Broad (multilevel) safety research and strategy. A sociological study

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Abstract

Studying safety from a broad (or multilevel) perspective in daily operations is a challenging prospect. The aim of this article, with the help of a case study, is to contribute to its development. In the introduction, broad (multilevel) safety research is introduced. This introduction indicates main authors who have produced in the past thirty to forty years a strong background against which one can build an idea of this challenge. It requires to decipher in real life situations the interactions between technology, task, structure, culture, strategy and environment of high-risk systems. An additional interest is, following the insights gained from the literature, to investigate the importance of strategic decision making in such broad (multilevel) safety approach. A first section discusses methodological issues linked to ethnographic research, and presents the methodology followed. The second section provides a narrative of the case study which combines a historical view of the plant, a description of some of the salient problems of working practices in a production department, an explanation of these problems through an organisational and managerial perspective, a description of the complex patterns of interactions between people in the plant and a strategic analysis of the situation. The last section discusses the interest of a broad (multilevel) research agenda explicitly incorporating the importance, influence and centrality of powerful decision makers, without simplifying the complexity of this issue.

1. Introduction

1.1. Grasping safety from a broad (multilevel) perspective

Safety is a product of the way artefacts, people and institutions interact in specific contexts. If one is interested in a research strategy with a broad or multilevel perspective of sociotechnical systems, one task consists in finding ways of empirically articulating together multiple facets. Good examples of empirical broad views can be found in sociologists' analyses of sociotechnological disasters (e.g. Perrow, 1984, Perrow, 1999, Vaughan, 1996, Vaughan, 1999, Hopkins, 2000, Hopkins, 2012). They conceptualise this broad view through an articulated combination of technology and tasks, structure, strategy and environment of organisations as represented in Fig. 1 (Le Coze, 2020).

Environment
↕
Strategy
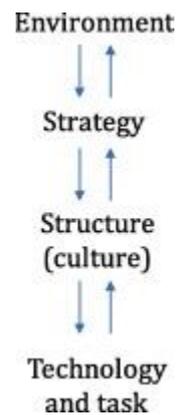↕
Structure
(culture)
↕
Technology
and task

Fig. 1. Sociological approach of safety.

They show that strategic decisions about organisational structures, management style, incentives but also profit targets or return on investment of companies in their environment (e.g. regulations, industry, markets, professions or demography) create a context which influences tasks and technology. They also reveal that technology can play an important role, influencing tasks and organisational structures by creating uncertainties, but technological design depends on choices of strategy and regulations too. Culture plays a role as well, as a product of people's interactions in contexts of organisational structure, leadership, environment (e.g. professions) and technology while a notion like power plays a strong part too.

To do so, they rely on extensive ethnographic data about these interactions through observations (when possible), documents and a rich material made of a multitude of people expressing their experiences, interpretations, views and opinions about many topics related to their work, organisation and context. These multitude of people represent the heterogeneous diversity of expertise, roles and hierarchies in high-risk systems and their environment, from workers to top managers, from engineers to inspectors of control authorities.

Of course, these sociologists do this each with their own sensitivities and case studies, granting different importance or weight to some of the dimensions introduced above but also incorporating slightly different nuances for each of these facets, and providing different articulations (more about this below). Empirically, this framework is most often and convincingly used retrospectively because of the availability of data through public inquiries of major events (i.e. reports, hearings), and the established connections between failures and decisions made across time, hierarchies, sites and geographies.

In contrast with this retrospective research, the high-reliability organisation (HRO) project proceeds with fieldwork while studying daily operations combined with conceptualisation (Roberts, 1993, Weick and Sutcliffe, 2007, Roe and Schulman, 2008, Ramanujam and Roberts, 2018). The intention is to build an empirical understanding from observations and interviews, and similar conceptual features are articulated in these studies, ranging from technology, task, structure, culture, leadership and environment of organisation, which are then discussed in terms of their content and relationships. One can summarise shortly some of the main outcomes of this research.

In their fieldwork, in the first empirical studies during the 1980s and 1990s (Rochlin et al., 1987, Roberts, 1989, La Porte and Consolini, 1991), they observe that tasks are redundant within teams to capture and to recover from potentially unnoticed mistakes; structure is underspecified to allow fast problem resolution to migrate towards expertise rather than following hierarchy when required;

training relies on strong socialising processes emphasising safety as a paramount goal; culture infuses people with a sense of unease about operations which makes them alert of small discrepancies before they escalate.

Learning favours the expression of mistakes without the fear of blame; decision making relies on a broad perspective of operations by a leadership which creates these favourable conditions for culture, training, learning and decision-making to respond to the very trying conditions described by the HRO researchers. Finally, a level of trust and scrutiny characterises the environment of these organisations (La Porte, 1994). This HRO empirical scope has been sustained but also questioned in more recent empirical research of the 2000s and 2010s (Schulman and Roe, 2018), while notions of structure, culture and power acknowledged as core ingredients (Carroll, 2018).

The fact that studies in retrospect use similar notions (e.g. technology, culture, learning, structure, leadership, tasks, power, strategy, environment) as studies in daily operations is not surprising. Most of our conceptualisations are framed by categories provided by different traditions which cannot be multiplied indefinitely. They are rather stable over the past thirty to forty years, in terms of their core facets, notions or dimensions (Fig. 1), despite evolutions in the way each are obviously understood for empirical and conceptual reasons (Le Coze, 2019a, Le Coze, 2020).

1.2. Strategy as a pivotal dimension in the literature

In all of these works, although authors' analyses are always multifaceted, strategic decisions by powerful people in companies (executives, top managers), play a pivotal role in the analysis of their case studies (Le Coze, 2019b). In retrospective accounts of major events by Perrow, Hopkins or Vaughan, the role of strategy is indeed emphasised but has a slightly different status for each. With Perrow, strategy is approached through a critical angle, targeting top management for putting profits first as the main explanation and reason for major events (Perrow, 2011). For Hopkins (who is more practically oriented than Perrow is), strategic decisions in relation to disasters correspond to, for instance, failure to give safety engineering functions a powerful voice at the top of the company through centralised organisational structures (Hopkins, 2019). Vaughan is more descriptive and sees strategy as a dimension which strongly influences engineering practices in a context of environmental, technology and bureaucratic complexities (Vaughan, 1999, Vaughan, 2005).

These nuances in the way the top of organisations is conceptualised in relation to disasters result first from the different cases that these authors researched. Vaughan studied space exploration (Vaughan, 1996) while Hopkins investigated mining and oil & gas industry (Hopkins, 2000, Hopkins, 2012). But there is a second aspect. There are indeed genuine disagreements. For instance, Perrow prefers stressing the power dimension of top managers and executives over engineers while Vaughan emphasises the cultural dimension of engineering in relation to professions, technology and bureaucracy (see Antonsen, 2009 for a discussion).

In the high-reliability tradition, strategic decision making is mostly covered by a consideration for leadership although links with strategic thinking were established in the 1990s (Meyer and Starbuck, 1993, Eisenhardt, 1993), but then pursued rather separately (Farjoun and Starbuck, 2007). In their developments, Farjoun and Starbuck have made the most explicit contribution to express the centrality of strategy in safety. They developed the metaphor of the "organisation at the limits" to conceptualise their view, in the aftermath of the Columbia shuttle disaster (Starbuck and Farjoun, 2005). They link these limits to strategic decisions. These authors do not reduce the problem to one of only strategy, but they insist on the crucial role it plays.

They frame the issue for executives and top management as one of steering companies amidst complex markets, and the difficulty of balancing "exploration of new possibilities and exploitation or protection of current assets" (Farjoun and Starbuck, 2007, 558). Exploring the limits consists in stretching the boundaries of current practices to enter new markets, to increase profits, to improve performance, to reduce costs, etc. Strategy in this respect is about taking risks but they also wonder about how some organisations end up going too far. The authors offer two options, depending on specific cases, with, on the one hand, the hubris, greed and ambition of executives and, on the other hand, the slow, incremental and unanticipated consequences of actions and decisions.

This approach is consistent with what Perrow asserted explicitly already back in the 1970s. "For both the social scientist and his management trainee, the most complete understanding of an organization will come through an analysis of its goal and basic strategies" (Perrow, 1970, 180). To grant a specific attention to strategic decision-making processes of top managers brings a most needed angle of analysis in current safety research. The empirical literature on this topic is indeed scarce and there is a need to bring empirical insights to comfort, refine or amend the current state of knowledge (Le Coze, 2019b). These authors bring indeed into relief the role of powerful actors but there is a need for more empirical work to understand their pivotal role together with technology, tasks, structure, culture and environment, as represented in Fig. 1.

To do so, not only in retrospect after major events when strategy appears clearly as one of the key dimensions1 or in the context of nearly-error free exceptional organisations (HRO) but in the acknowledged imperfect and messy realities of companies, is a good way of exploring this topic. The next sections elaborate on the challenges of studying safety from broad (multilevel) safety research, with an interest in strategy, with the help of a case study. In a first section, the methodological approach is introduced, describing the ethnographic and interpretive mix of observations, interviews and reading of documents. In a second section, the findings are presented in a narrative, deciphering the complex patterns of sociotechnical interactions exhibited in the case. The third discusses broad (multilevel) safety research and the pivotal role of strategy.

2. Methodology

2.1. Principles

Broad perspectives on safety as introduced above rely on a large amount of data based on interviews, observations and documents. This study is an ethnographic one, based on a method which is more visible, advocated and promoted in safety research than it was in the past. Turner was a user and developer of grounded theory in the 1980s (Turner, 1983), Perrow mostly exploited reports when writing Normal Accident (Perrow, 1984), Vaughan describes her approach of the NASA case as 'historical ethnography' (Vaughan, 2004), Hopkins as 'desktop ethnography' (Hopkins, 2006, Hopkins, 2016).

Rochlin refers to the proposition of an 'embedded sociology' (following Bourrier, 2010) to characterise his ethnographic fieldwork experience during the hro project (Rochlin, 2011a, Rochlin, 2011b). Their followers in safety research have shown the value of proceeding through interpretive and ethnographic work on a range of contemporary topics (Le Coze, 2019a, Gould Pettersen and Mcrae, 2021).

There is a long tradition of ethnography through anthropology and sociology which supports these approach (Weber, 2015), and established but contrasted methodologies exist. Grounded theory and

the extended case method are two visible examples of this situation, with distinct principles (Tavory and Timmermans, 2009). Differences about the status of the researcher as an insider or outsider, about the data-theory connection, about the consideration of macro dimensions in fieldwork differentiate these methods and translate sensitivities of their developers and their users (Le Coze, 2021).

In the study presented in this article, the researcher is not considered to be an objectively detached observer, but a fully immersed and engaged individual instead, bringing a perspective based on research development, to the understanding of a specific situation, without the pretention of neutrality. The data-theory connection is seen as a nuanced and non-standardised interplay between collection of evidence, a priori knowledge and the process of interpretation. Consistently with the spirit of ethnography (and without entering complex philosophical discussion), data is first and is sensitised by a reflexive process of carefully using concepts. This applies to the micro-macro relation, which considers descriptions and interpretations of situations to be part of wider trends in which case studies should, ideally, be situated.

Considering what has been said in the introduction and in this section so far, conceptual lenses sensitising the following case study consists in problematising the relationship between several key dimension articulated in any broad (or multilevel) approach safety (Fig. 1). This consists in exploring through empirical data how technology, task, structure, culture, strategy and environment of organisations combine to produce (or not) safe performances.

2.2. Empirical investigation

These principles structured the case study presented in this article, an industrial case in which safety problems in one of the production department of a plant were the reason and the focus of the analysis (Fig. 2). The approach consisted in descriptions of practices and interactions of artefacts, machines, workers, shift supervisors, foremen, engineers, managers in this production department by a team of two persons2. Their interactions with actors of other departments, services or collective actors (unions) of the plant were also part of the study. The aim was to identify patterns of interactions, dynamics which helped understand the recurrence of safety problems in this production department.
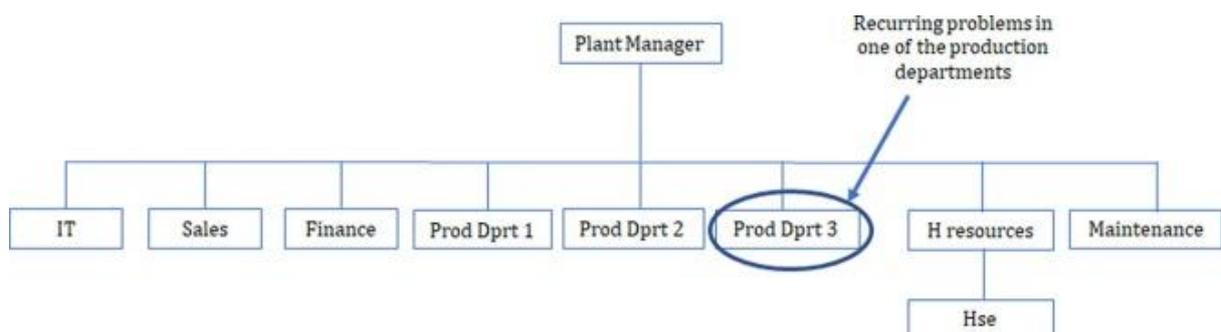

Fig. 2. Simplified organigram of the plant.

To proceed with this description, 18 days (of about 8–10 hours each) of observations, of informal and formal interviews were programmed during a period of 6 months (3 days a month), followed by 8 individual feedback sessions of our interpretations (of 2 hours each) then 4 collective ones (3–4 hours each). These individual and collective sessions were important moments during which people views could be expressed about our interpretation of the situation and brought additional data in this

respect. This amounted to a total of more than 200 hours of lived experience within the company, and about 100 hours to interpret the data and prepare feedback sessions.

A first phase included observations and informal interviews in the production department and consisted in freely observing work practices, guided visits by the production manager, foreman then shift supervisors providing explanations of the technical processes and machineries but also of their practices at different moments of production lifecycles. They also consisted in discussing with workers, informally, when possible, to help us understand their activities, their interactions with colleagues and other actors, and of course safety. These moments were also more broadly dedicated to their views on work, its evolution, on management, the company or unions. Observations and informal interviews during shift work were performed sometimes early in the morning (5am) to see changes between teams, as well as in the evening (9 pm).

This phase of the case study occupied 4 sessions of 3 days over a period of 4 months. The production department of the plant studied is an important one, considered to be the most complex because at the heart of the process, finalising the product by giving it its shape in multiple sizes, configurations and weights for different customers of different industries (more about this below), and requiring a diversity of machines not met in other production departments.

Shift work based on 5 teams of 22 people supervised by 5 shift supervisors and a foreman (from 7 am to 4:30 pm everyday), who is also in charge of a team of several engineers and technicians (working from 8 am to 5 pm) themselves in charge of projects, process improvement and subcontractors. There is a department production manager in charge, with three additional functions by three people: a quality manager and his team of three technicians, a human resources person to help with recruitment, production planification and training and a person with a role of interface with the project department. This represents about 150 people in total, in plant of about 600 people (Fig. 3).
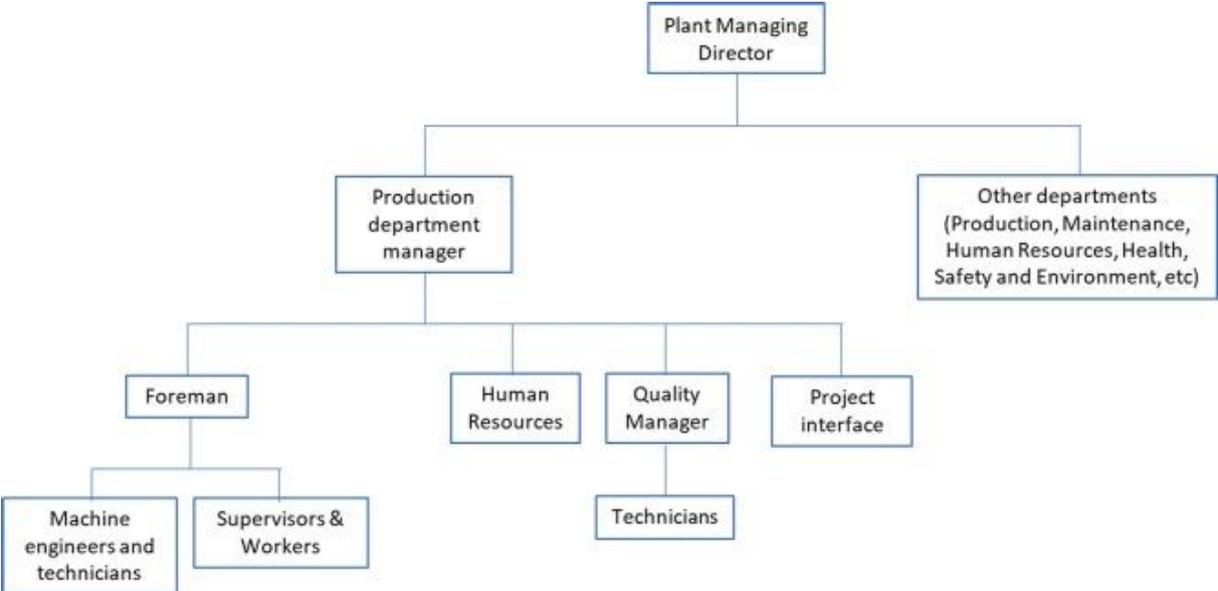

Fig. 3. Simplified organigram with a focus on one production department.

Observations of four types of meetings were also included in our fieldwork in several occasions:

- mornings' meetings, dedicated to the allocation of tasks by supervisors to workers during their shift,
- second mornings' meeting, dedicated to coordinate work between shift and day personnel (technicians, engineers)
- afternoons' meeting, consisting in coordinating plant activities with all of the managers of departments and plant manager, followed
- by another one in the production department to coordinate work with the afternoon shift.

We also observed shift supervisors interacting in their office when one team replaced another (we observed 4 of them). A total of more than 60–70 people were met, sometimes briefly, sometimes for longer observations and discussions when work allowed it.

The idea behind the observation of these multitude of practices and interactions was to get to know as much as possible the production department, its industrial processes, the machineries, the work principles and rhythms, workers background and practices, evolution of careers, constitution of teams, shift supervisor practices, foreman activity and practices, team climate and interactions within and among teams of shift workers, and their interactions with the technicians, engineers and manager of the production department, working on a day basis (7 am–4 pm, and much longer hours for some).

The second phase of the study (twice three days over a period of 2 months) consisted in planning interviews with technicians, engineers and managers of the production department, then with managers of the other departments of the plant, and the plant manager, based on our understanding of the production department, and its problems. These departments included human resources; health, safety and environment (hse); quality; maintenance; methods and projects; and the two other production departments. Managers of finance, sales and IT departments were not met, considering that they would not add substantial insights to an already rich material which provided enough data to figure out some of the most prominent issues.

Each interview followed a similar thread of asking interviewees about their educational and professional experience, then a description of their daily activities (practices, and interactions), their view of the company, its evolution, their view of the management committee to which they participated and the current problems and the reasons of our study. Performing these interviews after several days of fieldwork in the production department created favourable conditions for very rich discussions. We also saw many people several times, sometimes formally (during planned interviews), sometimes informally when observing practices, but also during many lunches at the restaurant of the plant, with one or several managers (which was more difficult with workers because of their different rhythms due to shifts).

We had two formal interviews with the plant manager for instance. We saw him the first day of our study, then at the end of our study (the idea was to discuss, to compare and to exchange about his description of the situation, and ours). We also saw many members of the hse department that we met regularly during our fieldwork, first because their office was on the way from the entrance of the plant to the production department (so we would stop to say hello and have a chat) but second, mostly because the theme of the study was safety in a production department for which they worried. They thought this study had a wider implication for the plant more generally, and not only one department. We met 30 people in total in formal interview contexts.

In terms of documentation, we had access to safety procedures, safety management systems, description of company's activities, a book on the history of the plant, a list and a selection of causal analyses of events, some documentation about management committees, previous analyses of the company by external experts from economic, social and performance point of view commissioned by unions. All observations and interviews were hand noted, in ten notebooks, of 96 pages each, filled with writings, sketches and drawings. Pictures of workplace, warning signs, work situations, meeting rooms (with the consent of people when in the pictures) were also taken when possible and used later during feedback sessions.

Interpretation of data was performed over a month period, following which feedbacks of the study to the company were organised first individually, then collectively, in various configurations (management committee, health and safety committee ran by unions, production department staff). Two times two days were needed for these feedback sessions, during which people debated our interpretations, findings and propositions deriving from the analysis. The sessions were important moments confronting our interpretations, but also for participants to hear, take in collectively and express to each other aspects of their understandings of the situation with our help as moderators. We visited the plant a year later to discuss the evolution of practices.

2.3. Data analysis

Data analysis and interpretation is based on sociological lenses combined with inputs from several safety research traditions, looking into patterns of (material and social) interactions between multiple aspects (see references in Section 1, Fig. 1). One analytical principle is that neither technology, task, structure or any other dimensions are deterministic influences in isolation. Their influence is, first, a result of a combination and, second, quite fundamentally for a sociological study, mediated by complex patterns of interactions made of interpretations, decisions and actions of multiple people across, expertise, hierarchies and departments. Technology doesn't determine tasks. Tasks don't determine structure. Structure does not determine culture. Etc.

Let's illustrate this point with one example. Technology requires to be sensitive to its characteristics, its hazardous processes, its design and maintenance and how it influences concrete situations as diverse as workers' tasks or managers' strategy. But, all of this is also a product of how people in organisations deal with it. For instance, design options in relation to hazards is not a given but a product of engineering choices. Technology is an influence, but one which is not deterministic. Thus, tasks carried out by workers surely depend on technology and its design, but not only.

They also depend on training of workforce and its supervision, on relationships in teams, on production targets and time allocated to perform tasks but also social relations. Tasks depends in turn on other dimensions, including organisational structure. Structure entails the design of functions, responsibilities and designed coordination principles (e.g. meetings) distributing and organising work (tasks) between workers, technicians, engineers and managers inside and outside a department. This is again made by people, and organisational structure does not determine social interactions even if it constitutes a strong constraint, a context.

This reasoning applies to all the dimensions described in Fig. 1. Of course, as introduced above, one strong outcome of the literature is that strategy and powerful decision makers play a pivotal role in this picture. But, what matters for the analysis in a broad (multilevel) approach, is to be able, first, to keep these different dimensions together, describing, deciphering, weighting and articulating their reciprocal influences mediated by patterns of interactions between people, and second, to understand how these patterns are favourable (or not) to safe performances (by correlating events to technical, social, cultural, organisational, managerial and strategic contexts).

It is only after empirical observations of artefacts, people's practices and interactions that one can elaborate on causal relationships. Again, this process has a certain degree of subjectivity associated to it because it reflects an author's sensitivity. In this respect, the safety narrative developed and presented in this article for this study combines several key insights which explain the case, it includes:

- a historical view of the plant to situate the strategic context of this case study ("history and new strategic challenges"),
- a description of some of the salient problems of working practices in the production department in relation to quality and safety events ("a production department in the red"),
- an explanation of these problems through an organisational and managerial perspective ("problems running deep"),
- a description of the complex patterns of interactions between people one can infer from the data ("powerful unions", "a vicious circle") and,
- a strategic analysis of the situation ("a strategic blind spot").

The narrative addresses salient features of the specific situation investigated to fit the format of a readable article. The trade-off is between a detailed description which would be very long and a superficial account which would excessively simplify the case. The narrative strikes a balance between these two opposites and relies therefore on a chosen level of details needed to convey the big picture obtained when proceeding with a broad (multilevel) safety research.

3. Safety narrative

3.1. History and new strategic challenges

After many years of uncertainties about the future of the plant, which was supposed to shut, a new investor made an offer, and invested several millions in the following five to six years for upgrading the industrial processes and modernising the plant. Previously part of a national group with a strong industrial expertise over fifty years (1950–2003), the plant had been sold twice in the past fifteen years to two different multinationals (2003–2007; 2007–2013), with a financial strategic mindset for the last multinational. This multinational company acquired indeed several assets in the world to avoid a takeover by a hostile competitor. Without much interest in investing in the new acquired plant, and with a different industrial expertise and vision of its development in which the plant did not fit anymore, this international group decided to shut it. Production was divided by two, experimented employees retired earlier when they could, and production was maintained to a much lower level, by an inflow of temporary younger recruits when needed, to compensate.

But, fighting for the plant and their jobs, unions, management and political officials of the territory in which the factory was implanted gained support and expertise from the state, and together, they found in 2013 a new investor with an industrial mindset (it is a family owned business), ready to envision another future for the plant. The new company director decided to invest in the plant to create a competitive tool on the market for its development. The task for the people of the plant consisted therefore in organising for an increase of activity and for a new strategic approach consisting in managing many simultaneous projects to modernise the plants, with an annual budget up to 50 million euros, for several consecutive years. Whereas the plant had been slowly shutting production lines over the years, they had then to reopen these lines, while upgrading them and opening new ones.

The task required to disconnect the activities of the plant from a multinational to reconnect them within a smaller company. There were gains and losses.

The plant manager decided to stay rather than leave and reconstituted a management committee for the plant with the managers who wished to remain in the new acquiring company, rather than pursuing their career within the multinational which sold the plant. For the vacant positions, he recruited some managers outside, while promoting insiders when possible with the help of the human resource manager who stayed too. Production increases from ninety to hundred forty-five thousand tonnes within a few years, and all departments go through a burst of activity: maintenance; health, safety and environment, human resources; projects; production department (three of them); IT; sales and finance. Investments in upgrading the production processes means also an increase of subcontractors, engineers and workers on site, to manage.

3.2. A production department 'in the red'

Four to five years later (2017/2018), out of the three production departments, one is in the red (Fig. 2). Several events, a fire in one area of the factory delaying production for weeks, a loss of containment of a chlorine line close to workers triggering an evacuation of the department building and, another time, a worker burning one of his feet with a drop of hot liquid metal. He is sent to hospital and stopped for several weeks after a skin transplant. The plant is indeed a hazardous place, with industrial processes entailing risks of fires and explosions due to the use of liquid metal, risks of toxic exposition to chlorine and risks found in any factory due to the different mechanical and moving parts of machines, due to practices during some production phases exposing workers to hot metal in complex configurations or due to circulating forklifts and trucks outside and inside the plan. The analysis of the events reveals that they have in common managerial and organisational underlying problems (Table 1).

Table 1. Events and their common associated organisational issues.

Several events	Common organisational issues
Operator's foot burnt	Insufficient training of new workforce, standards' production and compliance (combined with a lack of authority in production department)
Fire	Coordination and cooperation problems between people in production department and with people from other departments
Leak of chlorine	Issues in supervision of workers' practice in teams linked to organisational weaknesses and difficulties (tensions, conflicts, low morale)
Other events related to products' quality, projects, social tensions	Problems in design and maintenance of machines

The fire is due to problem of training, coordination, organisation and supervision of work: a young recruit forgot to install an equipment that he should have installed for a maintenance task, but this is combined with a second mistake of delivery of hot liquid metal in the wrong oven which was in maintenance. The loss of containment of chlorine is linked to design and maintenance issues of a valve. The severe burn of the operator is linked to a design flaw compensated by an unsafe practice which was insufficiently supervised. To this list of events can be added less serious but frequent near-misses;

quality problems of products; projects delivered with engineering problems to sort out afterwards and mounting tensions between people of this department and people from other departments who interact with it (e.g. maintenance; project; hse). These common organisational problems are represented in Fig. 4.
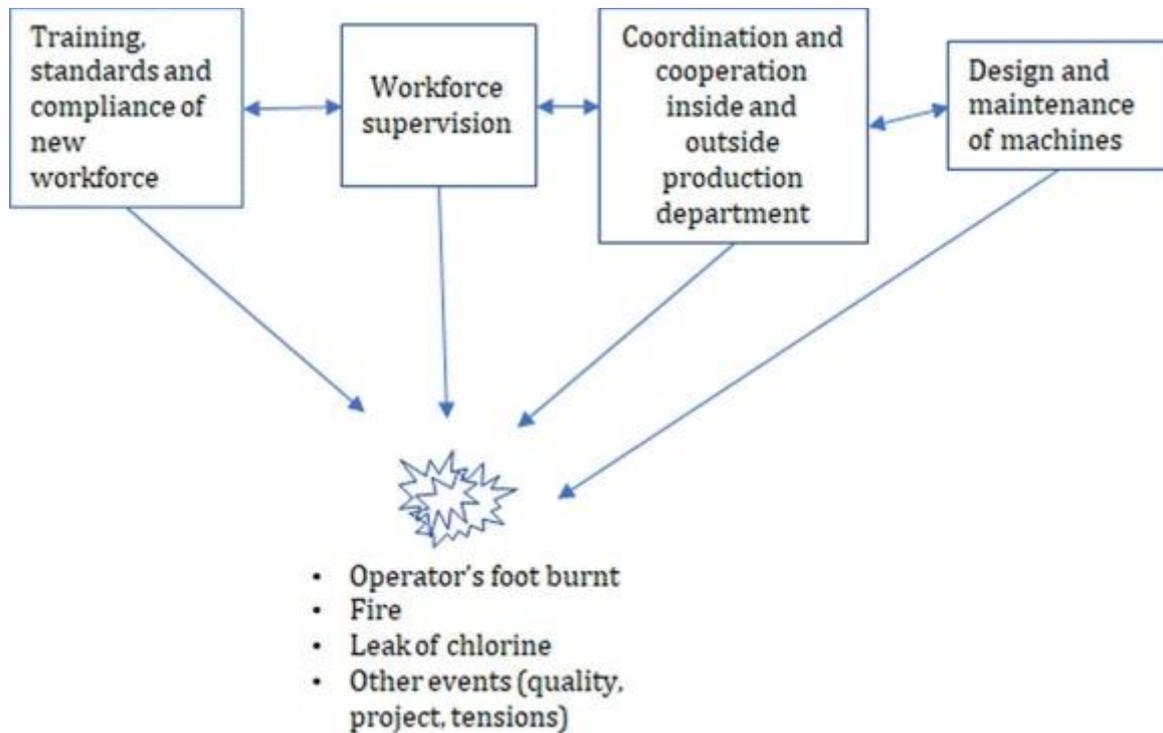

Fig. 4. Events and their common organisational issues.

Regulators are aware of some the most visible events. An environmental and process safety inspector visited the plant after the release of chlorine which had triggered the alarms of the internal emergency plan, but there were no consequences outside, environmental or human, and an action plan was required without any sanctions. The fire which caused production delays, although indicating serious process flaws, did not injure, kill anyone or pollute the environment either. Plus, the organisation spends resources to comply with the legal requirements and submits regularly the expected analyses (safety cases) to the authorities, which are instructed. From the point of view of health and safety inspectors (another legal authority), there is no casualty in the plant that could trigger the need for a thorough investigation of working practices in the production department.

In the two other (operational) production departments (Fig. 4), there are no incidents, no events of that magnitude or frequency, despite also an increase of their activity in the past years following the change of company and the associated investment policy. Yet, the new owner of the company does not put any pressure on the plant manager to lower the number of events, the strategy is mainly customer oriented and linked to an increase of production through modernising the plant, and the achievement of better result in safety is not a strong issue. The plant is considered, globally, to be at the same level than the other plants in the group. Health and safety is not high on the agenda of the owner, and results not catastrophic enough. In the absence of corporate pressure, the plant manager leaves the problem to the manager of the production department but still expect improvements.

His approach of the problem is to consider that this department manager and the foreman should organise production better. He does not want to intervene, following a management philosophy which sets objectives rather than solutions to attain these objectives. However, aware of the problem in this part of the plant, he visits it from time to time, meets the workers and, in contradiction with his proclaimed managerial philosophy, does not hesitate to intervene and to ask the managers and the foreman to solve problems that he hears expressed by the workers. Another strong philosophy of the plant manager is indeed to pick up weak signals from workers, which should help anticipate problems before they happen and impair production.

3.3. Powerful unions

But his visits are not the only way to hear from workers about operational problems. Unions are historically very strong in a plant with a high percentage (about seventy percent) of workers in the population. Violent strikes which stopped production for days with half of the workers at the gate of the plant blocking the access to other employees are now a thing of the past, to the credit of the plant manager. He indeed instigated a more peaceful relationship over the years but unions remain powerful. They still have an influence, in decision making processes at the highest level of the plant, not least because they played an important role in saving the plant future back in 2013. Some influential union leaders are team members in the production departments, and their voices count, and particularly one operator in the production department in the red. They have a direct access to the plant manager when they consider problems not to be dealt with appropriately by the management of the production department they belong.

This situation creates a complex, sensitive and uncomfortable position for the production department manager and the foreman who live with the threat of being pressurised by the plant manager based on union's inputs, a situation which undermines their credibility and authority in the production department. But the power of union is also felt on the health and safety side because of an active health and safety committee, ran by their members. Legally, a plant of this size must delegate hours for elected people to play an advisory role in health and safety. In this plant, one worker is dedicated full time to this committee, and relies moreover on an active network of several other committee members in the different departments of the plant, who participates not full time, but to a fair percentage which can go up to 30%.

This network is very active, connected to the daily practices of workers, and in a position to gather a wealth of information about what is going on in the plant, with a dedicated eye to health and safety issues. The plant manager who is legally responsible for this advisory committee finds it a very useful canal, bypassing his managers, bringing alternative (with a different filter) data to his ears. Members of unions and of the health and safety committee working in the production department in the red complain, along with the managers of the other departments, about the latent problems of the department.

3.4. Problems running deep

In this respect, there is a consensus among workers, members of unions, engineers and managers within and outside this operational department that there are things not going well and that the number of events related to safety, quality or engineering projects experienced in the past few months translate deeper managerial and organisational issues in this department. "Who does what in this department?" is often heard during observations and interviews, and many comment, analyse and suggest solutions during our interviews but the big picture seems difficult to elaborate because of the

multidimensional nature of the problem (Table 2). The study confirms indeed the causal connections between the events and deeper managerial and strategic issues, but which remained unstructured in people's minds.

Table 2. Events, organisational, managerial and strategic connection.

Several events←	Common organisational issues←	Managerial and strategic problems
Operator's foot burnt	Lack of quality of workforce training in production department, issue in standards' production and compliance (lack of authority in production department)	Investments and modernisation program requiring the management in parallel of several projects while increasing production
Fire	Coordination and cooperation problems between people in production department and with people from other departments (maintenance, project)	Management style of plant manager in relation to unions, production management and workers, and also plant management committee
Leak of chlorine	Issues in supervision of workers' practice in teams linked to organisational weaknesses and difficulties (tensions, conflicts, morale, difference in management style)	Weak organisational structure in production department leading to mounting difficulties for the management team, including: Number and positioning of meetings
Other events related to products' quality, projects, tensions	Problems in design and maintenance of machines	Interface issues with other departments

Indeed, problems running deep in this department started few years back when the strategic increase of production volume meant opening again processes (while modernising some of them), which had been shut for some years. It implied, first, that new recruits were needed (representing sometimes up to half of a team of 22 workers), and second, that training was needed while most of the experienced and qualified workers who could teach, mentor and supervise new workers were in limited numbers because most of them left when the plant was expected to shut (few years back). But this is not the only problem. Due to the nature of its business, high flexibility is also required to satisfy customers demands for a diversity of products, involving the need for workers to move from one machine to the other, despite different expertise requirements associated with each machine (which poses training and production planning complexities).

On top of these demanding operational constraints, the organisational structure of the department also suffers from a lack of adequation to the volume and number of tasks to be performed following the increase of production. It is understaffed. The consequence of this is that the production manager and the foreman are overloaded (in particular the foreman who cannot cope with his workload), struggling to allocate their time adequately between operational activities and managerial ones. Coordination meetings at several levels are missing, impairing resolution of problems because delegation of problem solving to technicians, engineers and managers of the production department is poor, which create tensions and problems left unsolved, and piling. This organisational, managerial and strategic situation explains the recurrence of events introduced earlier and reveals the deeper causal connection (Fig. 5).
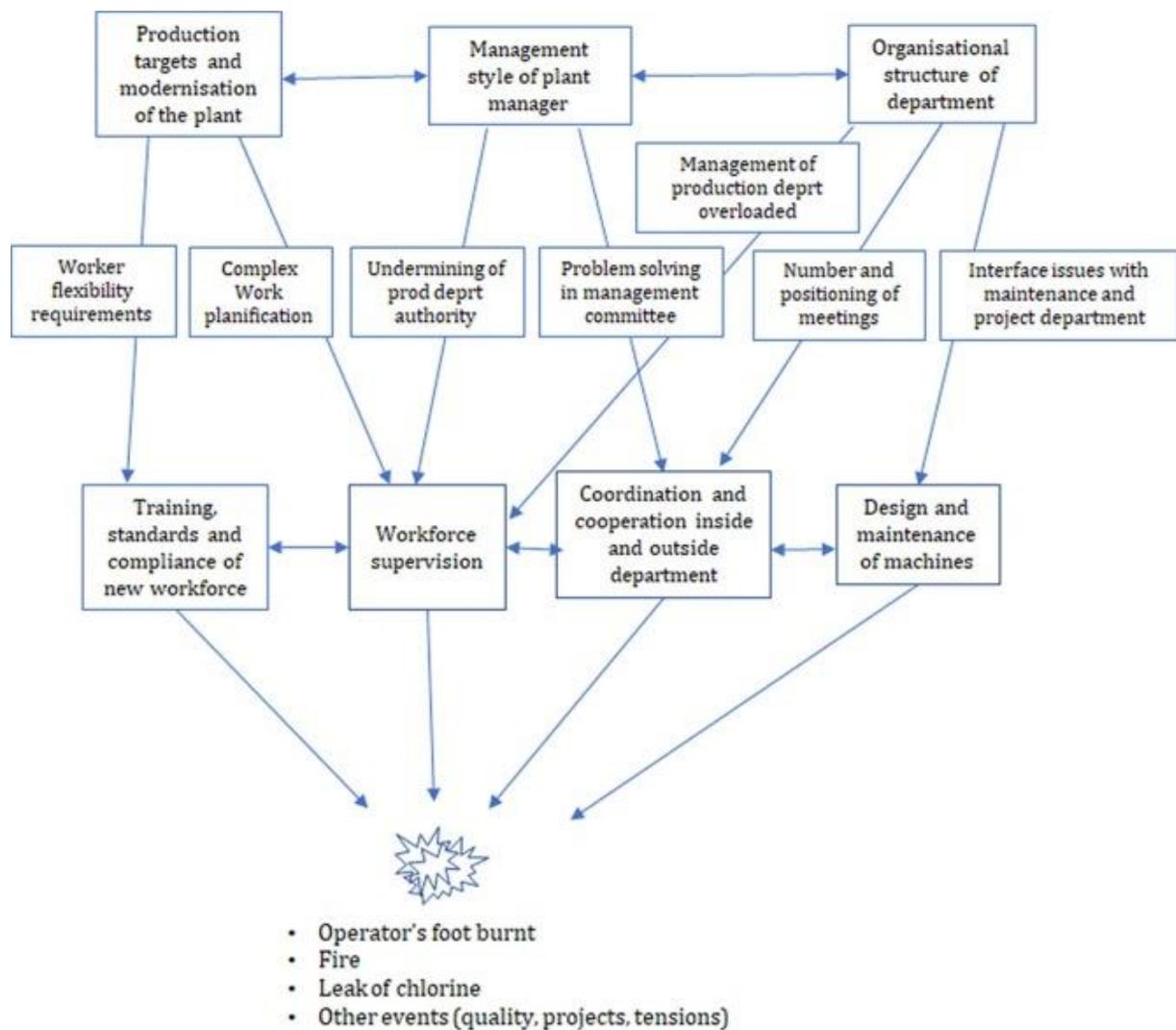
Fig. 5. Events, organisational, managerial and operational connection.

Yet, globally, production targets are met to a level that satisfies the new owner who spends two days from time to time in the plant, who does not interfere with the internal management of the plant. Overall, the picture is therefore globally one of success, surely with one department facing some difficulties translated into events of different nature and intensity (quality, safety, projects) but not to an extent that measures are felt to be taken from the point of view of the group. However, internally, the motivational cost is high, the morale is low in the production department, working hours of the managers and the foreman rocket, with associated mental, emotional and psychological costs, and the likelihood of a more serious accident one day is in the mind of many, from managers to unions to the HSE department members.

These members of the hse department play a strong role when it comes to regulatory compliance with environment, health and safety laws (e.g. safety cases), but not from an operational point of view. They make sure that the response to authorities' demands are fulfilled, as much as possible. Divided in several expertise for each of these areas, it is a relatively small department considering the size of the plant, five members for six hundred employees, with lack of hse qualifications apart from the

manager of this unit, and an experienced technician but to retire shortly who is mainly dealing with sub-contractors.

This unit is under the supervision of the HR manager, who had an operational safety function in the past, and inherited this unit with the change of owner. Although under HR, the hse manager participates to management committees with all of the other managers (Fig. 2). Presence in the field in the production departments of the plant by the members of HSE is scarce, and when they do, their approach of safety is mainly one of control, based on a compliance mindset which misses a good understanding of practices which is not perceived too well by operational people. But the hse people can tell that the production department is badly performing from a safety point of view, and the manager of the HSE department initiated this study.

It is important to stress that people in the production department manage to reach their production target because of their collective expertise despite the problems. Their ability to fill the gaps, their ability to compensate for coordination problems, their ability to rely on their networks of relationships, trust and experience when needed, is what makes it work. This comment does not apply only to workers but also to supervisors, foreman and engineers of the production department who, all of them, but some more than others, allow to produce to acceptable levels despite the difficulties described above.

A closer look at practices in this respect reveals different managing style of shift supervisors. Some exert a close supervision, expect results, autonomy and problem-solving capabilities of members of their team, while others are more conservative, do not try to compensate as much, and require workers to stop when problems are met, not to expose people. Learning is in this context is strongly impaired collectively because of supervisory styles are so different, and this diversity of practices left undiscussed. This situation is stretching the boundaries of what one would expect of a reliable and safe organisation, with some human, production and social climate costs associated and indicated earlier, among which low morale, frequent tensions, persisting conflicts, problem of authority, and events, from time to time (Fig. 5).

3.5. A vicious circle

For an external observer, familiar with industrial plants with a sociological and broad perspective, the issues identified above are not entirely surprising and come as a product of the patterns of interactions created by complex sociotechnological realities in evolving strategic orientations. Imperfection of organisations is expected. The question is one of degree. In this case, and as one can infer from the narrative, this imperfect situation is maintained by a vicious circle (Fig. 6). When the plant manager hears from workers, when he is alerted by unions members of the health and safety committee or when he observes himself problems during his visits of the production department, he exerts additional pressure on the department production manager to solve them, amplifying the feeling that there is a real need for managerial improvements in the production department.
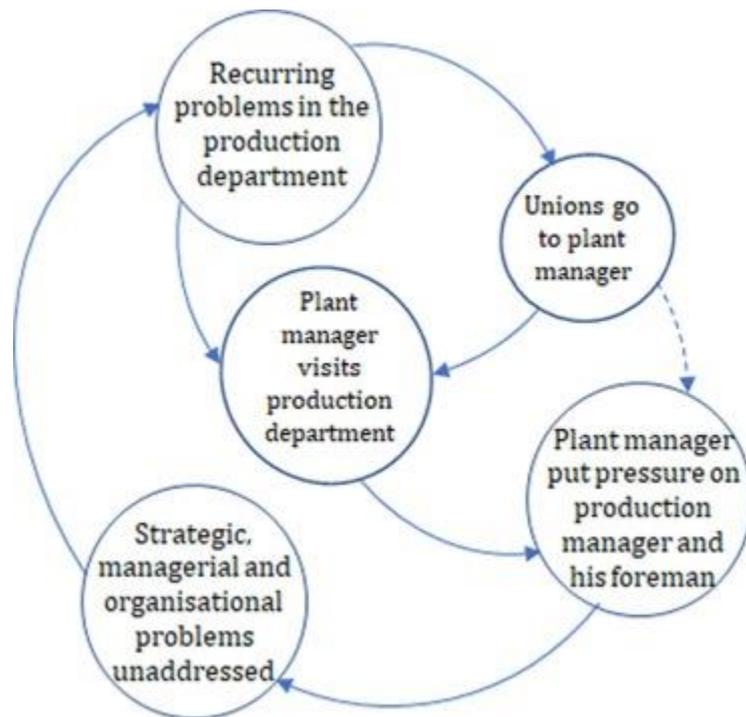
Fig. 6. A vicious circle.

Yet, without addressing a number of issues as described above, namely the lack of sufficient amount of qualification of workforce to tackle the flexibility expected by production, and an organisational structure of the operational department which is inadequate and not sufficiently staffed to meet the production targets, the result is a vicious circle creating the background of a higher likelihood of events. This situation is created by the interactions of several actors: company owner, plant manager, production department manager and foreman, unions and regulators, supervisors and workers, human resources managers as described in the narrative. This is a dynamic made of circular causalities, patterns of interactions, which one can attempt to visualise with the following figure (Fig. 7). A stylised and summarised description, emphasising some salient aspects of the vicious circle created by these patterns of interactions is associated with it (Box 1).
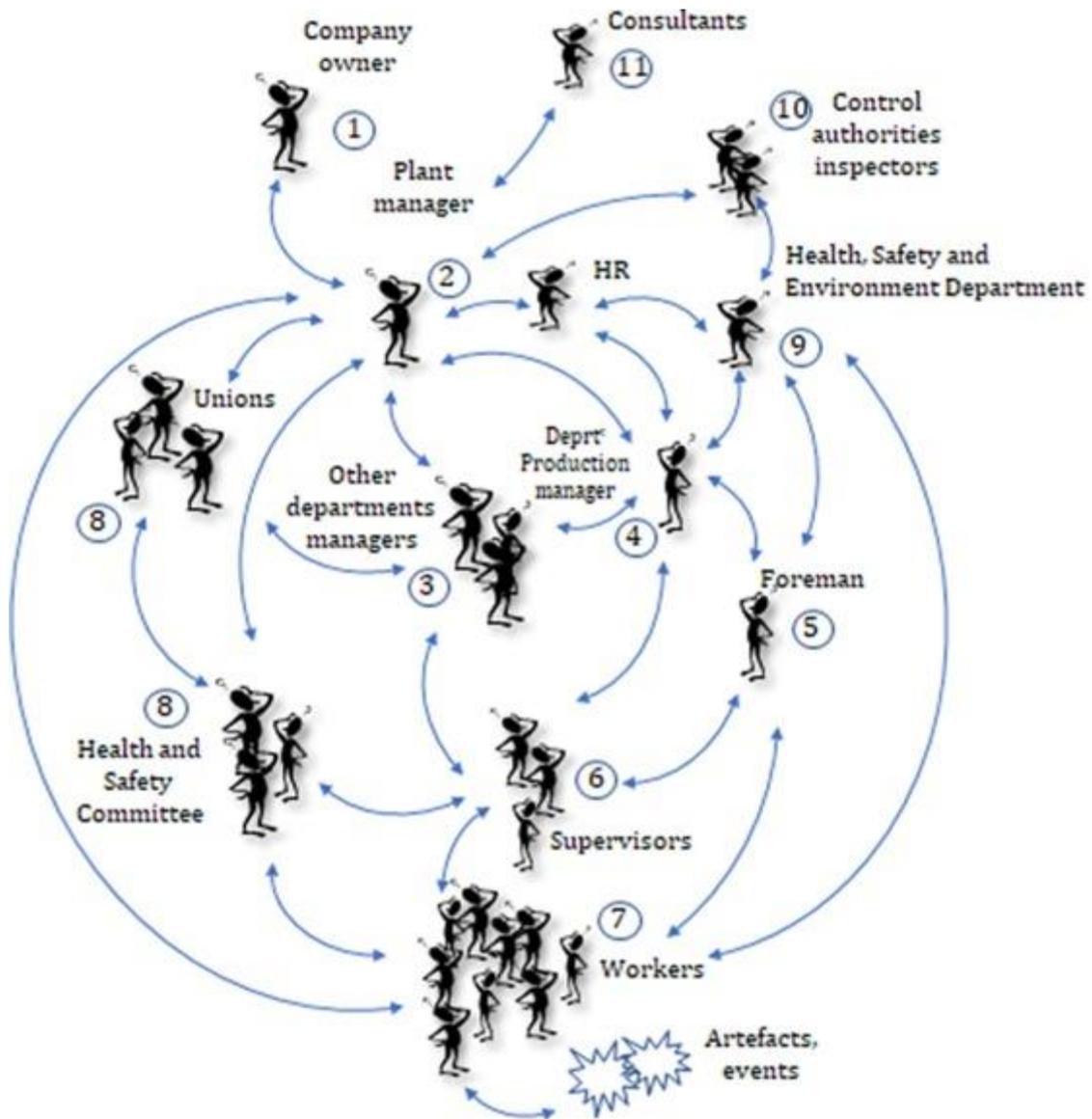
Fig. 7. Complex patterns of interactions.

Box 1
Complex patterns of (material and social) interactions, key aspects derived from narrative.

1. Owner new strategy consists in investing in the new acquired plant to increase production, but does not particularly emphasise safety as a paramount goal
2. Plant manager develops the operational, managerial and organisational capabilities to handle the level of investments and increase production targets in the plant, but problems met in one of the production department 'in the red" is misunderstood in its complexity (described as a blind-spot)
3. Productions managers of other departments witness the problems, sometimes suffer (maintenance, projects) from coordination issues with the production department in the red
4. Production department manager (and his foreman) struggle to find a solution to their problems when confronted to flexibility requirements, insufficient organisational structure and management style of plant manager in the context of strategic investments

5. Foreman's heavy workload of managing both production workers, teams' supervisors and technicians/engineers leads to difficulty in coordinating and planning activities
6. Supervisors develop different strategies to cope with the problems, including opposite supervisory styles in teams, leading to various practices of workers' in daily operations in order to handle flexibility requests
7. New workers are not socialised through the mentoring of more experienced workers; training, standards and compliance suffer from modernisation, increase of production and flexibility expectations
8. Unions through health and safety committee complain to plant manager, expecting problem resolutions, but equally fail to address organisational problems of the production department in the red, contributing to a vicious circle
9. Health, safety and environment department (under the human and resources department) is legally oriented in its activity (control mindset versus operational mindset), complying with regulatory obligations (i.e. safety cases, environmental studies).
10. Environment and industrial safety control authorities inspect plant regularly and are satisfied with compliance with legal expectations, despite knowing about problems which remains, nevertheless within the boundaries of the plant
11. A consultant contracted to improve relationship between plant departments does not address the specific problem of the production department in the red, and underlying difficulties remain hidden (this point is developed below).

Although the situation is felt unsatisfactory by the plant manager, no solution is yet found, no way out is made possible before the patterns and associated problems described above are discussed during various feedback sessions following the study then acknowledged as a valid interpretation of the situation, collectively, by the different actors of the plant during the feedback session of this study. Instead, accumulating problems without a shared, agreed and organisational analysis of the situation only amplifies the feeling of poor performance, that people tend to shift on the production department manager and the foreman.

Change of structure of the production department, change of management style by the plant manager in relation to unions and management in the production department, stabilisation and increase of expertise (and standards) of the new workforce by slowing down investment and projects are some of the agreed measures to make sure to come back to a safer mode of operating. A year later, after the implementation of these measures with the help of a consulting firm, the situation greatly improves, with no recurring events as witnessed a year before. This situation could be described as a strategic blind spot with strong implications for safety but was left unsolved and could have very well be ended with a serious injury, or worse, a casualty in a too well-known scenario of an "accident waiting to happen". Let's elaborate further about this strategic blind spot.

3.6. A strategic blind spot

Although the performance issues were obvious (e.g. safety events, quality problems, climate within the production department, Table 1, Fig. 4), and discussed during management committees, the problems running deep in the production department were not fully exposed (Table 2, Fig. 5), and many proposed solutions could only scratch the surface of the enduring patterns which locked the operational department into the problematic situation, into the vicious circle described (Fig. 6, Fig. 7). The plant manager recognised that his analysis of the situation was too simplistic, and recognised the need for change, especially of a change of organisational structure including more resources, but the insights to trigger this shift of mindset came from outside, from the study.

None of the conditions, from a management point of view, were met to happen independently of the help of an outside analysis. From a strategic point of view, his approach of the managerial problem of providing adequate resources and a mode of operating to reach in a satisfactory manner their production targets brought by the modernisation of the plant was structured by three key ideas. The first was to avoid intervening too much, setting objectives and not solutions, to meet these objectives (1).

He therefore (to a certain extent), refrained from taking operational decisions for the department, thinking, additionally, that the solution was not more resources, but a better way of organising with the existing level of resources, which leads to the second idea. This second idea was that management must anticipate problems by picking up signals from operational activities, early on, to prevent them from escalating (but his insistence on doing so only amplified the difficulties, see above) (2). A third one, was not to openly criticise managers of departments, or to question their ability to find solutions, either when meeting them personally for their monthly individual report or during management committee (3).

During these committees, exchanges of managerial experiences were therefore limited. How other managers of departments found solutions to their problems was not openly discussed. There was a diversity of management styles in the three production departments as gathered from interviews, a wealth of experience but never shared openly during these meetings. A leadership consultant had been contracted (recommended by the owner) to increase and to improve coordination between functional and operational departments, but the specific problems of the production department in the red did not seem to be part of the program. Documents which came out of these meetings, such as analyses and actions plans, were not dealing with the enduring, running deep, problems.

The option to replace the manager of the production department (and/or his foreman) was discussed between the plant manager and the human resources manager together but, with the move out of the multinational few years back, opportunities to do so by finding someone else internally and by moving the current one to another position, were gone. This would have however restricted the difficulties to a problem of management, whereas, as described, the issues were much wider (Table 2). This managerial style was based on the reliance on managers of departments to translate some of the operational complexities of the new investment strategy, and that a failure to do so was, in the mind of the plant manager, more a failure of implementation than of strategy. Indeed, his managerial style, so far, had proved its worth with the other production departments' managers, workers and union, contributing and reinforcing his blind spot (Fig. 8). What was needed was a more thorough analysis of the situation which was not available and came with this study.

Fig. 8. Success of plant manager style with most departments, except one.

Thus, the qualification of a "blind spot" comes from the inability of the plant manager to explicitly formulate the problems of the production department in order to find a suitable solution. Of course, there is a collective dimension to this because, as exposed in Fig. 7, it is the product of many interacting people, and not the plant manager alone. But it is an important managing role to make sure that problematic situations are exposed in a way that their deleterious consequences are corrected. He is the only one with the decision-making authority to take the measures identified in the study which involves spending more resources for hiring new employees, slowing down investments or reflecting on (perhaps even changing) his own managerial style.

4. Discussion

The aim of this study is to advocate an understanding of safety from a broad (multilevel) angle conceptualised in the literature as a product of technology, tasks, structure, culture, strategy and environment of safety-critical systems (Fig. 1). An analytical principle associated with this option is to recognise the non-deterministic, combined and mediated influences of these multiple facets, and the importance of strategy as a pivotal one. These facets are indeed mediated through complex patterns of (material and social) interactions made of interpretations, actions and decisions of people across a range of expertise, functions and hierarchies in dynamic contexts. If these facets are heuristically useful dimensions, an understanding of how they combine to produce specific outcomes comes when enough qualitative data is available. To describe, decipher, weight and articulate them can only be the result of in-depth acquaintance with concrete situations and realities of daily operations through ethnographic work.

In the case study introduced in this article, a way of describing, deciphering, weighting and articulating their mutual influences can be framed as follows:

-   First, tasks and technology in the production department have evolved too fast in relation to individual skills, team supervision and training considering requirement of work flexibility created by the new strategy of investments and production increase.
-   Second, structure is too weak in terms of staffing and design to handle the increase of production in the department to make sure to achieve the degree of coordination needed, but it is also too weak internally (at the plant level) when it comes to creating adequate and quality safety oversights (safety department mainly on a control and compliance mode), which both are also a problem of strategic choices.

- Third, as a result, cultural traits are not stabilised but fragmented and heterogeneous throughout the production department across teams, depending on supervisors' management styles, as indicated in the narrative.
- Fourth, the new strategy is challenging in terms of the speed and intensity of transformations and the production department cannot handle it without finding a solution to overcome the limitations of its organisational structure but this remains a blind-spot for the plant manager.
- Fifth, the environment contributes to create and to maintain the situation because the owner does not consider safety as a paramount issue and the regulators do not require actions either, remaining unaware of the extent of the problems in one of the production department. These problems do not trigger a strong response from the point of view of the authorities.

Identifying then evaluating the consequences of this dynamic from a safety point of view is much of a challenge and clear description of strategic orientations a way of addressing this problem but only when situated in the complex patterns of interactions as discussed in the narrative. Thinking safety this way helps connect these multiple facets in a dynamic way. Strategy translates indeed the way leaders envision the future of their business in their environments. But, the importance granted to strategic actors should not be considered as a new hindsight bias, a reductionist or a simplistic view of complex organisations or as a way of shifting the blame from operators to top managers. Let's develop this issue further.

One interest in studying safety from a broad (multilevel) perspective is to move away from micro descriptions of workers' practices, which is one of the most common way of introducing humans' contribution in safety for many empirical research. Workers practices trigger events, sometimes with consequence but they trigger events in broader and strategic contexts, which most often determine both likelihood of operators' errors and extent of their consequences as illustrated in this case study.

Yet, much of practice and research in safety dedicate resources to workers, abstracted from their rich, complex and dynamic contexts. In the worst case, it is from a restricted, simplistic and normative view (blaming workers for not complying and creating unsafe situations), and in the best case, it is from a positive, rich and proactive view of workers' expertise (as promoted in resilience engineering). In both cases, the bad and the good, the focus remains workers. One obtains indeed a concise and easily understood picture when focusing, empirically, on workers because of the direct causality link (i.e. temporal, spatial, material) between events and action, hence the success of the notion of "human error" (which has been criticised and deconstructed since the 1980s, e.g. Rasmussen, 1990).

With a broad (multilevel) approach, the empirical analysis also considers other people and their interactions such as middle managers, managers and top managers. How top managers influence practices through business orientations and profit targets, management style, choices of organisation structure, analysis and resolution of problems, and ability to adjust to avoid detrimental consequences on safety when set on a strategic path is a crucial question that this case study illustrates.

As introduced in the first section of this article, Perrow had a critical view of strategy, seeing behind accidents executives' sacrifice of safety for production, or, in his own word, "executives not trying hard enough". Hopkins, more practically oriented, sees senior managers in charge of complying with their legal duty but also good practices available in this industry, and accidents as a failure to do so while Vaughan situates top managers dealing with constraining environment and complex sociotechnical systems.

Farjoun and Starbuck (2007) also portray top managers as taking risks in tough environments, including the risk of pushing their organisations beyond the limits, when setting, for instance, ambitious goals. When elaborating on the topic, they suggested two different reasons for failures associated with pushing the limits, with, on the one hand, the hubris, greed and ambition of executives and, on the other hand, the slow, incremental and unanticipated consequences of actions and decisions.

They are of course very careful and warn "people and organizations do not always know how far they are from the true limits or the extent to which limits are elastic, relative, or arbitrary. Therefore, progress in general, and exceeding limits in particular entails ambiguity, risk and uncertainty" (Farjoun and Starbuck, 2007, 543). This is a topic which must be carefully pondered indeed considering its complexity, and if one wants to avoid the drawbacks of reductionism and hindsight bias which were applied to frontline workers and their errors. Let's elaborate.

First, strategy, as an object of study is a construct in the sense that it abstract flow of events, decisions and people in the complex realities of companies' innumerable interactions. As Carter, Clegg and Kornberger eloquently express it "the strategy we assume we observe is a result of an assemblage of practices. It is only the process of objectifying and reifying these practices that leads to what we think as objects" (Carter et al., 2013).

In this case study, and consistently with the findings of the field of strategy as practice (Jarzabkowski et al., 2016), success depends on the ability of managers, engineers, technicians, workers and unions through their practices and interactions to translate new orientations and expectations. And, one problem is the dynamic, sometimes temporary nature of these patterns, and the difficulty of predicting how long they will last before shifting, perhaps in some cases, quite notably. These patterns indeed move on as a result of new problem formulations which lead to new options, interpretations, decisions and actions (not necessarily in this linear order) by different actors.

So, strategy should not be simplistically understood, limited to top management only. Realities are more complex. Yet, and that is a second point, many of the important decisions of companies' fate remain situated at top management levels decisions as this case study shows. How perceptions, interpretation, decisions and actions of powerful actors greatly matter, as illustrated by the blind spot described in the narrative which locked the dynamic into a vicious circle (Fig. 6, Fig. 7) which created conditions for recurring and worrisome events which seemed to constitute a "accident waiting to happen" momentum for many (Table 2, Fig. 5).

In this respect, the view of powerful actors depicted in the narrative is one of people facing sociotechnical complexity which requires on their part an ability to grasp the modes of operating of their organisations. This includes an ability to link incidents, events to their rich operational, managerial and organisational contexts when companies explore the boundaries of what is reasonably achievable. Like Perrow formulates it, expectation for top managers is indeed to "try hard enough". But to know what it is that they need to do, and the associated complexities of this task in their work contexts, demands further empirical studies. Such studies must describe their practices in daily operations within the context of complex patterns, to complement what we know in retrospect, in the aftermath of major events. The case provided in this article is one contribution towards that goal.

5. Conclusion

This article advocates a broad (multilevel) sociological approach of safety with an interest in the role of powerful decision makers and their strategies. Based on two to three decades of literature on the importance of understanding safety through the combination of technology, tasks, structure, culture, strategy and environment of organisation, a case study is presented which relies on an ethnographic methodology of observing practices, interviewing people and reading relevant documents, traces and reports available in relation to the situation investigated. The case study concerns a plant with hazardous industrial processes including risks of fires and explosions, moving mechanical parts and hot liquid metal.

In one of the three production departments of the plant, several events within a few months (i.e. a fire, a leak of chlorine, a serious injury), along with other issues, challenge its performance. Analysing the events and linking them to wider transformations of the plant following a new investment and an increase of associated production targets, it appears that common managerial, organisational and strategic issues explain their occurrence. These common issues, when considered from the perspective of the complex patterns of (material and social) interactions made of interpretations, actions and decisions of multiple peoples from workers to supervisors, from production manager to owner of the company, reveal a vicious circle.

It is argued that this vicious circle is sustained by the inability of the plant manager, described as a blind-spot, to decipher the difficult situation confronted by the management of the production department because he relies on a set of principles which detracts him from realising the extent of the difficulties met in this department when trying to cope with the new context. Change in organisational structure of the department, change in plant manager leading style and change in training as well as supervision of workers are recommended and implemented to break the vicious circle. Coming back on the broad (multilevel) approach developed in the study, the article concludes on the importance of considering the role of powerful actors in safety as pivotal, without reducing or simplifying the complexity of their work.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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