registers of action that could be deployed in response to a new threat.
- Sometimes, an excessive confidence in the actual safety level of the activity, attributable to a misunderstanding of the often superficial nature of the verifications carried out during audits **[Hutchinson et al. 2024]**.

[4] This trend has not disappeared, and the 2023 annual report of the General Inspector for Nuclear Safety and Radiation Protection of EDF indicates, "*Too many non-qualities have led to a form of reassurance by the continuous addition of requirements, signatures, risk analyses, lines in procedures, materials, and criteria in the general operating rules. It is necessary to show that the work on the gesture is sufficient and effective, where the 'proceduralization' of activities often only promotes the illusion of control.*

4.1.3 The growth of the compliance function

In parallel to the development of audit functions, we have seen an expansion of "*compliance*" programs aimed at ensuring the conformity of companies' activities, their leaders, and employees with legislation, but also more broadly with prevailing legal and ethical standards **[Gaudemet 2016]**. **[Huising and Silbey 2021]** use the term "**accountability infrastructures**" to refer to

> *a network of offices, roles, programs, and procedures dedicated to aligning the organization's operations with external standards, codes of conduct, ethical expectations, and regulations.*

Compliance can also be seen as a function whose role is to help company actors understand the prescribed exogenous framework or navigate the maze of rules. This assistance is made necessary by the growth in the volume of regulations, standards, and codes that apply to industrial activities, as well as by an evolution in their formulation, which relies less on prescribing means obligations and more on setting objectives to be achieved.

Finally, the emphasis on the compliance function can, in some situations, be interpreted as an action by the managerial line to regain control over experts within the organization who develop organizational power deemed too significant. **[Huising 2014]** recounts a case of conflict between experts managing safety in medical research laboratories (handling radioisotopes, biological pathogens, and toxic products) and their managers. The managers imposed a standardization of risk management practices and a strengthening of the prescribed framework to better control the activity of the experts, whose practices were not always compliant with regulatory requirements.

4.1.4 Algorithmic management and control via digital tools

From a historical perspective, the era of paper-based guidelines was succeeded by the era of **computerized tools** that assist practitioners in identifying the applicable rule and enforce task completion by following a predefined algorithm. This evolution enhances the influence of designers on the overall performance and operation of the system. For instance, some medical professions are swiftly transitioning from a model based solely on human expertise to one where professionals must follow instructions provided by a computerized system.

The **algorithmic management of work** is also extensively developing within the platform economy, significantly impacting the activities of self-employed delivery workers, whose every minute at work is specified ("pick up a package at this location, follow this route to deliver it"), monitored (a worker who refuses offered tasks is less likely to be assigned future tasks), and tracked. It also affects certain employees working with computerized assistance and management in production lines, call centers (standardized "scripts" that teleoperators must follow when interacting with clients), and logistics warehouses for online commerce. This algorithmic management, relying on the collection of massive amounts of data on frontline workers' activities through various digital tracking tools **[Ajunwa et al. 2017]**, can be interpreted as an **automation of certain management activities**.

Key issue

More recently, this reduction in leeway and algorithmic supervision also affects **executive employees**, who must record **reporting** information (not only on operational criteria but also on extra-financial issues[5]), and whose decisions and choices are restricted by enterprise resource planning (ERP) systems.

These software tools constitute a form of **dematerialized guidelines**, integrating constraints directly into the user interface, such as checkboxes limiting possible choices and workflows that are difficult to deviate from, without necessarily having the associated "rules" explicitly

[5] Reporting obligations now concern not only the performance of each organizational unit but also a series of ESG indicators (criteria related to the environment, social issues, and governance of the organization). These obligations respond to the demand for greater visibility on these issues from financial markets and civil society.

written out[6]. In this sense, management software acts as a forcing function for activities, similar to interlocking devices that ensure the safety of certain dangerous machines even if usage procedures are violated[7]. By recording every action and message, they also enable traceability and *ex post* control of work. They lead to, or result in, the constraint and control of work activities in a form of **algorithmic panopticon [Zuboff 1988]**.

Definition

The Panopticon according to Bentham and Foucault

The panopticon is a prison architecture imagined by J. Bentham at the end of the 18th century. It allows a guard in a central tower to observe prisoners, whose cells are arranged in a circle around the tower, without the prisoners knowing when they are being watched. Thus, they would feel a constant surveillance, leading to a form of self-regulation of their behavior. The concept was popularized by M. Foucault, who highlighted the ability of such devices to allow power to control in an automatic and deindividualized manner while remaining invisible **[Foucault 1975]**. Foucault noted, even before the rapid development of video surveillance and "surveillance capitalism" by smartphones and social networks, that panopticism can be seen as a political technology that establishes new forms of organizational control and power in society. Notably, Bentham's panopticon included a democratic principle of "controlling the controller" through pathways within the prison allowing citizens to observe how prisoners were treated, a principle rarely respected in digital panopticon architectures.

Some authors refer to "digital Taylorism" **[Pellerin and Cahier 2021]** to describe the inclination to use digital management systems not only for assistance but also for control and surveillance of operators. The operator is not augmented but rather *diminished* by the confining and encapsulating nature of digital systems. **[Kellogg et al. 2020]** identify six mechanisms through which algorithms are used to control and constrain workers' activities:

- ▷ Algorithmic recommendations that nudge workers towards a choice preferred by the system designer, based on mass data analysis indicating it will be more effective or safer, for instance.
- ▷ Algorithmic restrictions that limit workers'/users' access to information or prevent certain actions (e.g., preventing "gig workers" using digital platforms from communicating with each other).
- ▷ Recording of activities and real-time production of statistics, such as the productivity level of a worker.
- ▷ Algorithmic evaluation and rating, requiring users of a service to rate their satisfaction to identify the best-performing workers.
- ▷ Algorithmic replacement, ceasing to assign tasks — and thus income — to workers deemed less efficient.
- ▷ Algorithmic remuneration, providing real-time benefits to workers whose activities are judged compliant with objectives, possibly incorporating "gamification" mechanisms.

These examples particularly concern the platform economy, where the controlling nature of technology is intentional. However, detrimental effects on employees' trust in the organization[8] can also result from well-intentioned decisions aimed at improving productivity, quality, and safety.

[6] In the dystopian future described by G. Orwell in *1984*, where "nothing was illegal, since there were no longer any laws", and where Newspeak was structured so that subversive ideas could not be expressed, "the fundamental deprivation of freedom suffered by a member of the Party is not due to the prohibitions on what he is allowed to say but to the destruction of the conditions that would enable him to develop the capacity to come up with something worth saying."

[7] A common example is the interlocking device in microwave ovens that physically cuts off the power to the microwave source when the oven door is opened. This follows the design principle highlighted by J. Leplat, "*For every rule, it is always good to ask: what should be done to eliminate the necessity for this rule?*" **[Leplat 1998]**.

[8] A study published in the Harvard Business Review in 2022 indicates that employees who feel monitored at work are more likely to break organizational rules.

4.1.5 The increasing distance between prescriber and user

Another historical development that tends to generate safety issues is that rules are increasingly **written far** (in terms of physical distance, hierarchical and organizational levels) **from the point of implementation**. Moreover, implementation often relies on an information system, making it more difficult to circumvent the rule and **informally manage deviations**. Thus, the digital traceability systems and the "built-in auditability" mechanisms discussed in § 4.1.2 lead to rules imposing themselves more strongly on actors than in the past.

Employees implement informal **workarounds** to mitigate the adverse effects of these digital management tools. For example, an inability to accurately calculate necessary stock, due to poor software configuration, might be bypassed by using an Excel spreadsheet. These workarounds sometimes lead to accidents when a new team member is not informed of the official tool's limitations and how to circumvent them.

For instance, a medication error in prescribing a radiopharmaceutical drug led to the death of a child undergoing chemotherapy in France. Following a change in the drug's packaging and name by the manufacturer, the active ingredient dose per tablet per container increased tenfold. The hospital pharmacy's dosage calculation software used to prepare treatments via an automaton based on doctors' prescriptions was not updated immediately, and the preparers used the old denomination still present in the reference list, applying a correction factor to the prescribed dose. A temporary staff member, not informed of this workaround, ordered the treatment dosage without the corrective factor, resulting in a fatal overdose.

4.2 Ruled-based and managed spheres at the macro level of the system

By the "macro level" of the system, we refer to the organizations involved in the oversight of industrial firms (in particular, safety authorities), the legal system, accident investigation bureaus, the media, elected officials, and the public. In this section, we analyze inter-organizational interactions and the various pressures and tensions that can exist between these categories of entities.

4.2.1 The role of safety authorities

A significant part of the activity of a **safety authority** or inspectorate is heavily based on verifying compliance with a prescribed framework, thus following a rule-based approach to safety. However, it would be incorrect to assume that authorities are limited to this scope. The oversight of the design or modification of new installations or equipment often relies on a **technical dialogue** between the regulator and the regulated dutyholder, allowing for an in-depth exploration of various design options and co-production between the authority and the industrial sector. This dialogue is framed by organizational rules, but is not comparable to compliance verification; the ability to imagine destabilizing elements within the system is essential to the quality of the resulting analysis. This "safety dialogue" between the ASN, IRSN, and operators in the French nuclear sector has been thoroughly analyzed in the doctoral theses of J. Eydieux and G. Rolina **[Eydieux 2017; Rolina 2008]**. This safety dialogue allows for "managing the fundamental tension between a 'strict policeman' attitude and a 'collusive' attitude"; its main challenge is to transition, through debate and negotiation, from "what is problematic to what is demonstrable" and formalize it in written texts, as aptly summarized by **[Eydieux et al. 2018]**.

The appropriate balance between dialogue and compliance verification for an authority is the subject of numerous debates and controversies. In the nuclear sector, for example, the French approach, which heavily relies on dialogue, was historically referred to as "French cooking" by some U.S. critics **[Rolina 2008]**, while the position of the U.S. Nuclear Regulatory Commission, more focused on regulatory compliance, has been criticized for its occasional focus on "paper compliance" that is distant from real safety issues, potentially leading to poor resource allocation at the expense of safety. The Kemeny Commission report after the Three Mile Island accident noted that "*NRC tends to focus industry attention narrowly on the meeting of regulations rather than on a systemic concern for safety*" and stated that:

> *We note a preoccupation with regulations. It is, of course, the responsibility of the Nuclear Regulatory Commission to issue regulations to assure the safety of nuclear power plants. We are convinced that regulations alone cannot assure safety. Indeed, once regulations become as voluminous and complex*

> *as those regulations now in place, they can serve as a negative factor in nuclear safety. [...] The satisfaction of regulatory requirements is equated with safety. This Commission believes that it is an absorbing concern with safety that will bring about safety – not just the meeting of narrowly prescribed and complex regulations.*

Another practice which is very different from compliance verification and used in the French nuclear sector is the permanent expert groups (GP) organized by the nuclear safety authority ASN. These groups bring together participants from the industrial, academic, and expert organization sectors, as well as the authority, to address specific themes over time (e.g., nuclear reactors, pressure equipment, decommissioning). Their work is based on in-depth studies conducted by the IRSN (the TSO), formal debates in sessions, and collective discussions. The GP serve as a forum where compromises or trade-offs between different issues, such as nuclear safety, the availability of facilities, and industrial imperatives, can sometimes be negotiated between the three parties: the operator, the regulatory authority, and its expert organization. A study based on observations of some of these instances shows that different types of negotiation processes can occur: "bargaining negotiations" that allow open debate on flexible interpretations of the prescribed framework and avoid underground decision-making on deviations; "influence negotiation" that makes it possible to clarify disagreements and sometimes change positions on values, beliefs, and knowledge; "decision negotiation" that achieves adjustments and exemptions; and "exploratory inquiry negotiations" that explore areas where parties are uncertain about each other's practices or positions and exchange information to better understand each other without necessarily disclosing all details of their stance **[Journé and Stimec 2019]**.

Key issue

It would be beneficial for the safety authority to advocate for the necessity of debates to ensure safe tradeoffs at all levels[9].

4.2.2 Public acceptability of the contribution of initiative bhaviours to safety

[Meyer and Rowan 1977] note that decision-makers tend to use the prescribed framework to limit their liability, avoid accusations of negligence if a tragedy were to occur, and demonstrate that they are taking action:

> *Many of the positions adopted, policies, programs, and procedures implemented by modern organizations are determined by public opinion, the views of influential stakeholders, legitimized knowledge by the educational system, social prestige, the judicial system, and definitions of negligence and reasonable prudence used by judges.*

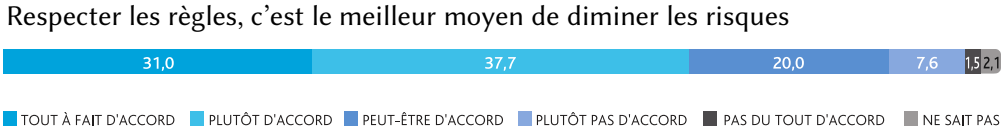


Figure 4.3 *Excerpt from the chapter "French perspectives on expertise" from the IRSN Risk Perception Barometer, 2019 edition, regarding the statement "Respecting the rules is the best way to reduce risks". Seven out of ten respondents completely agree or somewhat agree with this statement. In 2017, the proportion was 80%.*

This assertion concerning the role of rules in producing safety, which is confirmed in each annual edition of the IRSN risk perception barometer (*cf.* figure 4.3), shows that the public predominantly leans towards a "normative/rationalist" view of safety (to use the vocabulary introduced by figure 2.1), based on compliance with the prescribed framework, rather than an "adaptive/constructivist" view based on the value of frontline expertise.

Similarly, the public tends not to accept the principle of a control relationship based on negotiation and dialogue, rather than compliance verification, seeing it as a risk of **opaque**

[9] This suggestion was made by F. Daniellou, professor of ergonomics and scientific director of FonCSI between 2015 and 2019.

bargaining that could compromise safety ("safety is non-negotiable" [Journé and Stimec 2015, 2019]).

Following the analysis of sociologist P. Bourdieu regarding dominant ideology[10] and its reproduction, several researchers have shown (for example, in the healthcare sector) that the arrangements and know-how deployed to manage complex situations are difficult to analyze as scientific objects, as they are heavily negatively connoted by not belonging to the reassuring discourse carried by the "most authorized thinkers among the dominant factions" [Bourdieu and Boltanski 1976]. The dominant discourse revolving around control, mastery, and rule compliance weakens the legitimacy of discourses related to the managed sphere of safety.

The **social acceptability of managed systems** can be interpreted as making the safety of a system dependent on the reactions and improvisations of a **single individual**. In a more systemic view, managed safety certainly involves individuals in unique situations, with all the subjectivity of the individual facing complexity, but also engages the work collective and, more broadly, the entire organization: the capacities or impediments to action are always determined by the organization. This also aligns with the idea that the managed sphere of safety is not just a response to the unexpected, but also a set of skills and capabilities that, to function well, must be recognized, prepared, and legitimized by the organization, safety authority, justice system, and the media.

Key issue

We can regret a caricatural juxtaposition of "initiative behaviours = individual tinkering", which tends to delegitimize managed safety in favor of sometimes blind rule-based safety, which, when it fails, is limited to seeking out a culprit (of non-compliance) to judge and sanction.

4.2.3 Facades, myths and hypocrisy

As discussed in chapter 1, the rule-based framework can be used by the leaders of an organization as an **organizational facade**, which allows them to conceal the truth about the actual functioning of organizations (the compromises, trade-offs, deviations, and adjustments that produce performance, including safety performance).

[Meyer and Rowan 1977] refer to the "**myths and ceremonies**" established by organizations to satisfy external audiences (such as regulatory authorities) and manage partially contradictory expectations. These "neo-institutionalist[11]" sociologists challenge classical theories which posit that coordination and control of activities are critical dimensions enabling the success of formal organizations. They note (p. 341) that:

> *conformity to institutionalized rules often conflicts with efficiency criteria, and conversely, coordinating and controlling activities to promote efficiency undermines an organization's ceremonial conformity, sacrificing its support and legitimacy. To maintain this ceremonial conformity, organizations reflecting institutional rules tend to shield their formal structures from the uncertainties of technical activities by introducing a decoupling between their formal structures and the actual activities conducted.*

This decoupling manifests in various ways: the "professionalization" of certain activities (in the sense that responsibility for proper functioning is delegated by managers to the profession or trade); the use of ambiguous objectives (hospitals are tasked with "treating" patients rather than curing them, schools and universities produce students rather than learning; ethical charters promulgated by many organizations are generally not designed to assess whether a concrete action is compliant; data on the actual performance of organizations are swept under the rug). The ability of individuals to coordinate an activity despite — and violating it when

[10] That is, the "discourse in and through which the dominant class announces its interest to itself", in a process of self-legitimization of its domination, but also playing a performative role by bringing about what it announces.

[11] Neo-institutionalist theory assigns a central role to institutions in understanding social, economic, and political phenomena.

necessary — the procedural framework is valued[12]. Meyer and Rowan write that the more an organization's structure is determined by organizational myths, the more it will develop elaborate rituals aimed at demonstrating commitment to the organization, good faith, trust in individuals, and confidence in the proper functioning of the organization.

A concept closely related to the myths and ceremonies established to satisfy external audiences is that of "**fantasy planning**" developed by L. Clarke in his analysis of the implementation of emergency plans and civil protection plans **[Clarke 1999]**. Based on an *ex post* analysis of the execution of environmental cleanup plans following a massive oil spill and a critical examination of an evacuation plan to address a nuclear accident, he suggests that the plans established by companies and governments are fundamentally rhetorical rather than practical: these plans have no chance of succeeding, but they serve organizations and the public by symbolizing control, order, and stability. The documents produced aim to **inspire confidence** in the companies and organizations managing risky activities, but Clarke concludes that society would be safer and more just if organizations were able to recognize the limitations of their capabilities.

The political scientist C. Gilbert, an expert on public debate concerning risks, notes that there is a form of **divorce** between the way safety is actually produced within organizations at risk of major accidents and the way risk is discussed in public debate[13]:

> *Risks project us into the future. Attention is focused on what is likely to happen, with different scenarios, including the worst-case scenario. The mechanisms leading to catastrophe are thus at the center of concerns. However, this approach leads us to neglect what, in our societies, constitutes the ordinary aspects of safety. In other words, the set of procedures and practices, formal and informal, perfect and imperfect, that allow the regular functioning of activities, including the most dangerous ones. This results in a certain divorce between the extraordinary aspect of risk, omnipresent in public debates, and the ordinary aspect of safety, increasingly less visible.*

A proposal by C. Gilbert aimed at overcoming these relationships based on hypocrisy is described in the following box.

A proposal

Effective management of industrial risks: beyond hypocrisy?

Extensive research on industrial risks, whether in academia or within expertise and consultancy domains, highlights the existing disparity between the representation of risk management and its reality.

In fact, even though many studies acknowledge it, it is **seldom admitted in public** that the management of risks that can severely affect communities involves trade-offs, **compromises among various imperatives**, with safety being just one, albeit the foremost.

Therefore, in the event of serious problems — accidents or disasters — their occurrence is often attributed to these compromises, to a failure to adhere to regulations aiming for "zero accidents". This overlooks the fact that the management of hazardous activities is based on compromises, which can be good, less good, or bad, but are, in any case, central to the operation of high-hazard activities.

One can view the refusal to acknowledge this in public forums as a form of hypocrisy, which researchers have pointed out but have been unable to remedy. Essentially, it seems as if those involved in risk management accept this hypocrisy as an inevitability, adjusting their discourse to the necessities of the moment. It is quite rare for a public official of a high-hazard organization to openly discuss the necessary adjustments for the entity to function and be profitable. Even less common is any mention of the recurring uncertainties associated with such activities.

[12] The most in-depth ethnographic analysis of managers' work within organizations is likely that of M. Dalton, who spent about ten years observing the work of managers in three manufacturing companies in the USA. He highlighted the significant gap he observed between the prescribed organizational structure (organizational chart) and the informal structure that determined actual functioning. Dalton also analyzed the characteristics of a manager who was perceived as effective. Simplifying his arguments, he writes (p. 246) that a strong manager is results-oriented, entrepreneurial, and creative (including sometimes deviating from the procedural framework), while a weak manager adopts a bureaucratic approach oriented towards the method of work and is dominated by rules **[Dalton 1959]**.

[13] C. Gilbert, retired from the French CNRS, chaired the Scientific Council of FonCSI and then its strategic analysis scientific group from 2007 to 2018. This citation is a summary of his intervention at a colloquium organized by MSH Alpes in 2017, a recording of which is available online.

Is it possible to overcome this problematic (in many respects) situation? On one hand, it limits reflection, as it is difficult to define what would be a good compromise between the multiple factors that need to be considered. Compromise, after all, often connotes concession, implying a deviation from what is formally prescribed by regulation or law. On the other hand, as noted earlier, this situation places all actors involved in managing high-hazard entities in difficult positions: how can one account for the reality of things, especially when responsibilities are involved? Lastly, although it is not the most important point, this usual hypocrisy is intellectually unsatisfying.

As long as this situation persists, the many contributions to the effective management of risks, as reported in this report, are bound to remain in the shadows. Is it possible to escape this "curse" and one day have a truthful discourse on these matters? This is uncertain and perhaps we should admit that this is a **sociological inevitability**, with there always being, in every domain, a gap or even a divorce between the world as it is and as it is represented. It might even be necessary to bear contradictions…

Nonetheless, this does not preclude considering some **avenues** to attempt to **remedy this situation**:

- The first is to continue, in various forums, the work of **highlighting the compromises made in all high-hazard activities**. This can only be done within organizations capable of bringing together directly involved actors without them being directly exposed to the public debate, as it occurs today. This is a condition for this reflection to succeed.
- The second avenue is to develop, with the help of researchers, academics, and experts, a **doctrine of "sustainable compromises"**, those that allow navigation, without excessive risks, between regulatory injunctions and managerial adaptations. This would occur in a more public context, without (always) being dependent on polemical injunctions.
- The third avenue is not to hesitate to **publicize critical situations** where actors have had to make multiple trade-offs to maintain an adequate level of safety. It is indeed possible that, contrary to what one might think, **a portion of the public is ready to hear these stories** that provide an accurate picture of reality. This might be because everyone lives in an imperfect world and is increasingly aware of it.

Of course, these are merely proposals for debate.

– Claude Gilbert

Organizational hypocrisy

Definition

The Swedish organization theorist N. Brunsson develops the concept of **organizational hypocrisy** to explain how organizations respond to partially contradictory societal and institutional expectations. This hypocrisy arises when there is a gap between what an organization claims to value or practice (such as safety policies or corporate social responsibility policies) and what it actually practices. Speech and action are sometimes very loosely coupled.

Within any organization, two spheres coexist: the action organization that coordinates informal actions within the enterprise and the political organization that creates legitimacy *vis-à-vis* the external environment. According to Brunsson, this separation of the political organization and the action organization is possible by cultivating organizational hypocrisy, which satisfies the interests of various groups both inside and outside the organization **[Brunsson 1989]**.

Organizational hypocrisy can sometimes be exposed, for example by whistleblowers, leading to scandals (such as Dieselgate affecting several European car manufacturers, or textile companies selling clothes made by child labor), but this bad press seems to have little impact on the policies and practices of the companies.

The necessary hypocrisy regarding violations

Definition

Members of the strategic analysis group have theorized the existence of a "necessary hypocrisy" concerning adherence to prescribed standards in organizations at risk of major accidents. Every complex system requires a certain flexibility in the interpretation of regulated standards, but if a company formally acknowledges this, it may fear that the consequence will be an unacceptable level of initiative and risk-taking. Therefore, companies establish an official policy based on compliance while expecting — and indeed relying on — a certain degree of initiative from those closest to the risk; this degree will be measured and managed over time.

This theory of necessary hypocrisy aligns with studies on the **production of ignorance** among managers, which demonstrate that it is easier to arbitrate when there is no illusionary belief that it is possible to gain complete knowledge of the details of every frontline situation. Thus, **[Girin 1995]** views "I cannot know" and "I do not want to know" as fundamental management principles and suggests that organizations, especially those requiring the coordination of diverse and specialized activities, can only function based on a particular form of ignorance: one where some individuals (including managers) are kept — or themselves ensure they remain — ignorant of what others are doing. **[McGoey 2012]** writes that ignorance should be considered "*not as a precursor or an impediment to more knowledge, but as a productive force in itself, as the twin and not the opposite of knowledge*".

For example, it may be beneficial for a person responsible for an industrial activity not to be informed of non-compliances, because the **legal implications** in the event of an accident, where evidence indicates that the responsible person knew but did not immediately act to correct the non-compliances, can be significant.

The organizational hypocrisy visible at the micro-level of a company (the injunctions to frontline actors to "know how to take responsibility" while increasing surveillance of their activities and introducing behavioral control mechanisms) is often a consequence of contradictory pressures on company management, as noted by **[Ughetto and Haradji 2023]**:

> *Companies [...] initially had to invent management formulas striving to hold together strategic options that normally exclude each other, in the sense that one cannot both generate the increasing investments required by innovation and high-standard products and contain costs to keep prices under control. Companies resolved this contradiction by tightening control over the modes of work execution, simultaneously hoping to manage the quality resulting from employees' responses to managed situations and reducing the workforce and other means provided for this work, while also promoting a mobilizing discourse inviting employees to know how to take responsibility.*

Key issue

This hypocrisy has detrimental effects on **technical democracy**: while early studies on the role of civil society in putting risks on the agenda show that public pressure forces public authorities to address new risks previously neglected (as they challenged dominant interests or established powers, for example), the result here seems to be a refusal to acknowledge certain risks, to "de-equip" them, in the sense of disassembling the vocabulary and venues that allow for debate on the trade-offs made between different objectives **[Gilbert 2003]**. The hypocrisy also has negative effects on the daily work of safety production, as it forces people to speak in ways often disconnected from the reality of their work.

4.2.4 Role of the legal system

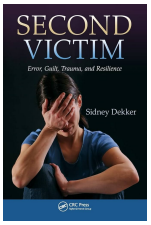
The judicial system tends to use the prescribed standards to help **establish responsibilities** in the event of an accident. The prosecutor will seek to identify **deviations from the procedures** and standards, information that will serve — typically relying on a simple and linear accident model — to designate those responsible and therefore culpable. The judiciary will seek to distinguish the responsibilities of the equipment or installation designer from those of the manufacturer, then those of the operator, and even the entity responsible for maintenance; this search for responsibility concerns organizational levels (legal entities) as well as — increasingly — the individuals involved.

This is while the criminal classification of an error is a partially socially constructed phenomenon, as noted by **[Christie 2004]**:

> *The world comes to us as we constitute it. Crime is thus a product of cultural, social, and mental processes. For all acts, including those seen as unwanted, there are dozens of possible alternatives to their understanding: bad, mad, evil, misplaced honor, youth bravado, political heroism — or crime. The same acts can thus be met within several parallel systems as judicial, psychiatric, pedagogical, theological.*

In his report on the Clapham Junction rail crash (United Kingdom, 1988), A. Hidden emphasized the detrimental effects of **hindsight bias** in judicial inquiries:

> *There is almost no human action or decision that cannot be made to look more flawed and less sensible in the misleading light of hindsight. It is essential that the critic should keep himself constantly aware of that fact.*



This **criminalization of error** can create "second victims", individuals who have suffered once due to their involvement in a situation that led to a fatal accident, and then a second time by being implicated by the judicial system, which is often very distressing. **[Dekker 2013]** discusses several such cases in the medical field, where medical errors lead to numerous preventable deaths, great suffering among frontline actors who receive little institutional support (and sometimes commit suicide), and sometimes criminal prosecution for criminal negligence. This criminalization of work induces defensive reactions that harm the quality of incident reporting and investigations and hinders the emergence of a "just culture" **[Michaelides-Mateou and Mateou 2010]**. In the medical field, professionals are encouraged to practice "defensive medicine", over-prescribing costly and low-diagnostic-value tests out of fear of a subsequent administrative or judicial investigation.

Example

Legal inquiry into the decisions of Wivenhoe Dam operators

In 2011, floods in Queensland (Australia) caused numerous deaths. An inquiry committee analyzed the management of the Wivenhoe Dam, whose operators had decided to release significant volumes of water to preserve its structural integrity, producing consequences for the city of Brisbane. Despite expert testimony indicating that the operators' actions yielded the best possible outcome given the conditions, the inquiry committee (whose mandate was to assess not the quality of the operational decisions made, but their compliance with the prescribed standards) criticized their work due to deviations from operating procedures. Indeed, the written records of their decisions and their subsequent descriptions of their motivations did not refer to the four operating strategies outlined in the dam's technical guidelines. This inquiry sparked significant debate within the professional engineering community (a regulated profession in Australia) about the links between expertise, compliance, and responsibility, and the long-term detrimental effects of this type of inquiry on safety **[Maslen and Hayes 2014]**.

Key issue

The legal system tends to focus its attention on evaluating compliance with the prescribed standards, rather than on the much more complex task of understanding and analyzing the decisions made by experienced actors working in complex environments and under various uncertainties. This detrimental simplification produces inappropriate judgments of work and leads to negative effects on safety.

Regarding accidents, the work of the justice system occurs in a context of significant media and political pressures, having to respond to a social expectation for understanding the causes and documenting responsibilities, which are often nuanced. For instance, during the trial of the AF 447 crash (which caused the death of 228 people aboard a flight between Rio de Janeiro and Paris in 2009), held in 2023, the prosecution stated that it was "unable to request the conviction" of Airbus and Air France. The prosecutor declared that "*We know that this position will very likely be inaudible to the civil parties*", and this decision indeed faced numerous challenges. Upon announcing the indictment, police had to form a barrier to protect the magistrates.

Accident investigation bureaus represent another type of organization that assesses the safety of high-risk activities by analyzing deviations from prescribed standards when associated with an accident. Their role is not to establish responsibilities but to understand the causes and circumstances of accidents and to formulate recommendations to improve safety **[ICSI 2017]**. Accident investigation bureaus, along with public inquiries undertaken after major accidents, also help to **depoliticize disasters**, facilitating the social acceptance of high-risk activities by "producing myths that highlight our omnipotence and capacity to control", as noted by **[Brown 2004]**. While their recommendations often pertain to modifications of regulated standards, they can also address the managed sphere of safety.

BEA Report on Air France Flight Brazzaville-Paris in 2020

Example

A BEA investigation report was published in mid-August 2022 concerning an incident during an Air France flight from Brazzaville to Paris in 2020. A fuel leak was detected mid-flight, and the crew decided to divert to a nearby airport but did not fully follow the "fuel leak" procedure, which requires shutting down the affected engine. After consulting with the crew, the captain decided to keep the engine running to avoid other risks. The landing was successful, but this choice was later deemed risky by the BEA investigators. The report concludes with three other recent situations where pilots of this airline deliberately deviated from operational procedures, leading to an incident without justifiable circumstances, according to the investigators.

Several parts of the conclusion, illustrating how the compliance-initiative articulation can be appreciated by an accident investigation bureau, are excerpted below:

> *The BEA acknowledges that certain rare technical or operational situations may require the crew to exercise discernment and be able to step outside the framework of procedures when they believe safety demands it.*
>
> *This is particularly true in the context of severe damage, leading to multiple failures for which electronic monitoring system messages or procedures may be unsuitable or inapplicable (for example, the accident of the Airbus A380 registered VH-OQA operated by Qantas on November 4, 2010, in cruise) or in cases of extreme urgency (uncontrolled onboard fire).*
>
> *This was not the case for the aforementioned events, nor for the event under this report, for which a compliant application of the procedures would have helped maintain an adequate level of safety. [...]*
>
> *Procedures result from a thorough risk analysis by the manufacturer, assuming they will be applied by the crew. The prevailing safety principle during procedure design is based on the assumption that it will be executed at the appropriate time, rigorously, and in its entirety. The expected application of the FUEL LEAK procedure thus both preserves the remaining fuel quantities in the tanks and prevents the risk of fire.*
>
> *Many reasons can motivate crews to deviate from procedures under operational conditions, including the desire to simplify a procedure deemed too complex given the workload, or the belief that the deviation benefits flight safety. These deviations or simplifications are mainly based on the crew's personal experience and may sometimes result from poorly understood, not always explicit, or incorrectly taught procedures. [...]*
>
> *The review of the aforementioned events suggests a certain culture among some Air France crews that promotes a propensity to underestimate the contribution of strict procedure application to safety.*
>
> *Thus, the BEA considers that Air France should place the respect of procedures at the center of the company's safety culture.*

4.3 Emergence, adaptation, and resilience

A systemic approach to safety considers that accidents are sometimes **emergent phenomena** produced by the **complexity of systems**, whose behavior cannot be predicted by the simple addition of the behaviors of each component analyzed in isolation. In the previous sections, we analyzed the rule-based/managed tension and phenomena appearing at the meso level (different layers of management within companies) and the macro level (oversight bodies, legal system, media, the public) of the system. In this section, we analyze the rule-based/managed articulation as resulting from the complementarity between predetermination and adaptation, examining in particular the contributions of theories developed by **resilience engineering**[14]. This multidisciplinary research field focuses on how systems adapt and cope with disturbances and uncertainties in a volatile, uncertain, complex, and ambiguous context (VUCA). It aims to shift the analysis angle of safety "from an approach focused on failures and identifying the causes of undesirable events (accidents, incidents, errors, violations, etc.) to a broader understanding of safe operations" **[Cuvelier and Woods 2019]**. The term "managed" thus refers to the system's adaptability mechanisms at different physical and temporal scales, as well as the trade-offs between stability and maneuverability, and between performance and resilience.

[14] Resilience here is defined as the system's future capacity to implement adaptive actions in response to contingencies.

4.3.1 Complex adaptive systems

A second school of thought, explicitly inspired by complexity science and particularly the work of the Santa Fe Institute (New Mexico, USA), including researchers such as D. Woods and R. Cook, has focused on the stability of performance (including safety) of complex adaptive systems in the face of variability (including exceptional variability) in their internal and external contexts. These systems continuously develop and regenerate in response to the constraints they encounter: function creates form.

This allows for both adaptation to past invariants (and thus to the present in the absence of discontinuity) and short- and long-term readaptation in the event of discontinuity. Compensation mechanisms absorb common variations, creating a certain indifference in system performance with respect to these variations, at least within a certain range of variation that defines the adaptation domain. Outside this limit, the system's survival is conditioned in the short term by the activation of rapid readaptation mechanisms (analogous to physiological stress) based on hierarchical reorganization and the intensification of common compensation mechanisms. However, the stress response is not sustainable, and long-term survival requires structural readaptation. The system's resilience depends on the extent of the degradation experienced when crossing the boundary and the effectiveness of the readaptations. There is an antinomy between the level of system adaptation within its domain of adaptation (its level of optimization, specialization) and its capacity for readaptation outside of it. From this perspective, "rule-based safety" roughly refers to the exploitation of invariants, and "managed safety" to both the mechanisms of compensating for common variability and the mechanisms of compensating for exceptional variability. The term "roughly" is used here because the exploitation of invariants involves much more than the promulgation of rules, and conversely, the management of unforeseen events partially relies on rules.

4.3.2 Graceful degradation at operational limits

The behavior of a system at the limits of its design domain is a determining factor for its controllability and, consequently, for its safety. A system that provides warning signals as it approaches its operational limits, and whose performance degrades gradually rather than abruptly once these limits are exceeded, will be safer. This is the principle of **graceful degradation [Woods 2019]**. It is important to note that it is not necessarily easy to know when a system is operating near its limits, as these limits can evolve over time and according to external and internal contexts, and pressures for economic performance and task optimization push the system towards its limits.

Stall characteristics of aircraft wings

Example

The phenomenon of aircraft stall (the loss of lift caused by an excessive angle of attack) is a gradual process, indicated by the onset of wing vibrations that become more pronounced as the stall limit approaches. This gradual nature gives the pilot time to understand the developing situation and facilitates recovery.

Technological advancements have improved the performance of flight surfaces. This improvement is accompanied by a faster transition between lift and stall as the limit approaches. This more abrupt transition is more challenging for the pilot to manage.

This trade-off between performance (or specialization for a particular environment) and gradual degradation is found in many situations. For example, the optimization of genetically modified crops increases performance within a narrow climatic range but tends to make them less resilient to climate change.

An important finding from research on resilience engineering is that management practices aimed at constantly increasing compliance with plans and regulated standards increase the system's fragility (in the sense of its susceptibility to a brittle failure when it exceeds its operational limits) and degrade the system's and the organization's ability to adapt to future threats **[Woods 2018, 2024]**. Indeed, it is the humans within systems who originate adaptive capacities, relying on their situated expertise, initiatives, and reciprocity with other actors. The extreme pursuit of compliance hampers these adaptive capacities by forcing frontline actors to reject or hide any innovation, experimentation, or adaptation perceived as a deviation to be eliminated.

4.3.3 Vicariance or dynamic reallocation

In medicine, vicariance refers to the process by which one organ compensates for the functional insufficiency of another (in the same way as a vicar may replace a priest). Thus, blind individuals activate their visual cortex to read (though tactilely) Braille, and deaf individuals use auditory areas of the brain to perceive (visually) sign language. Within organizations, this principle of **dynamic resource reallocation** (a form of **plasticity**) allows for responses to environmental demands that were not anticipated during design. For example, during the Covid crisis, the shortage of caregivers due to illness was mitigated by the assistance of surgical interns, whose activities were halted by the cessation of surgical interventions. Conceptually, this means that the organization's structure-function correspondence matrix is dynamic rather than static. Practically, this plasticity requires organizational principles that allow and anticipate such rearrangement of roles and responsibilities at various levels of organization: individuals, teams, professions, and services. It also requires skills management in line with this possibility: dynamic resource reallocation (such as changing positions to assist overwhelmed colleagues) necessitates versatility.

4.3.4 Trade-offs and compromises

The resilience of complex systems is largely determined by how they handle trade-offs or compromises between different objectives:

- between stability and maneuverability **[Holling 1973]**;
- between optimality and fragility, as mentioned earlier, particularly when the system is characterized by strong coupling between its components;
- between efficiency ("faster, better, cheaper") and safety, or efficiency and thoroughness (the so-called "ETTO" principle **[Hollnagel 1999]**).

Key issue

A widely shared critique among resilience engineering researchers aligns with findings from research on managerialism mentioned above: the pursuit of optimization by eliminating "downtime", discussions between team members, "slack", everything that seems superfluous when the system operates in an ordinary context, and which resilience researchers refer to as "organizational slack", is detrimental to the system's detection, adaptation, and recovery capabilities when an unexpected or abnormal stress occurs.

5

Conclusions

We have explored various forms of possible articulation between the rule-based spheres (anticipation of situations likely to occur and the establishment of rules and means to address them) and the managed spheres (competent real-time reaction of present individuals who respond appropriately) of safety. This exploration aims to move beyond the classical vision of these spheres as communicating vessels, where strengthening one would necessarily imply weakening the other, in order to propose a reflection in terms of complementarity, inclusion, or co-development, which we believe is more conducive to the production of safety.

While the majority of work on this theme has concerned the work of front-line actors, our analysis, derived from the strategic analysis conducted by FonCSI with its sponsors and partners and supported by the academic community, has broadened the analytical focus to consider **organizational dimensions** (including strategic decisions of companies), **inter-organizational dimensions** (including relations with the safety control authority and the justice system), and **systemic dimensions**.

The main messages of the document are summarized below:

- Taylorism is no longer highly regarded in the field of industrial efficiency optimization. Promoters of neo-management concepts prefer to emphasize the development of professional autonomy for employees, the "liberation" of their initiative, and attention to their personal fulfillment, with the objective — or at least the consequence — of improving profitability and the method of eliminating bureaucratic control mechanisms.
- In the field of industrial safety, the Taylorist principle of tight prescription and firm control over front-line workers' behaviors has remained very popular, but management professionals seem more willing to recognize than in the past the **limitations of an exclusively rule-based approach** to safety, based solely on (an illusory impression of) compliance with a procedural framework imposed by an authority figure located far from the sharp end of operations. The importance of professionalism, expertise, know-how, and the adaptive capacities of front-line actors seems, in general, to be better recognized by industrial decision-makers.
- Despite these trends, and to a variable extent depending on the industry sector and companies concerned, we observe at the sharp end of high-hazard operations, an increase in efforts to **ensure compliance** with the prescribed framework (monitoring contractors and service providers, audits and inspections aimed at detecting deviations rather than understanding the complexity of each local situation, peer control and other "human reliability" practices). The reduction of professional autonomy for front-line staff has detrimental effects on their motivation, work engagement, and mental health.

  The development of auditability as a principle for structuring work activity can lead to **auditism**, an organizational pathology in which people can no longer imagine designing a work situation or performing a task whose safe execution relies solely on the professionalism of workers, without the pre-planned possibility for a third party to audit and certify its correct execution.
- The scope of this **organizational control** effort has gradually extended in recent decades to **managerial work**, through the phenomenon of "managerialization" and the proliferation of digital management tools associated with it. This reduction in managers' room for maneuver hinders their ability to ensure negotiation, adaptation, and arbitration work following the principle of **subsidiarity**, and reinforces **organizational silence**.

- The organizational control exercised over managerial work is accompanied by the growing importance of **reporting obligations**, including in recent years concerning extra-financial dimensions of activity (environmental and ethical issues that overlap with safety issues), as environmental, social, and governance factors (ESG) take on greater weight in corporate governance.
- The pressure on auditability, the process of managerialization and its digital tools, and reporting obligations touching on ever-broader issues, produce "**safety bullshit**", a deliberately provocative term used to designate bureaucratic tasks that serve to document the activity as it should theoretically have been carried out. These tasks are performed in the name of safety but produce nothing in terms of effective safety.
- The public expresses a **higher expectation of transparency** on the internal functioning of companies and on the trade-offs made between different issues such as financial profitability, environmental damage from industrial activity, and the safety of employees and populations. At the same time, there seems to be a lower acceptance of the notion of professionalism and expertise of sharp-end workers as the main source of safety, even in a context where the management of these qualities is recognized as an organizational mission which must not rely on exceptional characteristics of certain individuals, and even when this management process is monitored by a safety authority.
- The legal system tends to use the prescribed framework to help **establish responsibilities** in case of accidents. The prosecutor will seek to identify deviations from the procedural framework, information that will serve — typically being fed into a simple linear accident model — to designate the individuals who are responsible and thus culpable. This misunderstanding of the nature of the work of experienced actors who use rules and procedures as a resource rather than an algorithm provokes **defensive reactions** that are detrimental to safety (this point has long been understood, but there is little evidence of a change in practices of the legal system).
- The growing gap between, on the one hand, the pragmatic convictions of managers about the factors that contribute to creating safety and, on the other hand, the obligations arising from policies, organizational tools, regulatory frameworks, judicial decisions, and public expectations, necessarily generates **organizational hypocrisy** among companies and safety authorities as a way of managing these contradictions. This hypocrisy has detrimental effects on technical democracy, by preventing debate on the trade-offs made between different objectives, as well as debate on the daily work of producing safety, as it constrains people to sometimes speak in ways that are far removed from the reality of work.

From the perspective of safety strategies, this seemingly inexorable rise of the "rule-based" component in safety management has two main consequences. On one hand, it improves safety performance within the domain of adaptation/design of industrial production systems (in the broad sense), and we owe to it the considerable progress made over the past half-century in all areas of activity. On the other hand, it reduces resilience in the face of the unexpected and the unforeseen, and we owe to it the majority of major disasters that have occurred over the last two decades (Deepwater Horizon, AF 447, Fukushima-Daiichi, etc.).

The increasing complexity and instability of the world, with the enormous challenges of energy and ecological transition, foreshadows an equally inexorable march towards "robust yet fragile" systems. Indeed, the gap is widening between a strategy increasingly based on prediction and an increasingly turbulent, thus unpredictable, world. It is unlikely that technology, big data, AI, and digital twins will help us avoid this inconsistency: all our disasters will be storms in a blue sky. Is this serious? The answer depends on the response to another question: will the gains from the "positivist" strategy of total predetermination compensate, overcompensate, or undercompensate for the generalized cost of future accidental "bypasses" of our Maginot Lines? Today, we have no tools to answer this, other than convictions. But asking the question is often a useful step towards the answer…

This work naturally does not exhaust the question of the articulation between rule-based and managed approaches to the production of safety, between prescribed and actual work, between compliance and proactivity at work, and the various tensions (but also resources allowing different actors to position themselves in relation to each other and with each other)

that it encompasses. The “FonCSI 4” scientific program will allow for continued reflection on some of these questions. In particular, the issue of the progressive complexification of control mechanisms, generated by a dual dynamic of internal normative production within companies and strengthening of external prescriptions, will be the subject of a strategic analysis with the evocative title “simplification”.

A

Intervention to support frontline staff working on gas transport pipelines

Author: Romuald Perinet, GRTgaz

This appendix, written by a member of the FonCSI strategic analysis group on the tension between compliance and initiative in safety management, highlights the beneficial effects of an intervention undertaken to support a high-risk professional activity. This intervention improved the interaction between the rule-based and managed spheres of industrial safety. The initial situation, where the prescribed framework was not fully optimized for professionals in their daily work due to technological and organizational changes and external constraints, is not uncommon in the industrial world. This testimony illustrates the contributions that HOF (Human and Organizational Factors) experts can provide in redesigning a framework intended more as a resource for frontline operators than as a set of rules imposed by external parties. The numerous verbatim accounts demonstrate how this type of intervention can ease organizational relationships and facilitate safe working conditions.

A.1 Technical and organizational context

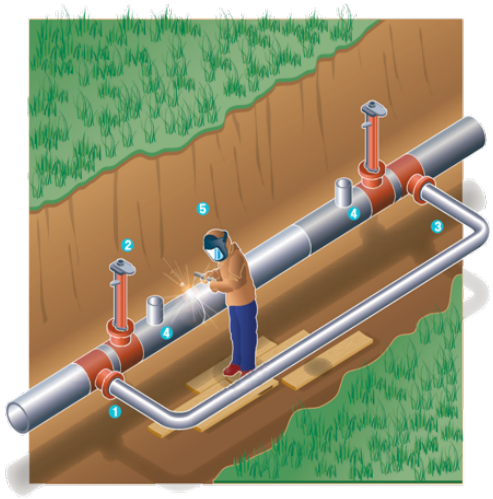
GRTgaz is the operator of high-pressure gas transportation pipelines in France. One of the roles of the intervention teams at GRTgaz is to divert the gas flow within a pipeline during a specific technical operation. These high-precision interventions, referred to here using the French acronym OPC for "Opération de Perçage en Charge" or under pressure tapping operations, are conducted entirely under pressure (even if the pressure is reduced, it remains high, around 60 bar), allowing the continued supply of gas to customers. Within GRTgaz, OPCs involve two teams of 5 to 7 agents each, based in Angoulême and Lyon, who operate throughout France.

OPCs typically last an hour and a half. On average, 80 to 100 interventions are conducted annually (plugging and unplugging, drilling, sealing, etc.). While most operations are planned, some may be urgent. The stakes and complexity of the operations depend on their location (proximity to other installations), the spatial configuration of the site and excavation, weather conditions, the pressures involved, and the diameter of the pipeline. Thus, the loads and equipment handled, as well as the age and history of the installations, play significant roles.

The execution of OPCs relies on recognized expertise and proven methods. They require mastery of complex technology, heavy equipment, and difficult maneuvers, such as the **crane lifting** of the milling machine and its hydraulic motor into the excavation or its slinging to keep it above the pipeline (when an operator works atop a vertically positioned milling machine, they are several meters above the ground). The **drilling** of pipelines is done "blind", with the operator guided by a gauge and preliminary measurements.

The necessary skills are acquired primarily through training, mentorship, and hands-on experience: the goal is to learn to "feel the machine" and to know "how far one can go". OPCs are also subject to a set of prescriptions provided by the Safety Management System to control the risk of ignition throughout these operations. Organizationally, managing this activity relies on an expertise hub, which ensures doctrine and prescription compliance, team training, practice conformity, and feedback facilitation.

The process of conducting an OPC is presented in figure A.1.



1 «Té-stopple»

2 Obturateur

3 Bipasse

4 Piquage d'évent

5 Intervention sur le tronçon vide

Figure A.1 Under-pressure tapping operation (OPC)

The first step involves installing two "stopple" tees, each equipped with a stopper (to prevent gas passage) at each end of the pipeline section. These T-shaped pieces, welded onto the pipeline, are equipped with a valve on which a milling machine with a diameter close to that of the pipeline is mounted. Under pressure drilling, i.e., drilling under pressure, can then begin. The duration will vary depending on the diameter and thickness of the pipeline. Once the drilling is complete, two additional "stopple" tees are installed to allow the installation of a bypass, a flexible or rigid pipeline through which the gas is diverted. Finally, two other pieces are used for purging and re-gassing the section, as well as for safety. This setup allows for safe intervention on the isolated and emptied section of the pipeline, enabling the repair of a defect or the connection of a new pipeline, while allowing the gas to continue flowing through the network.

A.2 Requested intervention and approach

In the context of structural changes (decentralization of the risk management function by the expertise center) and staff renewal, with recurring observations of variability in professional practices among teams, and an increased number of incidents over the year, both management and teams expressed concerns about compliance with practices, fearing potential errors and incidents. Examples include misjudging the margins of progression inside the pipeline, errors in assessing the system's tightness, misdiagnosis following a potential machine blockage, or errors in managing a leak. This context led to a request for intervention.

The issue of prescriptions and their application was the most critical, despite significant work on doctrine and training carried out 7 to 8 years earlier using a participative approach: "*We realized in the field that the operating procedures were old, cumbersome, and not necessarily easy to digest. There was a lot to read, and not everything was applicable*". A steering committee was formed, comprising the two managers of the two teams, the head of the expertise center, and the department head. The intervention framework was designed based on the following requests, addressing both the prescription issue and, beyond that, the animation and supervision of activities by the expertise center, and more broadly, safety management (risk analysis, feedback, training...):

- How can we reconcile the need for high levels of compliance and rigor with the necessary autonomy of people working on sites with many constraints and site-to-site differences? At what level of detail should prescriptions be formalized and their implementation controlled?
- How can we move beyond the almost "sacred" nature sometimes attributed to the current "doctrine"?
- How can we evolve reference documents based on actual practices?

▷ How can we better frame the necessary daily initiative behaviors? What "safeguards" can be put in place to secure potential decisions? How can we address technical or organizational deviations with pedagogy?

This intervention involved about fifteen individual interviews with management and operational staff and approximately 12 days of field observation, each time attempting to combine different levels of analysis, understanding, and evaluation (work situation, team functioning, inter-service functioning, and safety management).

The intervention also included four workshops aimed at involving teams and management as much as possible and exploring possible improvements with them, each at their level, and potential connections. In total, the approach included 6 days of workshops implementing often innovative animation methods, taking the form of experiments for participants, promoting collective learning through reflection and explicit practice explanation:

▷ "Risk Analysis" workshop;

▷ "Feedback" workshop;

▷ "Collective Vigilance" workshop;

▷ and "Prescription" workshop.

These workshops implemented various animation tools to encourage exchanges, reflective and creative work: photolanguage, use of photos and videos related to the activity (seeking a "mirror effect"), co-evaluation in sub-groups on safety culture, use of models, site simulations, cooperative games, feedback concerning the relevant work context…

A.3 Results

The primary **shared observations** derived from the approach are as follows:

▷ The relevance/reliability of the rules and confidence sometimes undermined by their use and field experiences;

▷ Limited guidance and actual help from the prescriptions in problem-solving (e.g., leak or machine blockage);

▷ Prescriptions "disqualified" by unresolved discrepancies in practices with the prescriptions, within teams or between teams;

▷ Inadequate updating of prescriptions in relation to the evolution of complex technical contexts, field controls, and incidents.

In this context, daily safety of OPC operations seemed to rely more on professionalism, relationships, and cooperation within teams and with other trades present on sites, rather than on rules and control. This was especially true given that the intervention locations were often located at significant distances from workshops and supervision.

In other words, risk management was exercised less through hierarchical principles or adherence to rules, which were sometimes disqualified by the reality and complexity of the sites. Instead, it was exercised more through **flexible regulation** based on **expertise**, **autonomy**, **initiative**, and **collective problem-solving** (from a decentralized functioning allowing local arbitration and rapid responses).

These principles, synonymous with agility and robustness, were threatened by significant changes (movement of experienced individuals to key positions within teams and at the management level, evolution of the expertise center's positioning and expertise, activity changes…) sometimes mixed with anxiety about the future of the profession. The approach identified 20 action paths centered on the issues of formalizing prescriptions and safety management.

Regarding the formalization of prescriptions, the organization set the objective of defining a common foundation of simple, clear, and coherent principles and objectives, as well as a fair number of "non-negotiables", allowing sufficient margins to manage the diversity of field cases:

> *We worked a lot on the format of the operating procedures. We worked on a much more visual, much simpler format. [...] We reached a situation where everyone, everyone works together according to the same operating procedures, and it's much clearer and simpler for everyone.*

The revision of the prescriptions moved away from a technically-centered design logic based on machine types (user manual logic) to adopt a "path" or "route to follow" logic to successfully carry out operations, allowing for different possible "itineraries" (or practices). New concepts structured these new operating procedures:

- The concepts of "**yellow lines**" and "**red lines**" providing a new framework for the necessary "agility" on sites. Yellow lines are rules that can be deviated from under certain conditions. Red lines are non-negotiable (mandatory) rules referring to key safety parameters (e.g., pressure/flow). Two quotes illustrate these concepts:

  > *Red lines are conditions we will never allow ourselves to exceed. Under no circumstances, under no conditions. And yellow lines: these are conditions we consider, in some cases, with a specific study, taking into account the operators' experience, we can, by anticipating a bit and thinking about how we can organize, we can cross them in some cases.*

  > *An example of a yellow line: we set a limit of 55 bar under normal conditions to work. But it happens that on some sites, there is a need to exceed this pressure. So, we conduct a feasibility study of that site, determine if the personnel and equipment can safely carry out the operation. And then, there are the red lines, which, when we reach these red lines, we cannot safely carry out the operation.*

- The concepts of **best practices** (recommended but not mandatory) and **alert points** also found their place in the new prescriptive documents.
- A principle of openness to the variability of possible practices was also adopted:

  > *There were a few small differences in operation between the two operational teams. By bringing all the operators together in working groups, we realized these were just minor details... We didn't necessarily decide on one way of doing things or another. But when it was possible and had no impact on safety, we decided to include both possibilities in the operating procedures.*

These new guidelines help structure discussions, negotiations, and arbitration around any compensatory measures to define during activity preparation or handling of contingencies. They also serve to revise operating procedures and guide the choice of scenarios used for field checks and training. They enable a more open and constructive dialogue about actual work, especially during supervision visits or annual feedback meetings.

From an ergonomics point of view, the new procedures are more graphical, contain less text, and are more quickly accessible. They also include "QR code" links to informative content, such as video tutorials.

> *Today, with the new operating procedure, by just opening the operating procedure on the cover page, you can see at a glance the complete scheme of an operation. That already makes a difference. The other difference is the overall layout. This means we have much less text, many more illustrations, all the know-how.*

Regarding safety management, "*The approach helped to put things in their proper place*" in terms of organization ("*a subject we had been circling around for a while...*"), particularly by reaffirming and clarifying the role of management and especially the expertise center in controlling the implementation of prescriptions, managing skills, and facilitating feedback.

> *There was no change in the role of the expertise center... but perhaps a better acceptance by the teams of what is prescribed because it was ultimately co-constructed between the expertise center and the operational teams.*

Improvements were also made in **competence management**: simplifying agent qualification methods and a training module based on virtual reality.

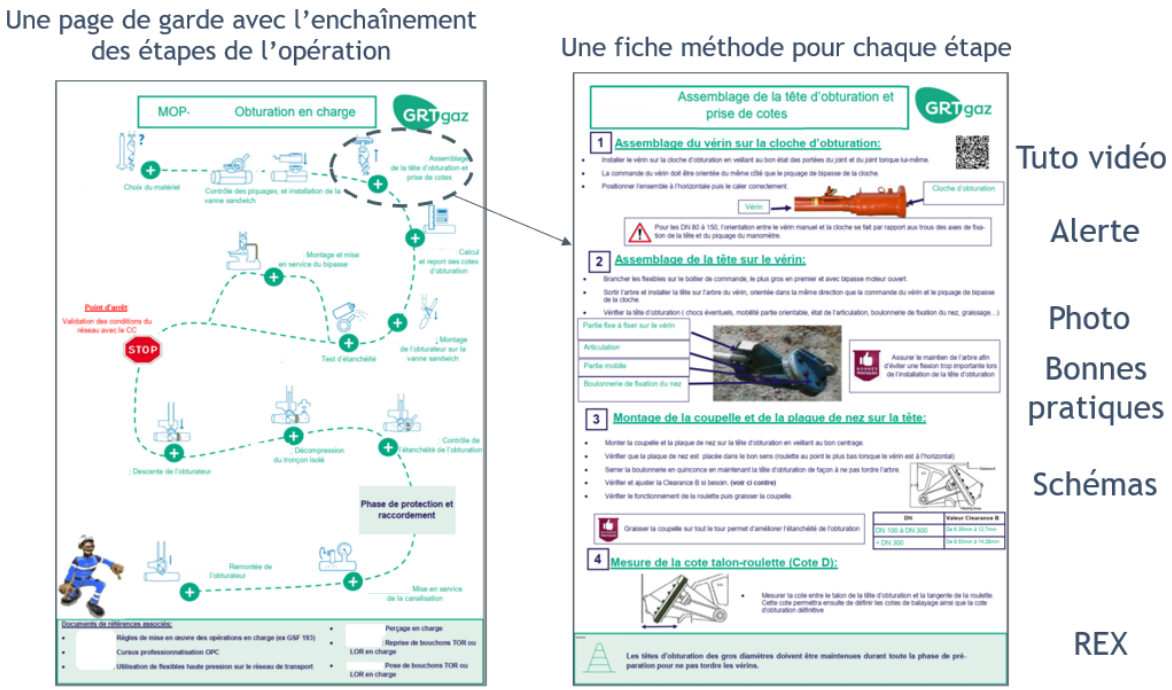


Figure A.2 Example of a revised operating procedure

> *Today, we can take the virtual reality headset, start an operation, try to carry it out. And if we make mistakes, understand why and especially discuss it with everyone. We realized that often, we didn't dare to ask questions, and not asking questions leaves room for doubt. Leaving room for doubt means leaving room for insecurity in operations.*

Finally, the approach improved the **quality of interactions** and exchanges within the organization, an essential condition for the collective articulation of rule-based safety and managed safety, as illustrated by the following quotes:

> *We realize we really have a work triangle. The expertise center is the point, and we have a real link between the expertise center with the two teams and between the two teams. Today, we work more hand in hand than before.*

> *What has mainly changed is the interaction between the teams, meaning that the work we did allowed these three teams to talk to each other again, quite simply... to become aware of what the other can bring to them.*

A.4 Conclusion

Through a comprehensive, multi-level approach and the implementation of **dialogue spaces** (*cf.* § 3.5.2) among the concerned teams, sometimes with management participation (risk analysis workshop, REX workshop, prescription workshop, safety culture workshop), the approach enabled participants, both teams and management:

- ▷ to review the specifics of the profession, its history, and daily safety (risks, incidents, "problem situations", "key moments", rituals),
- ▷ and ultimately better to understand the managerial and operational realities of OPC activities, thereby contributing to a **better articulation of rule-based safety and managed safety**.

Key issue

The case of this organization is emblematic of many other high-risk organizations today, torn between a risk management model based on prescriptions, standards, training, and control (often also encouraged by administration) and a risk management model relying more on autonomy, cooperation, initiative, vigilance, and discernment.

Within this organization, these tensions have resulted in a degradation of the quality of interactions, and consequently, the "real life of the organization" and the articulation of rule-based safety and managed safety.

> *"I now feel more relaxed and open relationships with a better understanding of each other's roles and responsibilities... And for me, this is a significant step towards organizational improvement.*

Ultimately, the intervention seems to have allowed the actors to better understand and recognize each other, each in their role, position, legitimacy, and power. More generally, the intervention enabled the organization to better negotiate with itself a partial relinquishment of a more "traditional" safety approach, i.e., building on "rule-based safety", centralization, control... inherited from the past, in favor of a more adaptive and resilient model, better aligned with the characteristics of the organization (decentralization), the activity (complex), and its environment (which is variable).

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6 allée Émile Monso – CS 22760
31077 Toulouse cedex 4
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ISSN 2100-3874

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