

Article

Safety Culture, Professional Practice, and Organizational Reliability: Mobilizing Social-Scientific Perspectives for Applied Research and Advisory Activities

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Abstract

This article develops a conceptual framework for applied social-scientific research and advisory practice on safety culture in complex socio-technical systems. It starts with the observation that contemporary safety problems increasingly require forms of analysis that go beyond technical reliability and managerial control. Existing approaches to safety remain fragmented across engineering, management, and social science, often treating safety either as a technical design problem, a compliance issue, or a measurable organizational attitude. Against this background, the article argues that a practice-theoretical perspective can help integrate these approaches by understanding safety culture as an emergent configuration of meanings, routines, communication patterns, responsibilities, and situated professional practices. Particular attention is given to the risk paradox as it unfolds in critical infrastructures and safety-related organizations, where communication about possible failure is necessary for safety but may also generate anxiety, resistance, or mistrust. The central claim is that professional practice mediates between safety culture and organizational reliability: safety cultures become effective only insofar as they are enacted through communication, coordination, judgment, reporting, learning, and responsibility. On this basis, the article derives analytical dimensions for empirical research, organizational diagnosis, and advisory work aimed at cultivating reliable performance under conditions of uncertainty.

Keywords: organizational culture; safety culture; risk and uncertainty; professional practice; risk governance; socio-technical systems; critical infrastructures; organizational reliability

Opening Quote

The way to be safe is never to be secure.

(Benjamin Franklin, American Statesman and Polymath)



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1. Prologue and Introduction: From Individual Experience to Research Question

During a flight to the Canary Islands—I was traveling with my family on vacation—the flight attendant asked us to stow all heavy luggage under the seats. This was necessary for safety reasons, as the overhead compartment doors could open during extreme flight maneuvers. This had recently happened during an Atlantic flight due to sudden turbulence. Personally, this immediately worried me. Are there signs of impending weather anomalies? However, given my background in safety research—which builds on earlier work in interdisciplinary risk research and crisis communication that culminated in my habilitation in sociology (Metzner 2002)—it suddenly became clear to me: “Wow, this is a precedent, a

prime example of the well-known and widespread risk paradox". If passengers follow the given instructions, the procedure helps prevent potential accidents and increases objective safety. Yet, communicating potential hazards and sharing knowledge about what could happen leads to an increase in the feeling of being at risk, i.e., the subjectively perceived insecurity. The paradox of risk communication is that more objective safety can only be achieved at the cost of less subjective safety. The same insight is reflected in the quote initially presented: "The way to be safe is never to be secure" (Franklin 1757).

The risk paradox illustrates a broader organizational problem: safety depends on communication about possible failure, yet such communication may itself generate anxiety, resistance, or mistrust. This makes safety culture crucial because organizations must develop practices that enable risk-related information to be communicated without undermining confidence, cooperation, or professional responsibility. Building on this idea, the paper develops a practice-theoretical framework for understanding the relationship between safety culture, professional practice, and organizational reliability in complex socio-technical systems. Its central claim is that safety culture becomes organizationally effective only insofar as it is enacted through professional practice. The following sections first clarify the contemporary problem context, then reconstruct key theoretical approaches to safety culture and reliability, and finally translate the argument into analytical dimensions for applied research and advisory practice.

Against this background, the guiding research question can be specified as follows: How are safety cultures constituted, reproduced, and transformed through professional practices? The paper analyzes these cultures as situated patterns of communication, coordination, judgment, reporting, learning, and responsibility through which safety is enacted in everyday professional work. This practice-theoretical perspective makes it possible to assess the characteristics and quality of safety cultures while also identifying the organizational conditions under which they can be cultivated and further developed.

2. State of the Art: Synthesizing Contextual Conditions, Subjects, and Approaches

Many stakeholders recognize, express, and provide evidence of safety concerns. Safety has become a prominent topic in political discussions, economic forums, public discourse, and among experts (Le Coze 2019). This increasing focus on safety across various sectors suggests that, due to new or evolving hazards and threats, many believe that the current safety situation is less comfortable than it once was, as indicated by Hardy and Maguire (2016), focusing on discourse-dynamics and the phenomenon of 'riskification', and Schulte (2020), with concern for the future of work.

2.1. Relating Safety and Unsafty: Changing Conditions and Constellations

If safety is given greater priority, theoretically—'ceteris paribus', assuming all other factors remain constant—this could either reflect a culturally driven increase in the need for safety or be a response to a genuine rise in insecurity. In the real world, where conditions rarely remain unchanged as ideal-typical models assume, both factors may unfold simultaneously within entangled configurations of shifting risk awareness and risk situations (Metzner-Szigeth 2009). An instructive concept of safety, introduced by Kaufmann (1973, 1987), differentiates between three contexts: feeling secure (external guarantor), having protection (system safety), and being able to manage (internal guarantor). With this framework in mind, it can be assumed that changes within the entangled complex will inevitably lead to tensions and reconfigurations among these three components.

2.1.1. Danger, Risk, and Uncertainty

In socio-theoretical analyses, a fundamental distinction can be drawn between danger, risk, and uncertainty as interrelated but conceptually distinct categories of dealing with problematic future contingencies. Danger refers to potentially harmful conditions or processes that exist independently of their systematic anticipation or control and may be attributed to external circumstances or structural properties of natural, technical, or social environments. In contrast, risk denotes a specific mode of dealing with such dangers, in which potential harms are cognitively framed, analytically decomposed, and made calculable in relation to decisions and their possible consequences. Accordingly, risk can be understood not as a subset of danger but as a socially constructed and operationalized form of hazard management—a ‘social technology’ through which dangers are rendered assessable and actionable.

Uncertainty, in turn, designates the epistemic condition under which both danger and risk are constituted, referring to the incompleteness, indeterminacy, or contestability of knowledge concerning causal relations, probabilities, and outcomes. It is precisely under conditions of uncertainty that dangers are transformed into risks by means of anticipatory reasoning, probabilistic assessment, and institutionalized decision-making practices. Thus, the relationship between the three categories can be conceptualized as a dynamic configuration in which uncertainty provides the cognitive horizon, danger the problematic situation, and risk the socially organized mode of processing and managing potential future harm (cf. Metzner (2002), in a practice-oriented revision of analytical distinctions introduced by Luhmann (2002)).

From this perspective, the aspiration to eliminate risk entirely is neither realistic nor analytically meaningful. In practice, no enterprise, organization, or project can operate under conditions of zero risk. Every means employed to achieve organizational objectives entails its own uncertainties and potential adverse consequences. The challenge therefore lies not in abolishing risk but in recognizing, assessing, and managing it in ways that remain compatible with the intended goals and acceptable levels of safety.

2.1.2. Emerging Hazards, Threats, and Vulnerabilities

In line with a broad historical analysis of the interplay of safety and risk in industrial societies, it may be concluded that between them a new—yet not really understood—dynamic has unfolded (Evers and Nowotny 1987). This dynamic, which is widely perceived and diagnosed as insecurity, has produced the result that the desire, the need, or the desideratum of an assessment of the appropriateness of our provisions for cases of hazard and threat has become ever more urgent—as has the wish to prevent them effectively.

Conversely, it should not be overlooked that modern civil societies often view measures aimed at enhancing safety with skepticism, particularly when such measures—beyond immediate costs and practical burdens—are perceived as constraining citizens’ liberties, rights to self-determination, entrepreneurial freedoms, and the capacity of actors to pursue innovation and reshape existing conditions and institutional arrangements. Consequently, all actors who perceive their interests to be affected by plans for further safety enhancements have a shared incentive to position themselves on the right side of potentially escalating safety and/or risk conflicts while demanding that their concerns, rights, and interests receive due consideration. This dynamic is reinforced by the fact that such conflicts often involve symbolic struggles over legitimacy and responsibility as much as substantive disagreements.

At best, this dynamic fosters dialogue in which available options are carefully weighed and a shared understanding emerges regarding the need to implement sound solutions.

Such dialogue, however, is not sufficient if it merely articulates and contests pros and cons; it must also lead to decisions that are implemented and sustained.

2.1.3. Changing Conditions of Safety Provision

However, the appropriateness of precautions designed to address or prevent new, altered, or intensified hazard and threat situations cannot be assessed solely with reference to those situations themselves. Rather, the relationship between objectives and means, as well as the selection of specific measures, must be considered against the backdrop of broader technological, organizational, and societal transformations. Three developments are of particular relevance:

- New technological possibilities—especially in information and communication technologies, sensing, artificial intelligence, cyber-physical systems, and logistics—have broadened the repertoire of safety and security measures. They complement established technologies, services, and operational procedures, including access control for people and goods, situational awareness systems, predictive monitoring, and the coordination of movements within complex infrastructures. At the same time, these developments increasingly intertwine physical and digital domains, creating new opportunities for prevention and control but also new vulnerabilities and dependencies (Boyes et al. 2018; Hollnagel 2014; Lee 2015; Leveson 2011; OECD 2015).
- A changed and increasingly complex constellation of actors has emerged with regard to the cooperation required between public authorities and private enterprises. This development is partly the result of politically driven privatization, deregulation, and liberalization processes, particularly in sectors such as telecommunications, energy, and transport. It is further reinforced by the growing diversity of service providers, the expansion of the private security sector, and the increasing reliance on public–private partnerships and network-based forms of distributed governance. Consequently, the provision of safety and security has become less a matter of hierarchical state control and more one of coordination across heterogeneous organizational actors with differing interests, responsibilities, and resources (Rhodes 1997; Kooiman 2003; Abrahamsen and Williams 2011; Shearing and Johnston 2003).
- Critical infrastructures (Masera et al. 2006; Perrow 2007), which provide essential functions of supply, transport, communication, and other societal services, have become increasingly vulnerable due to the growing density of activities and the intensification of interdependencies. Their high degree of interconnectedness creates the potential for cascading failures or domino effects that may propagate across sectors and organizational boundaries. This development is closely linked to an increasingly transaction-rich and accelerated modernity, characterized by the expanding mobility of information, goods, and people under conditions of multifaceted, intertwined and contradictory processes of globalization (Beck 1992, 1999; Metzner-Szigeth 2023b).

2.2. Technical Reliability, Professional Responsibility, and Social Acceptance

Any technological artefact, method, or system embodies an implicit promise of functionality, reliability, and safety. This general promise is particularly pronounced in the case of safety technologies and related services, whose legitimacy depends on their capacity to generate and sustain trust among users, operators, and affected stakeholders.

From the perspective of professional responsibility, credibility rests not only on technical competence but also on a willingness to assume responsibility for the foreseeable consequences of action and design decisions (Metzner-Szigeth 2004). Technologies and organizational arrangements must therefore be assessed not only in terms of whether they reliably achieve their intended purposes but also with regard to their side effects, residual

risks, and broader social implications. Beyond direct safety concerns, these may include issues of privacy, autonomy, acceptability, or ethical legitimacy, as illustrated by debates surrounding technologies such as full-body scanners (Mitchener-Nissen et al. 2012).

This distinction points to the difference between acceptability and acceptance. Whereas acceptability primarily concerns the normative and analytical assessment of technological means and their associated risks, acceptance refers to the perceptions, evaluations, and voluntary consent of those affected by their implementation (Alexandre et al. 2018; Grunwald 2018). In complex socio-technical environments, trust cannot be reduced to technical performance alone; it also depends on transparency, accountability, and the perceived legitimacy of organizational practices.

Historically, the credibility of modern, that is, science-based industrial technologies, has been supported through professional training, standards of qualification, technical norms, certification procedures, and institutionalized systems of oversight (Pye 1995; Adamson 2018; Uekötter 2013). Yet these mechanisms alone are insufficient. Their effectiveness ultimately depends on the organizational contexts in which they are embedded and on the collective practices through which they are enacted. For this reason, safety management, risk management, and safety cultures should not be understood as separate instruments but as complementary mechanisms through which organizations seek to uphold the promise of functionality, reliability, and safety. In this sense, safety culture provides the social and organizational infrastructure that enables technological systems and professional practices to operate reliably under conditions of uncertainty.

2.2.1. Safety and Security in Socio-Technical Systems

In socio-technical systems, two analytically distinct but operationally coupled dimensions of risk can be distinguished, conventionally expressed in English by the terms safety and security (Brooks and Coole 2020). Safety refers to protection against unintended harm arising from technical failures, human error, or complex interactions within high-risk infrastructures. Security, by contrast, refers to protection against intentional harm, such as sabotage, manipulation, intrusion, or other forms of malicious interference. The former is primarily hazard-oriented, whereas the latter is threat-oriented; however, both dimensions are embedded in the same technological, organizational, and institutional arrangements.

This coupling is particularly relevant for critical infrastructures and safety-related organizations, where system reliability and adversarial risks increasingly converge. Safety cultures must therefore address not only technical vulnerabilities and operational errors, but also intentional threat scenarios and the communicative, coordinative, and professional practices through which such risks are perceived, assessed, and managed. In this paper, the term safety culture is consequently used in a broad sense: it refers to organizational orientations and practices through which both unintended hazards and intentional threats are recognized, communicated, and handled in socio-technical systems.

2.2.2. Learning, Memory, and the Function of Safety Cultures

Socio-technical systems depend on reliable functioning, which is secured through both direct and indirect means. Direct measures include artificial safeguards based on material and digital technologies, as well as collaborative services grounded in human performance. Indirect measures, by contrast, involve establishing and maintaining organizational routines and treating reliability as a central responsibility of management and leadership.

Because socio-technical systems are exposed to both unintended hazards and intentional threats, ensuring their safe and secure operation cannot rely exclusively on technological safeguards. The management of dangerous materials, high energies, radiation,

and other sources of risk, as well as protection against sabotage, manipulation, and terrorism, requires organizational capabilities that extend beyond technical control. For this reason, engineering and operational practice frequently emphasize the need to establish and strengthen effective safety cultures.

Drawing on Geertz's (1973) concept of culture, Florian (1993) offers a useful working definition of safety culture as a system of meanings and symbols specifically related to safety. From this perspective, collective ways of dealing with safety are expressed in symbolic, cognitive, and practical forms. These forms help organizations create, share, and maintain understandings of what safety means and how it should be practiced.

In such cultures, well-known risks are not left to individual memory alone. They are preserved, for example, in standards used by construction and development engineers, even over long periods without hazardous events, such as decades without a bridge collapse. These risks can be recalled at any time and updated when rare events make this necessary (Hughes 2005; Leveson 2011). To perform this function, safety cultures must be continuously maintained: experiences, problems, and reflections—as part of a reservoir of explicit and implicit knowledge—need to be communicated, actively used, shared with others, and passed on.

In this sense, maintaining safety cultures depends less on simply putting technological safeguards in place and more on continuous learning, professional judgment, leadership, and reflection. In high-risk socio-technical systems, safety should not be seen as a fixed state, but as something that has to be actively achieved again and again (Le Coze 2023). It is supported by regulation, safeguards, and formal procedures, but it also depends on the everyday involvement of organizational actors who observe, coordinate, interpret, and intervene when needed. Recent work in engineering education and safety research also shows that safety and sustainability cultures can be developed through structured learning formats, such as case-based and incident-based approaches, which help address shared values, assumptions, and management decisions in complex socio-technical systems (Jamieson et al. 2021).

One crucial problem, or rather a permanent problem, which in such contexts must always be solved in the best possible way, is connected to the time factor, and that is backward on the one hand, in terms of memory, but forward on the other, in terms of foresight. Thus, vice versa, the maintenance of safety cultures also means not only learning by accumulating experience or even by trial-and-error but also by applying prospective methods (such as technology assessment or foresight scenarios). Consequently, safety cultures in the 'here and now' must be simultaneously informed by past experience and preventively oriented toward the future if they are to remain adequate to present circumstances, particularly in light of hazards and threats that may evolve, shift, or intensify.

Apart from its primary function of effectively addressing contingent hazards and threats, any safety culture has indeed also the function of creating trust among staff members who are supposed to work while being relieved from fear, among customers who are supposed to consume while being relieved from fear, and among politicians who are supposed to provide for the necessary licenses while being relieved from fear. Thus, the aspect of relief—primarily for all citizens who want to live in some carefree and lighthearted daily routine—is one of its constitutive functions.

2.3. Bridging Engineering, Management, and Social-Scientific Approaches to Safety

This section examines the contribution of social-scientific and humanities-based perspectives to the analysis and governance of safety in complex socio-technical systems. It first highlights their strategic value in linking technical, communicative, and organizational layers, particularly by focusing on actors' capacities to interpret, coordinate, and implement

safety-related measures in practice. It then addresses the persistent fragmentation of safety research and argues for a more integrated approach capable of overcoming the divide between engineering, management, and socio-cultural understandings of safety.

2.3.1. Strategic Resources: Combining Technical, Communicative, and Organizational Layers

If there is anything which in this context might be considered a particular contribution by the social sciences and humanities, which other disciplines could not provide in this quality, certainly two points must be mentioned (for a more detailed discussion of the following two matters, see [Metzner-Szigeth \(2026\)](#)). The first is related to the area of *governance* and concerns their capability to relate changing points of view to each other in such a way as to provide all those involved with a better general view and perspective. This makes it easier to meaningfully extrapolate different—possibly even conflicting or competing—problems and solutions. Consequently, the discourses on the perfection of the organization of the addressed provisions—for coping with or preventing hazards and threats—are supported in the sense of a way of proceeding which is as constructive as possible. The second is related to the area of *management* and concerns their capability of adjusting all technological and organizational strategies to the human actor, who, after all, is the crucial entity when it comes to the success or failure of the provisions. This concerns the actors' skills in implementing these strategies, their possible resistance to every measure resulting from these strategies, which, in their opinion, are unjustified, or, vice versa, their readiness to actively contribute to acceptable solutions or to at least passively tolerate them.

A review of major scientific funding programs in Europe ([European Commission 2021](#)), Canada ([CSSP 2023](#)), and Germany ([Federal Ministry of Education and Research \(BMBF\) \(2024\)](#); [Hoffknecht et al. 2010](#)) is instructive in this regard. While these initiatives increasingly acknowledge the societal dimensions of safety and security, their primary orientation remains strongly focused on technological innovation, engineering solutions, and, to a lesser extent, managerial frameworks. This reveals not only the continuing marginalization of social-scientific perspectives but also a broader lack of integration between social-scientific knowledge and dominant engineering- and management-oriented approaches. As a result, the human, organizational, communicative, and cultural dimensions of safety frequently appear as secondary considerations rather than as constitutive elements of socio-technical systems.

Against this background, there is a need for interdisciplinary research that systematically investigates the relationships between problems, solutions, and their organizational and societal contexts. Such research should combine qualitative and quantitative methods while placing particular emphasis on discourse-analytical, action-oriented, and empirical approaches. Its primary focus should be the capabilities of actors to assess situations, establish mutual understanding, coordinate action, and manage hazards and threats within complex socio-technical environments. Ultimately, the effectiveness of safety measures, organizational strategies, and technological solutions depends not only on their technical sophistication but also on the capacities of those who interpret, implement, and continuously adapt them in practice.

2.3.2. Fragmented Perspectives and the Challenge of Integration

Despite the growing recognition of organizational and cultural dimensions, contemporary safety research remains deeply fragmented across disciplinary and epistemological boundaries. A persistent and consequential divide in safety research reflects not merely disciplinary specialization but fundamentally incompatible epistemological assumptions about the nature of risk, control, and organizational action—and this divide is reproduced in both applied research and consulting practice. Engineering-oriented approaches continue

to privilege models of system reliability, hazard control, and risk minimization through design, thereby presuming that uncertainty can be progressively reduced through formalization and technical intervention (Hollnagel et al. 2006; Leveson 2011; Rasmussen 1997). In contrast, management-oriented approaches reframe safety as a matter of governance, safety culture, and performance optimization, yet remain largely anchored in instrumental and normative logics that assume safety can be effectively achieved through systems of control and compliance (Reason 1997; Guldennund 2000; Hale and Hovden 1998; Hopkins 2006). Despite their apparent complementarity, these paradigms rarely achieve genuine integration; instead, they reproduce a fragmented understanding of safety that oscillates between technical determinism and managerial functionalism (Le Coze 2019; Bieder 2021).

This fragmentation is not merely theoretical but empirically observable in the uneven translation of social-scientific knowledge into practice. Studies of safety culture interventions—a central domain of sociologically informed safety research—reveal a persistent gap between scientific knowledge and practical application, including a limited body of robust, evidence-based intervention studies and weak feedback loops between research and implementation. Empirical and review-based work further shows that safety culture research remains conceptually disjointed and insufficiently interdisciplinary, often relying on simplified measurement approaches that prioritize survey-based operationalization over deeper socio-organizational analysis (Van Nunen et al. 2018; Li et al. 2022). Case-based research in organizational settings shows that safety culture initiatives are frequently reduced to symbolic or rhetorical measures, with organizations struggling to translate cultural insights into sustained changes in practice (Muselela et al. 2025).

Taken together, these findings point to a structural asymmetry in the institutionalization of safety knowledge. Engineering and management approaches are stabilized through standardized methods, regulatory frameworks, and measurable outputs, making them readily deployable in consulting contexts, whereas social-scientific approaches remain more diffuse, contested, and difficult to operationalize (Le Coze 2019; Hollnagel 2014). As a result, social-science perspectives are typically incorporated only in an instrumentalized form—such as safety culture surveys or behavioral programs—rather than as fully developed analytical frameworks. From this perspective, the problem is not simply a lack of integration but a deeper misalignment between dominant models of safety and the realities of its enactment in complex socio-technical systems. Overcoming this divide therefore requires a paradigmatic shift toward reflexive, socio-technical understandings of safety governance, recognizing safety as an emergent accomplishment shaped by meaning-making, power relations, and situated organizational practices (Perrow 1984; Vaughan 1996; Weick and Sutcliffe 2007).

3. Understanding Safety Cultures: Conceptual Approaches, Practices, and Performance

The preceding discussion has shown that contemporary organizations operate under conditions characterized by increasing complexity, interdependence, and uncertainty. Emerging technological possibilities, changing governance arrangements, and the growing vulnerability of critical infrastructures have transformed both the nature of safety matters and the requirements for managing them. At the same time, safety-related knowledge remains fragmented across engineering, management, and social-scientific perspectives, each emphasizing different dimensions of risk, control, and performance.

These developments explain why safety culture has become a prominent topic in both research and practice. Yet they do not by themselves clarify what safety culture actually is, how it operates, or why it contributes to reliable performance. To address these questions, the following chapter shifts from contextual conditions to theoretical foundations. It exam-

ines safety culture as a specific dimension of organizational life, explores its relationship to professional practice, and discusses how communication, learning, and mindfulness contribute to organizational reliability under conditions of uncertainty.

3.1. Chernobyl and Safety Culture: Complementing Technical and Managerial Dimensions

As the safety culture of an organization may be understood as one element of its overall organizational culture, it follows that its definition may simply be oriented towards encompassing all safety-relevant aspects that are critical to the operation of a certain facility. In analyzing the causes of the Chernobyl disaster, the International Nuclear Safety Advisory Group (INSAG) introduced the concept of ‘safety culture’ to explain how such an event could occur precisely because—strictly from a technological standpoint—it was not inevitable (Künzler 2002). Consequently, the board defined safety culture as follows: “That assembly of characteristics and attitudes in organizations and individuals which establishes that, as an overriding priority, nuclear plant safety issues receive the attention warranted by their significance” (INSAG 1991). In the further course of their work, INSAG drafted a detailed model of positively judged indicators for a safety culture, presented in Table 1.

Table 1. Characteristics of safety culture, based on INSAG (1991), as cited in Grote and Künzler (1996, p. 19).

Strategy level	• Safety mission statement • Organizational structure • Resources • Self-regulation of reviews
Management level	• Definition of responsibility • Definition and control of safety measures • Qualification and training • Monitoring and inspection
Individual level	• Questioning attitude • Thorough and cautious approach • Communication

A definition that builds on this, formulated by the Advisory Committee on the Safety of Nuclear Installations (ACSNI), not only moves beyond the nuclear context toward a more broadly applicable conceptualization, but is also notably more interaction-oriented: “The safety culture of an organization is the product of individual and group values, attitudes, perceptions, competencies and patterns of behavior that determine the commitment to, and the style and proficiency of, an organization’s health and safety management” (ACSNI 1993).

Against this background, safety culture can be understood in a way that parallels the well-known distinction between ‘hard’ and ‘soft’ skills. Technical, logistical, administrative, and managerial forms of expertise are necessary for running complex projects, systems, and organizations safely, but they are not sufficient on their own. Just as complex projects cannot succeed through technical competence alone without social, psychological, and communicative capacities, safety cannot be secured merely by technological measures, formal procedures, further qualification, or organizational improvements. These dimensions provide necessary foundations, but they require a complementary cultural condition that enables them to work as intended.

Safety culture therefore refers to the organized and purposeful cooperation of all those involved, regardless of their specific responsibilities. This includes strategic actors such

as corporate governance bodies and supervisory institutions, managerial actors responsible for economic and operational decisions, and operational staff such as control-room personnel, shift supervisors, and operators. The point is not that each group acts and decides independently according to its own preferences, but that all groups cooperate in a coordinated manner toward the shared goal of effective and safe performance.

In this sense, safety culture addresses the 'human factor' not negatively, as an external disturbance to otherwise smoothly functioning technical and organizational routines, but positively, as the very condition that determines whether these routines can function reliably in practice. When this factor is neglected, it may become precisely the source of disruption. Where it is systematically integrated, however, safety culture fulfills the complementary conditions that allow complex projects, installations, and operations to perform effectively while simultaneously operating safely.

3.2. From Normal Accidents, over the Swiss-Cheese Model, Towards Collective Mindfulness and the Practice-Nexus

A seminal contribution to the discussion of the relationship between technical, organizational and human factors was provided by Charles Perrow's theory of 'normal accidents' (Perrow 1984). In his analysis of tightly coupled and highly complex technological systems, he argued that systemic accidents cannot be fully eliminated because complexity itself generates unforeseeable interactions, cascading effects, and unintended system dynamics. Under such conditions, accidents are not exceptional deviations from otherwise controllable operations, but structurally embedded possibilities inherent to the organization of modern socio-technical systems. Particularly in infrastructures characterized by high interdependence, accelerated flows, and dense technological coupling, safety can therefore never be understood as complete control over all contingencies.

James Reason's systemic approach to human error and organizational accidents complements and further develops this perspective by shifting attention from isolated operator mistakes toward latent organizational conditions (Reason 1990, 1997). According to his famous 'Swiss-cheese model', safety systems consist of multiple defensive layers whose barriers always contain weaknesses or 'holes' resulting from organizational pressures, communication deficits, inadequate training, maladjusted managerial decisions, technological limitations, or routine operational compromises. Accidents occur when such latent vulnerabilities align across several layers of defense, thereby allowing hazards to penetrate the system.

Against the background of both perspectives, human error appears not as an exclusively individual failure, but as the visible manifestation of deeper systemic and organizational conditions. Consequently, safety culture becomes decisive because it shapes how organizations perceive anomalies, communicate uncertainties, react to near misses, distribute responsibility, and maintain attentiveness toward latent failures before they escalate into critical events. This perspective has been elaborated by research on human error and just culture, emphasizing that accidents often emerge from organizational conditions rather than isolated individual failures (Reason 1997; Dekker 2014).

Reliability, continuing along this line, is not understood as the elimination of risk, but as the organizational capability to continuously detect, interpret, and respond to emerging problems before they develop into failures, accidents, or disasters. High reliability organizations (HROs) cultivate what Weick and his collaborators describe as 'collective mindfulness' (Weick and Sutcliffe 2007; Weick et al. 1999; Rochlin 1993): a heightened form of organizational attentiveness characterized by sensitivity to operations, reluctance to simplify interpretations, preoccupation with failure, commitment to resilience, and deference to expertise. Safety thus depends less on rigid control structures alone than on distributed processes of communication, practical judgment, learning, flexibility, and adap-

tive coordination among professionally acting individuals and groups. Empirical studies of aircraft carrier operations, air traffic control systems, and nuclear power plants have repeatedly demonstrated how high reliability organizations maintain reliable performance despite operating under conditions of complexity, uncertainty, and potentially catastrophic consequences. These studies highlight recurrent mechanisms such as distributed expertise, intensive communication, continuous monitoring, and organizational mindfulness, all of which contribute to the early detection and management of emerging problems (Weick and Sutcliffe 2007; Roberts 1990; LaPorte and Consolini 1991).

This perspective may be further deepened through Theodore Schatzki's theory of practice, which allows organizational culture to be conceptualized beyond both constructivist reductionism and essentialist historicism (Schatzki 2002, 2010). From this viewpoint, organizational culture cannot be understood merely as a symbolic construction reproduced through acts of self-description and communication, nor as a fixed historical essence unfolding through time. Rather, culture emerges as a nexus of socially shared practices materially enacted within concrete arrangements of humans, technologies, infrastructures, artefacts, bodies, spaces, energies, and institutional settings. Practices are organized through practical understandings, rules, teleoaffective structures, and generalized orientations, while simultaneously depending on material arrangements that enable, stabilize, and constrain action. Consequently, safety culture should not be reduced to managerial philosophies, mission statements, explicit norms, or organizational narratives alone. It must instead be analyzed as a dynamic matrix of situated activities through which purposes, acceptable means, perceptions of danger, forms of coordination, and modes of professional conduct are continuously reproduced and transformed within socio-technical environments.

Taken together, these approaches form a complementary theoretical progression. Perrow highlights the structural inevitability of systemic risk in complex socio-technical systems; Reason explains how latent organizational deficiencies condition the emergence of accidents; the HRO perspective demonstrates how reliability may nevertheless be actively cultivated through collective mindfulness and adaptive coordination; and Schatzki finally grounds these processes in the materially mediated nexus of organizational practices through which safety culture is continuously enacted in everyday professional activity.

3.3. Professional Practice as a Mediating Mechanism Between Safety Culture and Organizational Reliability

A conclusive central proposition of this paper is that the relationship between safety culture and organizational reliability is neither direct nor automatic. Safety cultures do not produce reliable performance simply by virtue of existing as sets of values, norms, assumptions, or managerial commitments. Rather, their influence is mediated through professional practice, that is, through the situated actions, judgments, interpretations, and interactions of organizational actors operating within specific socio-technical contexts. Safety culture provides the symbolic framework through which hazards, responsibilities, acceptable conduct, and organizational priorities are defined, communicated, and reproduced. Professional practice, in turn, constitutes the arena in which these orientations are translated into concrete forms of observation, communication, coordination, decision-making, and intervention. Organizational reliability therefore emerges not from culture alone but from the continuous enactment of culturally informed professional practices.

This perspective helps explain why organizations possessing similar formal safety policies, management systems, or regulatory frameworks may nevertheless exhibit markedly different levels of reliability. What ultimately matters is whether safety-related assumptions and commitments become embedded in everyday professional conduct and are reproduced through recurring practices of learning, reporting, collective reflection, and adaptive coordination.

The mediating role of professional practice is particularly evident in research on HROs. Studies of aircraft carriers, air traffic control systems, and nuclear facilities have demonstrated that reliable performance depends less on the existence of safety rules alone than on the capacity of professionals to enact collective mindfulness through continuous monitoring, intensive communication, deference to expertise, and adaptive problem solving (Weick and Sutcliffe 2007; Weick et al. 1999; Roberts 1990; LaPorte and Consolini 1991). Similarly, research on organizational accidents has shown that failures often arise when organizational routines normalize deviance, suppress critical communication, or weaken professional responsibility (Reason 1997; Vaughan 1996). Reliability thus appears neither as a purely technical achievement nor as a direct consequence of organizational values, but as an ongoing practical accomplishment emerging from the interaction of culture, expertise, and situated action.

From this perspective, professional practice functions as the crucial linking mechanism between safety culture and organizational reliability. Safety culture shapes how organizational actors perceive and evaluate situations, professional practice translates these orientations into concrete patterns of action, and organizational reliability emerges from the cumulative effects of these practices over time. The analytical relationship developed in this paper may therefore be summarized as a process in which safety culture shapes professional practice, while professional practice generates and sustains organizational reliability under conditions of uncertainty. This conceptual sequence provides a useful framework for both empirical investigation and advisory activities, as it directs attention toward the practical processes through which reliability is continuously produced, maintained, and renewed within complex socio-technical systems.

3.4. From Implementation to Cultivation: Quality Assurance, Assessment, and Adequacy

The preceding discussion has argued that safety culture is not an organizational attribute that exists independently of everyday activity. Rather, it is continuously reproduced through communication, learning, coordination, and professional practice. This understanding has important implications for the question of organizational change. If safety culture emerges through socially shared practices and interpretations, it cannot be directly implemented in the same manner as a technological device, a formal procedure, or a management system. Consequently, efforts to improve safety culture must be understood less as acts of implementation than as processes of cultivation.

The distinction is not merely semantic. The further implementation or new establishment of an efficient safety culture—frequently demanded in statements coming from the sides of engineering and/or management (Bach et al. 2010; Hughes 2005)—suggests a linear model of organizational change in which desired structures, rules, or programs are introduced through formal decisions and subsequently applied by organizational members. Such ‘top-down’ campaigns may undoubtedly influence safety-related behavior and contribute to organizational development. However, from a cultural perspective, they represent only indirect mechanisms of influence. The existence of safety procedures, reporting systems, qualification programs, or regulatory requirements does not by itself guarantee that organizational actors will interpret, accept, and enact them in the intended manner.

Cultivation, by contrast, emphasizes the gradual, interactive, and cumulative character of cultural development. Safety cultures evolve through ongoing processes of professional socialization, organizational learning, practical experience, and shared reflection. They are shaped by the ways organizational members interpret hazards, communicate uncertainties, negotiate responsibilities, and evaluate acceptable courses of action. Cultural change therefore requires more than compliance with formal rules. It involves modifications of

practical understandings, routines, expectations, and patterns of interaction that have often become deeply embedded in everyday organizational life.

This perspective is consistent with broader theories of organizational culture. Schein (2010) distinguishes between visible artefacts, espoused values, and underlying assumptions, arguing that lasting organizational change requires engagement with the deeper layers through which organizational members interpret reality and orient their conduct. Similarly, Hofstede's conception of culture as a form of collective mental programming (Hofstede et al. 2010) highlights the relative stability of culturally embedded orientations while simultaneously acknowledging their capacity for gradual transformation. From both perspectives, cultural change cannot be reduced to the introduction of new policies or structures. Rather, it depends on processes through which new understandings become integrated into everyday practice.

For this reason, the development of safety cultures should be conceived as a long-term process of organizational learning. Learning occurs not only through the accumulation of operational experience but also through systematic reflection on incidents, near misses, unexpected events, and emerging challenges. Equally important are prospective forms of learning that anticipate future developments through technology assessment, scenario-building, foresight activities, and resilience-oriented exercises. Safety cultures therefore depend simultaneously on memory and anticipation: they preserve knowledge derived from past experience while remaining sensitive to emerging hazards, changing conditions, and novel forms of uncertainty.

The cultivation perspective also helps explain why attempts to improve safety culture frequently produce uneven results. Organizations often introduce reporting systems, training programs, communication campaigns, or safety-management initiatives with the expectation that cultural change will automatically follow. Yet such interventions become effective only insofar as they are appropriated and enacted by organizational members in their everyday activities. Sustainable cultural development therefore requires 'bottom-up' processes that make use of opportunities for participation, dialogue, reflection, and collective sense-making. Organizational members must not merely comply with safety-related expectations; they must actively contribute to the ongoing construction and maintenance of safety-oriented ways of thinking and acting.

From this perspective, the role of leadership is reconfigured in significant ways, privileging transformational forms of guidance over the exchange-oriented mechanisms characteristic of transactional leadership (Jensen et al. 2019). Rather than acting primarily as designers and controllers of organizational behavior, leaders become facilitators of learning processes and guardians of organizational conditions that enable open communication, mutual trust, professional responsibility, and constructive engagement with uncertainty. Their task is less to impose a particular culture than to create environments in which desirable cultural orientations can emerge, stabilize, and evolve, thereby encouraging employees to contribute safety-relevant information regardless of their hierarchical status (Nembhard and Edmondson 2006).

Accordingly, safety culture should be understood neither as a static organizational property nor as a managerial instrument that can be introduced at will. It is more appropriately conceived as an evolving collective accomplishment that develops through the interaction of organizational structures, professional practices, and shared interpretations. The challenge of organizational development therefore lies not in implementing a pre-defined culture but in cultivating conditions that support continuous learning, reflective practice, and the sustained pursuit of reliable performance under conditions of uncertainty.

3.5. Combining Pattern Recognition and Performance Assessment

The call for a conceptual definition of safety culture that can be measured and empirically investigated—rather than remain at an idealized or purely programmatic level—reflects an implicit need for evaluation that should be made explicit. What differentiates good, better, and exemplary safety cultures? Conversely, what characterizes poor, deficient, or severely flawed ones? Even for those who regard such categorical distinctions as overly rigid or absolute—and I include myself among them—it remains necessary to consider the defining features of well-functioning safety cultures in contrast to those that are mal-functioning. While a comprehensive treatment of this issue lies beyond the scope of the present discussion (Glendon and Stanton 2000; Guldenmund 2000; Hale 2000), one fundamental point can nevertheless be highlighted: any meaningful assessment of the quality of a safety culture requires evaluative criteria and a scale of judgment that incorporates both a directional orientation and gradations of performance.

A prominent example of an approach to assessing the quality of safety cultures—one that incorporates both the directional dimension and the graduated scale discussed above—is Westrum’s typology of organizational cultures (Westrum 1988, 2004), summarized in Table 2. Using the handling of potentially safety-relevant information as the central criterion, he distinguishes between three types of organizational culture: pathological, bureaucratic, and generative. Each type is characterized by a distinct constellation of attitudes, practices, and modes of interaction. Presented in a synoptic overview, these features point toward particular ways of responding to the key question of how safety-relevant information is treated and can therefore be interpreted as indicators of the prevailing safety culture within an organization.

Table 2. Typology of organizational cultures according to Westrum (1988, 2004).

Pathological	Bureaucratic	Generative
Power oriented	Rule oriented	Performance oriented
Low cooperation	Modest cooperation	High cooperation
Messengers shot	Messengers neglected	Messengers trained
Responsibilities shirked	Narrow responsibilities	Risks are shared
Bridging discouraged	Bridging tolerated	Bridging encouraged
Failure → scapegoating	Failure → justice	Failure → inquiry
Novelty crushed	Novelty → problems	Novelty implemented

The significance of this distinction is reinforced by empirical research on reporting systems and incident investigations. Studies across healthcare, aviation, and other high-risk industries have shown that organizational climates characterized by blame and punishment tend to suppress the reporting of errors and near misses (Tucker and Edmondson 2003). In contrast, learning-oriented and just cultures encourage reporting, collective reflection, and the implementation of corrective measures, as has been shown by research on psychological safety demonstrating that individuals are more willing to report errors, uncertainties, and near misses when they perceive their work environment as supportive and non-punitive (Edmondson 1999). These findings suggest that Westrum’s distinction between pathological, bureaucratic, and generative cultures reflects not merely a set of normative ideals but empirically observable differences in the ways organizations process, communicate, and learn from safety-relevant information (Reason 1997; Dekker 2012; Khatri et al. 2009).

A comparison of the approach outlined above—which focuses on organizational responses to safety-relevant incidents—with an alternative approach centered on the determinants of human error (Lucas 1991), summarized in Table 3, supports the conclusion that any systemic approach to Health, Safety and Environmental (HSE) management must

go beyond traditional workplace-focused approaches. Its distinctive contribution lies in integrating the organization as a whole, including its underlying culture, into both the concept and practice of safety.

Table 3. Comparative overview of safety culture, human error model, and response to near misses, compiled by [van der Schaaf \(1992\)](#), according to [Künzler \(2002, p. 96\)](#); the predominant model of human error refers to [Lucas \(1991\)](#), and the response to incidents to [Westrum \(1988\)](#).

Organisational Safety Culture		Predominant Model of Human Error	Response to Incidents	
Occupational safety management	→	Traditional safety model	←	Pathological
Risk management	→	Man-machine mismatch	←	Calculative
Systemic safety management	→	System-induced error concept	←	Generative

A point requiring further clarification is whether the performance of safety cultures can be evaluated according to a single general criterion applicable across organizations and contexts. Such a criterion would allow distinctions to be drawn between safety cultures that impose higher or lower demands on organizational practice. Alternatively, different criteria may be needed depending on the specific tasks, risks, and operational contexts involved. In that case, the question would not simply be whether one safety culture is ‘generally better’ than another, but whether a given safety culture is ‘more appropriate’ for a particular type of work or organizational setting ([Metzner-Szigeth 2025](#)).

3.5.1. Situated Performance, Embedded Relations, and the Criterion of Adequacy

From a practice-theoretically inspired perspective, it is difficult to assume that a fully objective scale exists by which one could straightforwardly determine whether a given corporate safety culture makes operations safer or less safe. This is because, within such an approach, the very meaning of ‘safe’ and ‘unsafe’ is not treated as self-evident or externally fixed. Rather, it is understood as the outcome of prior cultural processes through which certain standards, expectations, and practices come to be defined as appropriate, necessary, or normal. In this sense, safety standards are not merely objective benchmarks that exist independently of organizational culture. They are produced intersubjectively, through shared interpretations, institutional routines, professional norms, and cultural dynamics. Over time, these constructed standards may appear natural or unquestionable, although they are in fact the result of collective meaning-making. Consequently, the safety standard that a particular safety culture is meant to realize cannot be understood as entirely separate from that culture itself. The ‘purpose’ of safety and the cultural ‘means’ through which it is pursued are mutually connected.

Since the appropriateness of a tool cannot reasonably be judged in itself, but only in relation to what it is meant to serve, any assessment must be made with reference to a specific facility or project and to the particular profile of hazards and threats relevant to it ([Rosness et al. 2010](#)). The crucial issue, then, is the fit between a given safety culture and the facility or project it is intended to organize, operate, and sustain.

For the safety culture of a nuclear complex, a petrochemical refinery, or an automobile plant, other things are more crucial than for a post office, a university, or a kindergarten ([Perrow 1984](#)), although none of these institutions could do without safety culture. Related to and measured by what they have to do respectively, and related to and measured by the conditions under which they do so, all these particular safety cultures are elementary or important to the same degree. This is true in the sense of all institutions having to meet their specific requirements, no matter if it is about shepherding children until they are taken back home by their parents or about the operative control of a chain of chemical change processes in the course of producing PVC.

This is precisely where the broader cultural environment becomes relevant. A focal organizational safety culture is always embedded in wider rationalities, professional expectations, institutional contexts, and legal standards that shape what is considered safe, reasonable, or legitimate. This applies not only to the surrounding organizational and societal culture, but also—perhaps even more importantly—to internationally operating networks of knowledge and communities of practice, which play a significant role in defining, circulating, and stabilizing safety standards across organizational, corporate and/or national boundaries (Wenger et al. 2002; Wenger 1998).

3.5.2. Consolidating a Practice-Theoretical Perspective

The concept of safety culture has been characterized by considerable conceptual diversity and theoretical ambiguity. Since its introduction in the aftermath of the Chernobyl accident, safety culture has been interpreted in different and sometimes competing ways. INSAG defined safety culture as the “assembly of characteristics and attitudes” through which nuclear safety receives appropriate priority (INSAG 1991), while the ACSNI definition emphasized values, attitudes, perceptions, competencies, and behavioral patterns shaping health and safety management (ACSNI 1993). Subsequent reviews have shown that safety culture research has remained divided between normative-managerial, psychological, and socio-anthropological approaches (Glendon and Stanton 2000; Guldenmund 2000; Hale 2000). Guldenmund (2000), for example, highlights the difficulty of distinguishing between safety culture and safety climate, while Hale (2000) explicitly warns against conceptual confusion in the use of ‘culture’ within safety research.

The present contribution adopts a practice-theoretical position that seeks to integrate these perspectives while avoiding their respective reductionisms. Safety culture is understood primarily as an emergent social phenomenon that arises through the ongoing interactions of organizational actors within specific socio-technical and institutional contexts. It is therefore not treated as a static property of an organization, nor as a simple management instrument that can be introduced through formal decisions. Rather, it is conceived as a dynamic configuration of shared interpretations, practical understandings, communicative patterns, routines, values, and forms of professional conduct through which organizational members collectively define what counts as safe, risky, acceptable, problematic, or in need of intervention (Metzner-Szigeth 2023a).

Consequently, safety culture should not be reduced either to explicit norms and values or to observable behavior alone. Rather, it emerges through the continuous interplay of symbolic, cognitive, material, and practical dimensions. Organizational actors draw upon established understandings, professional knowledge, rules, technologies, infrastructures, and institutional expectations while simultaneously reproducing and transforming them through their activities. Safety culture is therefore both structured and structuring: it shapes organizational action while at the same time being reproduced through that action. This understanding is compatible with Vaughan’s analysis of the Challenger disaster (Vaughan 1996), which shows how organizational routines and normalized interpretations of deviance may gradually reshape what actors perceive as acceptable risk.

As a paradigm, this perspective has important implications for the question of whether safety culture can be managed. From a strictly instrumental perspective, safety culture appears as an object that can be engineered through management systems, leadership initiatives, training programs, indicators, and communication campaigns. Such interventions undoubtedly influence organizational conditions and may contribute to cultural change. However, from a practice-theoretical perspective, these interventions should not be confused with culture itself. Management can establish favorable conditions, provide incen-

tives, create learning opportunities, and influence routines, but it cannot directly produce a safety culture in the same way as it can implement a technical device or a formal procedure.

For this reason, the present paper distinguishes between the implementation of safety-related programs and the cultivation of safety cultures. While procedures, reporting systems, qualification schemes, or safety management frameworks may be introduced through formal organizational decisions, the corresponding cultural orientations emerge only insofar as they become integrated into everyday organizational practices and are accepted, interpreted, and enacted by organizational members. Safety cultures therefore develop through processes of collective learning, organizational memory formation, professional socialization, and practical experience. Wenger's theory of 'communities of practice' (Wenger et al. 2002; Wenger 1998) is instructive in this respect, because it conceptualizes learning as participation in collaborative networks and shared experiential spaces rather than as the mere transfer of formal knowledge.

This understanding further clarifies the distinction between the singular and plural use of the concept. In the singular, 'safety culture' refers to the general analytical concept describing the cultural dimensions of safety-related organizational practice. In the plural, 'safety cultures' refers to empirically observable and context-specific manifestations of this phenomenon. Different organizations, professions, sectors, and national contexts may therefore exhibit different safety cultures while nevertheless sharing certain underlying dimensions such as communication, learning, trust, responsibility, coordination, and collective mindfulness.

Accordingly, safety culture is not treated here as an isolated cultural domain detached from broader social and organizational processes. Rather, it is understood as a specific dimension of organizational culture that is shaped by and interacts with professional cultures, organizational structures, institutional arrangements, regulatory regimes, technological infrastructures, and wider societal contexts. National cultures, professional communities, organizational histories, and sectoral risk profiles all contribute to the conditions under which particular safety cultures emerge and evolve. Safety cultures are therefore best understood as situated configurations located at the intersection of multiple cultural, organizational, and socio-technical influences. From this perspective, the central challenge of safety research is neither to discover universal cultural recipes nor merely to catalogue organizational values. Instead, it is to understand how reliable performance is continuously produced under conditions of uncertainty through situated forms of communication, coordination, learning, and professional judgment. Safety culture can thus be freed from static understandings that treat it as a set of fixed organizational attributes and instead be conceived dynamically as an ongoing practical accomplishment: a collective achievement that remains continually open to reinforcement, erosion, adaptation, and transformation.

4. Approaching a Suitable Research Design: Outlining Basic Components

The challenge of studying safety cultures lies in connecting abstract theoretical concepts with empirically observable organizational practices. The previous chapters have argued that safety cultures emerge through situated processes of interpretation, communication, learning, and collective action rather than through formal structures alone. Consequently, a suitable research design must be capable of capturing both the symbolic and practical dimensions of safety-related organizational life. The following sections outline the conceptual assumptions, comparative strategies, analytical dimensions, and diagnostic approaches that can support corresponding investigations.

4.1. Comparatively Exploring Promising Fields and Opportunities

If the perspectives developed in this paper are to support applied research and advisory activities, it is necessary to identify contexts in which safety cultures become particularly relevant and visible. The purpose of comparison in this regard is not primarily to generate universally generalizable findings in the sense of a conventional project of academic research. Rather, comparison serves as a heuristic device for uncovering similarities, differences, challenges, and learning opportunities across diverse organizational and socio-technical settings.

From the perspective adopted here, safety cultures can be examined in a variety of contexts characterized by differing hazard profiles, organizational structures, professional traditions, and governance arrangements. Comparing such contexts makes it possible to identify both context-specific requirements and recurring patterns of communication, coordination, learning, and responsibility that influence reliable performance. Several comparative perspectives appear particularly promising for applied research and advisory activities:

- National and cultural contexts. Different countries and cultural environments may exhibit distinct understandings of safety, responsibility, authority, and risk (Flynn et al. 2018). Comparing such contexts can help identify cultural assumptions that shape organizational practices and influence the transferability of safety-related concepts and interventions.
- Sectoral and professional contexts. Different sectors—including information and communication technologies, critical infrastructures, energy systems, transportation, healthcare, safety technologies, and security services—face different constellations of hazards and threats (Adamson 2018). Comparative analysis can reveal how safety cultures are shaped by sector-specific operational requirements, regulatory environments, and professional traditions.
- Organizational contexts. Public institutions, private enterprises, public–private partnerships, and networked forms of governance frequently differ in their decision-making structures, accountability mechanisms, leadership practices, and reporting cultures. Exploring such differences can support organizational diagnosis and the development of context-sensitive improvement strategies.
- Operational and situational contexts. Safety cultures become particularly visible in situations requiring coordination under uncertainty, such as access control, crisis management, emergency response, the protection of critical infrastructures, or the operation of complex technological systems. Comparative reflection across such settings may reveal how organizational actors perceive, communicate, and manage hazards and threats in practice.

The selection among these perspectives should ultimately depend on the practical objectives of a given project or advisory activity. Rather than prescribing a fixed research design, the framework proposed here is intended to support the identification of relevant contexts, stakeholders, and problem constellations in which safety-cultural analysis may contribute to organizational learning, reliability, and improvement.

4.2. Analytical Dimensions and Indicators of Safety Culture

Comparative perspectives can, in principle, be combined. For the sake of a research design that remains parsimonious, transparent, and feasible, however, a clear selection is required. Building on the framework developed thus far, the focus should be on identifying and examining the fields and issues outlined below in relation to their respective objectives. Equally important in this regard are both the design and the implementation of safety

provisions, each of which calls for critical analysis as well as constructive contributions. This involves three key aspects:

- The field of communicative action in connection with the problem of effective communication and the coordination of behavior in heterogeneous contexts of cooperating organizations and/or professions, in particular in relation to the production and implementation of technology, insofar as this covers different actors, that is, constructors, operators, users, et cetera.
- The connections between estimating safety situations and the choice of appropriate counter-measures while considering their conditionality by the preceding technology-mediated communication of information on the one hand and the subsequent implications of the use of modern technologies for the implementation of alternative actions on the other (information flow, assessment of the situation, way of proceeding).
- Finding, identifying, or developing indicators for the quality of professional behavior, for the degree of safety awareness of those involved (which includes the extent of acceptance by those concerned) as well as for the maturity of safety cultures.

This raises the question of what the proposed framework is intended to assess. The framework is intended to assess safety culture as it is enacted in situated organizational and operational settings. Its primary object is therefore not the organization as a formal entity alone, nor professional groups or operational contexts in isolation. Rather, it focuses on the configuration of organizational structures, professional practices, and operational situations through which safety-relevant conduct is produced. It can consequently be applied at three interconnected levels: organizations as institutional settings with particular leadership, reporting, and learning arrangements; professional groups whose roles, responsibilities, and forms of expertise shape safety-related action; and operational contexts in which actors communicate, coordinate, assess situations, and respond to uncertainty. The framework is thus designed for context-sensitive diagnosis rather than for ranking organizations according to a universal safety-culture score.

The proposed framework assumes that safety cultures become observable through recurring patterns of communication, coordination, interpretation, learning, and professional conduct. Accordingly, empirical investigation should focus not primarily on declared values or formal organizational structures but on the practical enactment of safety in everyday organizational contexts. Core components of an approach for doing so are compiled in Table 4.

Beyond their analytical function, such indicators may also serve as practical instruments for organizational development. The diagnosis of safety cultures can provide a basis for identifying specific weaknesses and strengths in communication practices, reporting behavior, coordination processes, leadership approaches, and organizational learning capacities. Different diagnostic findings imply different intervention strategies. Deficits in reporting and communication may indicate the need for measures to strengthen psychological safety and learning-oriented reporting systems. Problems of coordination may point toward interdisciplinary training formats and improved communication structures. Indicators revealing blame-oriented organizational patterns may support the introduction of just-culture approaches, whereas deficits in situational awareness and adaptive capacity may suggest resilience-oriented training and simulation exercises. In this sense, safety-cultural assessment contributes not only to the description and evaluation of organizational conditions but also to the design of targeted measures for their improvement.

Table 4. Framework of analytical dimensions, research questions, and indicators for the empirical study of safety cultures (author’s synthesis informed by the cited literature).

Analytical Dimension	Main Question	Possible Indicators
Communication	How is safety-relevant information exchanged?	Openness of communication; cross-hierarchical exchange; clarity and timeliness of safety-related information
Reporting	How are incidents, errors, and near misses handled?	Frequency and quality of near-miss reporting; willingness to report errors; perceived reporting climate
Learning	How is safety-relevant experience transformed into organizational knowledge?	Use of lessons learned; feedback procedures; implementation of corrective actions; organizational memory
Coordination	How are actors synchronized under uncertainty?	Quality of interprofessional cooperation; coordination across organizational boundaries; clarity of roles and interfaces
Situation assessment	How are safety-relevant situations interpreted and translated into action?	Shared situational awareness; quality of risk assessment; appropriateness of selected countermeasures
Professional responsibility	How is responsibility understood and enacted?	Ownership of safety-related decisions; proactive safety behavior; acceptance of safety-related duties
Collective mindfulness	How are weak signals and anomalies perceived?	Sensitivity to weak signals; attention to operational detail; anticipation of emerging problems; reluctance to simplify

4.3. Safety-Cultural Diagnosis and Organizational Change

The practical value of analyses and assessments of safety culture—particularly those focusing on strengths and weaknesses—lies in their capacity to render underlying patterns visible and open to intervention, thereby creating a basis for targeted organizational development. Different diagnostic outcomes point toward distinct intervention strategies. The following compilation, in Table 5, presents exemplary pathways linking safety-cultural diagnosis to potential organizational responses.

Table 5. Bridging diagnosis and action: Operational pathways (author’s synthesis informed by the cited literature).

Safety Culture Dimensions	Diagnostic Findings	Developmental Objectives	Suitable Interventions
Communication and reporting	Flawed communication and inadequate reporting	Ensuring psychological safety; strengthening reporting systems; stabilizing feedback loops	Leadership training to encourage speaking up; introduction of anonymous near-miss reporting systems; regular safety briefings and debriefings; systematic feedback to employees regarding reported incidents
Situational awareness and understanding	Poor situation assessment	Simulation exercises; scenario training; interdisciplinary drills	Joint exercises involving operators, managers, and external stakeholders; table-top exercises; crisis simulations; cross-functional emergency response training

Table 5. *Cont.*

Safety Culture Dimensions	Diagnostic Findings	Developmental Objectives	Suitable Interventions
Safety awareness and professional responsibility	Low safety awareness and shirking of responsibility	Leadership development; peer coaching; forming communities of practice	Safety leadership programs; mentoring schemes; reflective workshops on incidents and near misses; establishment of safety champions within departments
Learning from mistakes and just culture	Strong blame culture	Just-culture programs and incident review reforms	Transition from person-centered blame to systemic incident analysis; introduction of learning-oriented post-incident reviews; revision of disciplinary procedures; implementation of 'lessons learned' meetings
Cooperation and coordination	Lack of cooperation readiness, weak inter-organizational coordination	Cross-boundary communication structures and cooperation mechanisms	Joint coordination committees; inter-organizational communication protocols; shared information platforms; multi-agency emergency exercises
Collective mindfulness and reliability	Low sensitivity to weak signals and unexpected developments	Mindfulness training and resilience-oriented exercises	Training in situational awareness and weak-signal detection; resilience engineering workshops; structured reflection on unexpected events; development of adaptive decision-making capacities
Leadership and organizational commitment	Low trust in management's commitment to safety	Visible leadership engagement and participatory governance structures	Safety walk-arounds by senior management; employee participation in safety committees; transparent communication of safety priorities and decisions
Organizational learning and knowledge management	Limited organizational learning from incidents	Systematic learning and knowledge-management processes	Incident databases; after-action reviews; organizational memory systems; dissemination of lessons learned across departments
Reflective practice and professional judgment	High procedural compliance but low reflective engagement	Strengthening reflective practice and professional judgment	Discussion forums on rule interpretation; case-based learning; balancing compliance requirements with adaptive expertise
Shared safety culture and integration	Fragmented safety culture across professional groups	Integration of safety perspectives and shared understanding	Interdisciplinary workshops; joint training programs; development of common safety language and shared safety objectives

For a toolkit intended to support applied research and advisory activities, the ‘diagnostic findings’ listed in the second column of Table 5 should not be treated as self-evident observations but as empirically substantiated hypotheses requiring systematic verification. Accordingly, diagnostic assessments should rely on the triangulation of multiple sources of evidence, including interviews, focus groups, surveys, observations of meetings and operational practices, document analyses, incident reports, and organizational performance indicators. For example, a diagnosis of inadequate reporting should not be based solely on a low number of reported incidents, as this may indicate either a genuinely safe environment or a reluctance to report problems. Additional evidence may therefore be sought through employee interviews, safety-climate surveys, or analyses of reporting procedures. Similarly, deficiencies in coordination may be investigated through observations of interdepartmental collaboration, simulation exercises, or after-action reviews following incidents.

The effectiveness of ‘suitable interventions’, presented in the fourth column of Table 5, should likewise be evaluated through systematic follow-up assessments that compare conditions before and after implementation. Leadership training intended to strengthen psychological safety, for instance, may be assessed through changes in reporting behavior, survey results, and qualitative feedback from employees. The introduction of interdisciplinary exercises may be evaluated by examining improvements in coordination during simulations or actual operational events. In this sense, diagnosis and intervention should be understood as elements of an iterative learning cycle in which findings are continuously validated, interventions adjusted, and organizational learning documented. Such an approach is consistent with the practice-theoretical perspective developed in this paper, as it focuses not only on formal structures and declared values but also on observable changes in communication, reporting, learning, coordination, and professional conduct.

The preceding discussion has translated the analytical dimensions of the framework into diagnostic findings, developmental objectives, and possible intervention pathways. To clarify how this framework can be used in practice, the following subsection applies it illustratively to a concrete organizational setting. The example is not intended as a full empirical case study, but as a demonstration of how the framework can guide context-sensitive assessment and advisory work.

4.4. Practical Application of the Framework: An Illustrative Example

To illustrate the practical use of the framework, consider the case of a regional airport that handles passenger traffic, cargo operations, maintenance activities, and emergency preparedness while operating with comparatively limited personnel and resources. Such an airport faces both safety-related hazards, including runway incursions, technical malfunctions, adverse weather, ground-handling errors, bird strikes, and coordination failures, as well as security-related threats, such as unauthorized access, suspicious behavior, cyber disruption, or intentional interference with airport operations. An assessment based on the proposed framework would not begin by asking whether the airport has a safety culture in general. Rather, it would examine how safety is enacted in the everyday practices of the different professional groups involved in airport operations.

First, the dimension of communication would be used to analyze how safety-relevant information circulates between air traffic control, airport operations management, ground handlers, maintenance personnel, security staff, fire and rescue services, airline representatives, and external authorities. This would include the clarity, timeliness, and reliability of communication during routine operations as well as during disruptions such as severe weather, delayed flights, technical failures, or emergency situations.

Second, reporting would be examined by asking whether near misses, procedural deviations, equipment defects, runway-safety concerns, wildlife hazards, or suspicious

observations are reported consistently and without fear of blame. Particular attention would be given to whether frontline personnel receive feedback after reporting and whether reports are treated as opportunities for learning rather than as occasions for individual fault-finding.

Third, learning would be assessed by reviewing how incidents, exercises, audits, inspections, and operational disruptions are translated into revised procedures, training formats, briefing routines, or organizational memory. For example, if a ground-handling incident or runway incursion occurs, the framework would ask whether the event leads only to a formal report or whether it becomes part of a broader learning process involving the relevant professional groups.

Fourth, coordination would be analyzed by observing how different actors synchronize their actions across organizational boundaries. Regional airports often depend on close cooperation among airport operators, airlines, contracted service providers, police, customs, emergency services, and regulatory authorities. The framework would therefore examine whether responsibilities are clearly distributed, whether handovers function reliably, and whether coordination remains effective under time pressure or during irregular operations.

Fifth, situation assessment would focus on how airport personnel interpret weak signals and emerging risks. This could include changing weather conditions, unusual passenger behavior, repeated technical irregularities, staffing shortages, communication breakdowns, or deviations from standard procedures. The question would be whether actors merely follow predefined routines or whether they are able to recognize when a situation requires escalation, adaptation, or cross-functional consultation.

Finally, professional responsibility and collective mindfulness would be assessed by examining whether staff members feel authorized and obligated to speak up, question routine assumptions, stop unsafe work, escalate concerns, and defer to relevant expertise regardless of hierarchy or organizational affiliation. In a regional airport, this is particularly important because safety often depends on the practical judgment of actors working at interfaces between different organizations and professional domains.

The outcome of such an assessment would be a diagnostic profile rather than a single score. For instance, the analysis might show that the airport has formal reporting procedures and regular safety meetings, but that contracted ground-handling staff rarely report minor deviations because they do not expect feedback or fear commercial consequences. It might also reveal that emergency exercises are conducted regularly, but that lessons learned are not systematically transferred into daily coordination routines between airport operations, security, and external emergency services. In such a case, the advisory response would not simply consist of adding another procedure. Rather, it would focus on strengthening non-punitive reporting, improving feedback loops, clarifying cross-organizational responsibilities, integrating contractors more fully into safety communication, and using scenario-based exercises to improve shared situation assessment. In this way, the framework links empirical diagnosis to targeted organizational development and demonstrates how safety culture can be assessed as a situated configuration of organizational structures, professional practices, and operational contexts.

This example illustrates how the framework can move from analytical diagnosis to practical organizational development. More generally, it also clarifies the role that such a framework can play in advisory practice.

4.5. Implications for Advisory Practice

The framework developed in this paper is intended not only to support empirical research but also to guide advisory and organizational-development practice. If safety culture is understood as something produced through communication, learning, coordination, and

professional conduct, advisory work must go beyond technical fixes or compliance-based recommendations. Its central task is to help organizations reflect on and improve the everyday practices through which safety and reliability are achieved.

Safety-cultural assessment can therefore serve as a practical diagnostic tool. The dimensions outlined above—communication, reporting, learning, coordination, professional responsibility, and collective mindfulness—offer entry points for identifying strengths, vulnerabilities, and development needs. Rather than treating safety culture as an abstract property of an organization, advisors can examine how safety-relevant information circulates, how incidents and near misses are interpreted, how responsibilities are negotiated, and how uncertainty is handled in practice.

Such advisory work should focus on interrelated processes rather than isolated measures. Communication problems, for example, may not be solved by adding reporting procedures alone, but may indicate deeper issues of trust, leadership, psychological safety, or organizational structure. Likewise, weaknesses in learning may require not only training but also better routines for reflecting on experience and integrating lessons learned into daily operations. Effective interventions therefore depend on understanding the links between structures, practices, and cultural orientations.

Leadership is particularly important in this regard. Leaders cannot simply create a safety culture by directive; their influence is mainly exercised through the conditions they establish. Advisory practice should therefore support leadership approaches that foster open communication, constructive reporting, participation, interdisciplinary cooperation, and reflexive engagement with uncertainty.

The relevance of such advisory services is likely to grow as organizations face increasing complexity, regulatory expectations, public scrutiny, and demands for reliable performance. This creates a need for advisory offerings that are not only analytically sound but also clearly packaged and convincing for potential client organizations. The framework can support this by translating a complex concept such as safety culture into concrete advisory modules: assessment, feedback, leadership development, learning-process design, reporting-culture improvement, and follow-up evaluation. Such packages can make the benefits of safety-cultural advisory work more visible, actionable, and communicable.

Finally, advisory interventions should be understood as iterative learning processes rather than one-time corrective actions. Diagnosis, intervention, evaluation, and adaptation form a continuous cycle. Sustainable improvements in safety culture require ongoing reflection, organizational commitment, and the development of internal capacities for observation and self-transformation. The main contribution of safety-cultural advisory work therefore lies not in prescribing universal solutions, but in facilitating guided organizational reflexivity. It helps organizations strengthen the collective capabilities through which safety and reliability are continuously produced.

5. Recapitulation and Prospects: Moving from Programmatic to Pragmatic

The present contribution has examined safety culture, professional practice, and organizational reliability in relation to the challenge of ensuring competent action in environments shaped by multiple and overlapping hazards and threats. Particular attention has been paid to socio-technical systems whose reliable functioning depends on the continuous interplay of technological safeguards, organizational arrangements, and professional conduct. At the same time, the conditions under which safety must be achieved are themselves subject to ongoing transformation. Digitalization, increasing interdependence, and the reconfiguration of public and private responsibilities create new vulnerabilities while simultaneously rendering established assumptions and routines open to question. Consequently, maintaining safety and reliability increasingly requires processes of organizational

learning and adaptation through which formerly adequate solutions are revised, extended, or replaced in response to changing circumstances.

Three central conclusions may be drawn from the analysis developed in this paper.

First, safety culture should not be understood as a static organizational attribute or as a managerial instrument that can simply be implemented through formal structures, procedures, or compliance programs. Rather, safety cultures emerge through ongoing processes of communication, learning, interpretation, and collective sense-making. They are reproduced and transformed through organizational practices and therefore remain continuously open to reinforcement, erosion, adaptation, and change. An organizational-culture perspective is indispensable because it provides a productive link between abstract notions of safety and the practical realities through which safety is enacted in everyday organizational life.

Second, the relationship between safety culture and organizational reliability is mediated by professional practice. Safety cultures shape how organizational actors perceive hazards, interpret uncertainty, communicate concerns, negotiate responsibilities, and coordinate action. Professional practice, in turn, translates these cultural orientations into concrete forms of observation, decision-making, intervention, and problem-solving. Organizational reliability therefore emerges neither from technological safeguards alone nor from cultural values in themselves, but from the continuous enactment of culturally informed professional practices. This perspective allows safety culture, professional practice, and organizational reliability to be understood as analytically distinct yet closely interconnected dimensions of the same socio-technical process.

Third, improving organizational reliability requires the cultivation rather than the implementation of safety cultures. Against the backdrop of the risk paradox—aptly captured by Benjamin Franklin’s observation that “the way to be safe is never to be secure”—the challenge is not the elimination of uncertainty but the development of organizational capabilities for dealing with it. In this regard, the High Reliability Organization (HRO) perspective provides an instructive model. Rather than promising safety through complete control, HROs achieve reliable performance through collective mindfulness, sustained attentiveness, reflexivity, and adaptive capacity. Reliability thus appears not as a stable condition but as a continuously accomplished organizational achievement.

From a broader social-scientific perspective, ‘organizational resilience’ complements the concept of safety culture by directing attention to the capacities through which organizations maintain, restore, and transform reliable performance under adverse conditions. A multi-level perspective further demonstrates how individual, team, and organizational resources jointly contribute to adaptive responses, organizational learning, and resilient performance in complex environments (Clements and Kinman 2024). The present framework also resonates with multilevel approaches that conceptualize ‘organizational culture’ as a dynamic process shaped by leadership, shared values, and locally enacted subcultures. Such perspectives underscore that reliable performance depends on the alignment of organizational goals, collective meanings, and situated practices across organizational levels, thereby complementing the focus on safety culture and professional conduct developed in this study (Hartnell and Walumbwa 2011).

The research design proposed in this paper has sought to translate these theoretical considerations into an analytical framework for empirical investigation and advisory practice. By focusing on communication, reporting, learning, coordination, professional responsibility, and collective mindfulness, it identifies dimensions through which safety cultures become observable and assessable in concrete organizational settings. The resulting framework is intended not only to support comparative research but also to inform

organizational diagnosis, leadership development, communication and reporting systems, interdisciplinary training, and organizational-learning initiatives.

Accordingly, the principal contribution of this paper lies in connecting cultural, professional, and organizational dimensions of safety within a coherent social-scientific framework. Rather than treating safety culture as an isolated organizational variable, the proposed perspective understands it as a dynamic process through which reliable performance is continuously produced under conditions of uncertainty. Future research may further develop this framework through comparative empirical studies across different sectors, professions, and governance contexts, thereby contributing to a deeper understanding of how organizations cultivate the collective capacities required for safe, reliable, and resilient action in increasingly complex societies.

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