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Organizational structure and safety culture: Conceptual and practical challenges

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ABSTRACT

This essay argues that:

(1.) The concepts of both "safety" and "safety culture" are under-developed in organizational analysis. This has led to ambiguity and confusion in our understanding of the causal connection of both to specific elements of organizational structure.
(2.) There is more complexity in the link between structure and safety culture as features of organization than might be supposed. The actual content of structural elements such as roles and rules, functional lines and limits of authority, accountability and communication – can themselves require closely supporting cultural norms of acceptance to actually function as formally described. Otherwise a formal organization chart can be a highly misleading picture, as they often are, of actual transactions occurring within a functioning organization.
(3.) But the relationship between structure and safety culture can be different in the different phases of (1) the initial *change* of cultural or sub-culture features that undermine safety, (2) safety culture *development* and finally, (3) the challenge of the continued *maintenance* of a safety culture over time in an organization.
(4.) Both specific safety management structures and a reinforcing safety culture are essential within an organization to reach across the scope of activities and time frames necessary for reliable safety performance.

The implications of these points are explored for both future safety research and regulatory practice concerning organizational structure and safety culture and, ultimately, to connecting both to the improvement of safety performance.

In December of 2018 the California Public Utilities Commission (CPUC), the major utility regulator in the state of California issued an order to investigate the Pacific Gas and Electric Company (PG&E), one of its largest regulated utilities, to "determine whether PG&E's organizational culture and governance are related to PG&E's safety incidents and performance record, and if so, to what extent." (CPUC, 2018). The underlying idea was to investigate whether restructuring the utility in both its overall corporate organization (as a single integrated investor-owned utility) as well as its internal governance and corporate management structure would allow PG&E "to develop, implement, and update as necessary a safety culture of the highest order."

Structural options to be considered included breaking up the utility into separate smaller, regional entities; or separate electric and gas utilities; or even reconstituting PG&E as a publicly owned utility or utilities. Governance restructuring questions to be asked in the investiation included should the utility's Board of Directors be accountable for safety apart from its other fiduciary responsibilities? Should the Commission require the creation of "a special audit committee constituted of independent directors possessing financial and safety competence, as defined by the Commission, to evaluate the Board of Directors' discharge of their duties"? Should the Commission require the appointment of several members to the Board who are experts "in organizational safety, gas safety, and/or electrical safety"? Also, should these Board members be subject to approval by the Commission or the state Governor? Finally, should the Commission form a "standing working group with the union leadership of PG&E to identify the safety concerns of PG&E staff"?

The Commission undertook this formal proceeding, which is still ongoing, to investigate these structural questions and others. But will a formal proceeding with public hearings actually help the

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Commissioners answer these questions? This essay argues that the prospects seem doubtful, and they are doubtful because these are still basically research questions and not legal or regulatory ones.

Consider two examples of the multiple dimensions of the Commission's questions concerning the structural options. One potential option to be considered under the proceeding is separating PG&E's gas and electric divisions into separate companies. What would be the likely impacts of this separation upon safety? It might lead to a clearer focus by managers and executives on the safety and risks of each specific infrastructure without having to compete for safety budgets with units operating another infrastructure. Smaller utility companies might develop more esprit among employees and a closer identification by each of them with company safety objectives and a common safety culture.

But is this assured with this strategy? Smaller companies with a smaller base of ratepayers might have fewer resources and capital available for risk reduction through safety investments. Splitting up the companies does not proportionately cheapen the foundational costs of achieving and maintaining safe operations in an infrastructure. Rate payer increases required to support these investments borne by a smaller base of rate payers might be prohibitive. At the same time companies with a smaller revenue base might find operating and personnel costs a strong motivation for their executives to cut overhead and production costs, and cost-saving demands imposed upon employees at all levels might undermine morale, increase workloads and reduce commitments to safety.

At the same time would these separate, smaller companies be more or less inclined to worry about and manage for interconnected infrastructure risks? Research on a variety of infrastructures in Northern California has found the complexity of possible interconnections and interdependencies among them to be formidable – more complex than even managers and operators of each infrastructure realized[1]. One important factor is that latent interdependencies among the infrastructures (water, electricity, gas, telecoms, shipping, levees) can appear suddenly in the shift from normal operation to periods of disruption, failure and then to recovery (Roe and Schulman, 2016).

Right now, PG&E is just beginning to appreciate the full extent of its own electrical and gas infrastructure inter-connections and vulnerabilities, mostly under the framework of sharing information or "interoperability" analysis. But even with its integrated corporate structure PG&E's separate utilities or "asset families" have separate management, budgets and operating personnel. Asset families compute and manage their own risks separately and compete with one another for priority in a general "risk register" which determines corporate risk mitigation investment decisions. How much less likely are a set of separate companies to cooperate collaboratively in identifying interconnected risks and investing for them? Meanwhile the CPUC itself is not organized (with its separate safety branches) and has not undertaken to research, identify or regulate interconnected risks.

Another option to be considered in the proceeding, restructuring PG &E into a non-profit publicly owned utility, also has many dimensions. The elimination of profit and shareholder return-on-investment pressure might indeed make safety a higher priority among board members, executives and managers throughout the utility.

But this too is not guaranteed. One recent study of over 3000 power plants (and hospitals) found that publicly owned plants (and public hospitals) had a 9% higher rate of non-compliance with health and safety regulations such as EPA Clean Air Act regulations than privately owned ones and were 20% more likely to have committed higher priority safety violations. Much of this difference was attributed to the increased difficulty of government regulators (federal or in cities or states) regulating other government entities.[2]

In actuality, studies differentiating public vs privately owned utilities find little variation in safety and reliability based on the ownership variable alone. Geography, technology, public levels of risk tolerance as well as managerial and regulatory quality are possibly more important variables.[3] What seems clear is that ownership does not by itself determine what attitudes and behaviors will actually prevail at the level of operations and task performance in real-time. Ownership and probably many other of the structural options being considered in the OII 15-08-019 proceeding are unlikely as single factors to settle the future of improvements in the safety management and safety culture that currently prevail in the gas and electric services operated by PG&E.

In other words, there will likely be no "slam-dunk" conclusions in the CPUC's proposed review of these options. Many other variables may well mediate the possible effects of structure on culture and of both on safety outcomes. Any structural options chosen by the Commission will therefore be uncertain, and possibly even risky, propositions with respect to their safety management and safety culture impacts if these and probably additional variables are not considered.

A positive safety culture[4] does not come "baked-in" to specific organizational structures, although structural elements can certainly be important factors in either encouraging or discouraging safety culture development and persistence (Hopkins, 2019). Instead safety culture seems to evolve over time by a process of widespread organizational commitments, incentives, motivation and personal identification, reinforced by mutual trust among employees across units, departments, specialties and hierarchical levels, all of which are then translated into actual real-time behavior all the time.

A safety culture should play into high-level decisions, including investments, resource and budget allocations but a safety culture should also penetrate down to work assignments and work planning, individual job descriptions, role and personal identities with respect to safety in these jobs, and finally, down to task content and the actual execution of tasks in real time (Grote, 2018; Sorensen, 2002).

Research findings linking specific structural variables as generic to safety culture development are, to say the least, equivocal[5]. The fact is that we do not have systematic and generalized, let alone predictive, knowledge about how actually to "grow" a safety culture in an organization. The National Academy of Engineering in a report on safety culture in the Offshore Oil and Gas Industry described the development process as "a long and uncertain safety culture journey"[6].

Further, statistical findings linking safety management systems themselves to safety outcomes such as accident and injury rates are also equivocal[7]. Importantly, however, some studies of performance

[1] For a description and analysis of these complex interconnections see E. Roe and P. Schulman, *Reliability and Risk: The Challenge of Managing Interconnected Infrastructures*. Stanford University Press, 2016.

[2] See D. Konisky and M. Teodoro, "When Governments Regulate Governments." *American Journal of Political Science*, 2016 (July), 559–574. https://onlinelibrary.wiley.com/doi/full/10.1111/ajps.12221

[3] See for instance World Bank, "Private versus public electricity distribution utilities: Are outcomes different for end-users?" 2018 (https://blogs.worldbank.org/developmenttalk/private-versus-public-electricity-distribution-utilities-are-outcomes-different-end-users), and John Goodman and Gary Loveman, "Does Privatization Serve the Public Interest?" *Harvard Business Review*, (November/December 1991). (https://hbr.org/1991/11/does-privatization-serve-the-public-interest).

[4] We will use the term "safety culture" to denote a positive culture with respect to the promotion of safe practices within an organization. This is in distinction to a more general organizational culture and its impacts either positive or negative with respect to safety.

[5] For an analysis of the complexities involved in connecting culture to organizational structural variables see Reiman and Oedewald (2007).

[6] National Academy of Engineering, *Strengthening the Safety Culture of the Offshore Oil and Gas Industry* (Washington, DC: The National Academies Press, 2016), p. 9. https://doi.org/10.17226/23524.

[7] See Steven Kaspers et al. "Measuring Safety in Aviation: Empirical Results about the Relation between Safety Outcomes and Safety Management System Processes, Operational Activities and Demographic Data." *Presario Conference*,

outcomes have found a stronger correlation with the mediating factor of "employee engagement" reflected in "satisfaction, commitment and discretionary effort" (Wachter and Yorio, 2013; Nahrgang et al., 2011). I will argue that these mediating factors between SMS structural features and safety outcomes are actually a reflection of safety culture and its necessary role in connecting structural features in an organization to safety outcomes.

Conceptual Issues in Understanding Safety Culture. Questions concerning the development of safety culture should still be research questions before legal ones because "safety culture" currently suffers from conceptual under-development (Cox and Flyn, 1998; Reiman and Rollenhagen, 2014). It is not clear what constitutes a safety culture[8]. A widely accepted definition of organizational culture offered by Edgar Schein is: "A pattern of shared basic assumptions that the group learned as it solved its problems of external adaptation and internal integration, that has worked well enough to be considered valid and, therefore, to be taught to new members as the correct way you perceive, think, and feel in relation to those problems." (Schein, 1985). In more specific terms culture consists of widely shared values, basic assumptions, rituals and physical artifacts.

But what makes an organization's culture or sub-culture a *safety* culture as opposed to an organizational culture that discounts safety? What are the specific values, assumptions and artifacts that constitute a safety culture[9]? Are these the same across organizational hazards, technologies, public vs private ownership, organizational scale and political environments?

In several places, a definition of organizational culture has been simplified down to "the way we do things around here" (Handy, 1993; Wakefield et al., 2010; Hopkins, 2019). But this seems to equate culture with behavior and leaves out the attitudes, beliefs and assumptions, values and motivations that lie behind the behavior. Organizational culture might be better defined as the prior *cause* of behavior. Andrew Hopkins has made this point when he asserts: "there is one context in which it is appropriate to identify culture as cause. That is when we are talking about the cause of individual behavior" (Hopkins, 2019).

This individual context is a quite useful way to elaborate descriptively a safety culture, because an important, though not exclusive, domain for safety itself is down at the "sharp end" of organizational structure and processes – that of actual human behavior that is induced, reinforced and legitimated. Again, the personal engagement dimension associated with safety culture is a critical element in safety. From high reliability organizations (HRO) research (LaPorte and Consolini 1991; LaPorte, 1996; Schulman 1993; Roe and Schulman, 2008; Hopkins, 2009; MacRae, 2014) it is possible to give a clear description of what actually constitutes at least one type of safety culture. This is one associated with a set of organizations with excellent records in managing hazardous technical systems – nuclear power plants, commercial aviation (including air traffic control) and other critical infrastructures including high-voltage electrical grids and large municipal water supply systems – to high levels of reliability and safety. Members of these organizations have displayed similar attitudes, assumptions, values and motivations, that have penetrated down to the level of their personal identity (Roe and Schulman, 2008).

HRO safety culture elements. A starting point is a sense of responsibility for the risks associated with the technical hazard and the accidents, failures, errors or other events that could threaten the lives of not only members of the organization but also the public. For some of these organizations public dread of the consequences of these events adds additional weight to the sense of individual and collective responsibility among organizational personnel.

A dominant value in these organizations is the primacy of safety over other values such as speed or efficiency or even service. Reflecting this value, these organizations will go offline and shut down operations rather than operate outside of what are widely considered acceptable margins of risk.

This value supports a specific attitude – a preoccupation with system accidents and failures and their causes. In particular, the prevailing assumption is that these accidents are often caused by errors of mis-perception, mis-specification, and misunderstanding leading to actions that did not take into account system-level causes and effects. These errors can lead to disastrous consequences as they did in the Chernobyl nuclear accident as well as many others (Medvedev, 1992; Vaughan, 2016; Reason, 2016; Dekker, 2018;Hopkins, 2012).

This concern leads to a constant worry about complacency and hubris. This is often expressed in an attitude of skepticism surrounding proposed actions and plans. "What if our assumptions in this decision are wrong?"; "What are we missing in this plan?" are comments not infrequently heard in decision-making and work planning sessions. Individuals at many levels may be accepted in a role as "partisans of the neglected perspective" regarding system safety. This role may even overlap and reinforce official roles they may occupy as supervisors, managers, department heads, or even high-level executives. A maintenance director in a nuclear power plant, after one maintenance procedure revision session, cautioned his maintenance crew supervisors about how they should communicate the change to their personnel: "Don't let them think we've thought of everything and that this technology can't still surprise them" he said. (Schulman, 2004). This skepticism is also a foundation for detecting uncertainty and potential errors in measures, models and planning assumptions.

An additional element in HRO's is the development of a "precursor" strategy in relation to errors and accidents. Great effort and attention is directed toward identifying conditions or states that, while not failures or accidents in themselves, can lead through chains of causation to more direct failure causes. These precursor conditions include not only physical conditions (e.g. excessive temperatures and pressures, loss of back-up equipment) that exceed a bandwidth of acceptable operating conditions, but also organizational conditions (e.g. cognitive load on operators, excessive noise in control rooms) that can degrade skills and invite error.

Within this strategy high reliability managers strive to keep operations out of precursor zones. In the case of nuclear power plants control operators may shut down reactors if they believe operations have moved into precursor conditions, commercial pilots may refuse to fly if they believe equipment or weather conditions are "hazardous". It is important to note that precursor conditions for high reliability organizations can also include new uncertainties surrounding operations and their risks.

The culture of these organizations supports taking precursors seriously, and through ongoing analysis, enlarging the "zone" of unacceptable precursor conditions. In some organizations, distinct language usage is used call attention to precursor conditions. During one test of new air traffic control software that required controllers to type the location, heading, speed, and altitude of each plane in their sectors, after two software "crashes" requiring data re-entry, controllers announced that if the software test continued they would "no longer accept responsibility for the separation of airplanes" in their sectors. This promptly ended the test. At other times control operators have said "I'm uncomfortable operating under these conditions" or "I find myself in unstudied conditions". In the culture of these organizations this

(*footnote continued*)
2017, (https://www.nap.edu/login.php?record_id=23662&page=https%3A%2F%2Fwww.nap.edu%2Fdownload%2F236) and also, Elan Head, "When Safety Management Systems Fail" *Vertical Magazine* (2015). (https://www.verticalmag.com/features/whensafetymanagementsystemsfail/).

[8] For efforts to define safety culture see Guldenmund (2000), Sorensen (2002), Cooper (2000), Antonsen (2009).

[9] Some industry-based safety culture descriptions have been offered in: "Traits of a Healthy Nuclear Safety Culture" (U.S. Institute of Nuclear Power Operators, 2012); "Safety Culture" (U.K. Health and Safety Executive, 2019) and "Introduction to Process Safety Culture" (U.S. Center for Chemical Process Safety, 2019).

language is taken seriously.

Finally, a key element related to safety culture in HROs is a personal identification with safety on the part of a significant number of individuals distributed across hierarchical levels, departments, units and within individual work crews. Many of these individuals, termed "reliability professionals" in some HRO analyses (Roe and Schulman, 2008) internalize responsibility for things going right in the management of their technical systems, and they see this responsibility in issues and actions that go beyond their formal job descriptions. They often are part of work teams and many have gained experience through work in a variety of different jobs within their organization. Over time they become consistent advocates for system-level perspectives on risk.

These individuals, and the culture which supports and protects them, are also important elements in organizational protection from reliability and safety "drift" – a move away from the concentration on system risks toward more parochial issues in individual departments and units, as well as the loss of safety priorities or a growing complacency concerning safety risks in the face of competing organizational values such as efficiency, cost reduction or speed in completion of tasks[10].

The Organizational Structure and Culture Relationship. Some of the formal structural elements typically associated with organizations are: roles, rules, communication links as well as authority and accountability assignments and distributions. But for each of these formal elements there are likely to be informal, shadow elements as well. Formal rules and procedures may conflict with informal norms to ignore certain formal rules. Rumors and other kinds of information may spread along grapevines and other communication channels that compete with formal ones. Along with formal authority positions there may be individuals, for example some reliability professionals, who because of long experience or technical knowledge and their ability to mix experiential and formal analytic perspectives, may function as informal leaders[11].

Sometimes lower-level roles contain formal veto authority assignments that may allow individuals such as nuclear control operators or airline pilots to veto orders of their nominal superiors if they believe them to threaten safety. At times informal norms, roles or routines may undermine safety objectives, but at other times and cases they may actually enhance safety. Informal norms and practices may supplement incompleteness or buffer errors in formal orders or procedures, for example.

Even the distinction between organizational culture and structural elements can be misleading. Leadership roles, both formal and informal, can in fact be cultural artifacts[12]. They may be legitimated by cultural norms that embrace these roles and convey power to their occupants. Conversely leaders in formal roles may find resistance among lower level personnel nominally under their authority. This can lead them to ignore or even sabotage the commands of superiors.

Out of the structural elements described above there are larger structural configurations that can characterize organizations. There may be centralized or decentralized communication and authority patterns; long or short spans of control between superiors and their subordinates; high degrees of task or role specialization or a significant amount of functional overlap; a density of formal rules or more flexible and fewer formal rules. These structural patterns may harmonize as artifacts with the cultural pattern dominant in the organization. Centralized authority and communication may be reinforced by the culture of a military organization. At another extreme, distributed authority and diffused communication may harmonize with the academic culture of university organizations.

Whatever its structural configuration, it is important to recognize that there are many different objectives, values and properties sought from any human organization[13] and that there is no single pattern of organizing that can equally serve them all. Any particular pattern of organization in place to organize in some values and properties will just as surely organize others out. For example, a high degree of specialization may promote local performance efficiencies but undermine larger system-level perspectives. Formalized rules may increase uniformity and predictability in behavior but reduce flexibility and/or innovation in the face of the unexpected[14]. Safety is a value that poses a number of challenging organizational requirements, and because some of these can be mutually undermining, they are hard to maintain in a stable balance, in any single structural configuration

It helps to consider some of the peculiar properties of safety as both goal and concept to understand some of these distinctive organizational challenges it poses.

The Paradoxes of Safety. Consider first the concept of "safety" itself. As James Reason has argued: "Safety is defined and measured more by its absence than its presence (Reason, 2000)." It's hard to establish that things are "safe". It's much easier instead easier to recognize "unsafety" or danger in the face of accidents (Atsuji, 2016).

Another source of confusion in the notion of safety is its relation to risk. Is safety the inverse of risk? Not according to an international group of aviation safety regulators who argue that:

> "Safety is more than the absence of risk; it requires specific systemic enablers of safety to be maintained at all times to cope with the known risks, [and] to be well prepared to cope with those risks that are not yet known." (SMICG, 2013, p. 2).

While risk is about loss, safety is about assurance. Safety is in many respects a perceptual property, risk is a calculated one. A number of failures or incidents can occur without invalidating the probability assumptions in a risk estimate (two 100-year floods in consecutive years, for example), but a single failure can disconfirm an assumption of safety.

These conceptual issues surrounding safety can also become practical ones. How does an organization assign a valuation or priority to something which, in effect, means that things don't happen? It is not surprising that many organizations will under-invest in safety relative to expenditures that produce determinate positive and measurable outcomes such as increased production, capacity or new physical facilities. Compared to these outputs what's the return on investment in relation to accidents that don't happen? Is it certain that they would have happened without a safety investment? Is it certain they will never happen with a safety investment? If an accident does occur can an organization get retrospective credit for at least making it less likely and thus possibly delaying its occurrence?

Questions such as these can undermine incentives for organizations and their leaders to undertake safety as a highest or even high priority commitment. Even regulatory organizations may be of mixed motives in their safety regulation when they seek also to promote service reliability and, in the case of U.S. public utility regulators such as the CPUC, low rates to consumers (Danner and Schulman, 2019).

[10] A good description of "practical drift" away from safety is Scott Snook, Friendly Fire (2002). For a more general description of the role of safety culture in resisting safety drift see Petersen and Schulman, "Drift, Adaptation, Reliability and Resilience" (2019). For a description of "moral disengagement" from the norms of process safety see Petitta et al.,"Safety Culture, Moral Disengagement and Accident Reporting" (2017).

[11] A classic description of this informal leadership is David Mechanic's "Sources of Power of Lower Participants in Complex Organizations" (1962).

[12] Social psychologist Geert Hofstede (Hofstede, 2010) has argued that organizational structures often are artifacts of larger national cultures within which organizations are located. See also Reader (2020).

[13] Among these are expertise, speed, predictability, control, accountability, adaptability, and flexibility.

[14] A classic statement of this problem was that of James D. Thompson in *Organizations in Action* (2003) in his discussion of "paradoxical demands" in organizations.

Alternatively, psychologist Karl Weick has defined safety as the continuous "production of dynamic non-events" (Weick, 2011). Here safety is not defined by the absence of accidents but as the process of positive actions – including a set of prospectively focused efforts to identify potential causes and consequences of future accidents; continuous learning from root cause analysis of "close calls" and other incidents as well as from prior accidents; identifying and constantly monitoring precursor conditions that can make accidents more likely and acting to prevent them; and training and planning for the containment of consequences of accidents if they do happen – in short *safety management*.

Safety, from this perspective, could be *operationally* defined as the effective implementation and operation of a safety management system, reinforced by a safety culture – and not simply by output measures of incidents and accidents as lagging indicators (Hollnagel 2014). But this requires that we can distinguish "dynamic non-events" in an organization from other organizations whose technical systems without careful safety management simply are so far "failing to fail" (Roe and Schulman, 2008). Often this distinction is not understood.

Consider this statement from lawyers for the Pacific Gas and Electric Company in a motion to a U.S. Federal District court concerning a criminal indictment by the U.S. Department of Justice over the San Bruno accident[15], a major gas pipeline explosion in 2010 that killed 8 people and destroyed an entire residential neighborhood:

> "The San Bruno pipeline explosion was a terrible accident which devastated many people and harmed an entire community. A pipe with a faulty weld was placed in service in 1956, where it performed safely for 54 years. Suddenly, it failed catastrophically." (*S.F. Chronicle* 9/4/14.)

This 54 years of non-events was *not* safety but the failure to fail. Understanding and identifying the difference is an important analytic and practical challenge. How can a regulator distinguish non-events that are simply "failing to fail" from those dynamic non-events that reflect effective safety management, without having to wait for an accident? The answer depends strongly on a reinforcing relationship in an organization between the organizational structure of safety management and its safety culture.

First, recognize that there is an important difference between implementing structural features of a safety management system – "safety" officers; safety plans; safety meetings; safety budgets; formal accountability and reporting relationships – and:

- achieving a widely distributed acceptance of safety management as an integral part of actual jobs,
- a collectively shared set of assumptions and values concerning the pursuit of safety and
- a responsibility for safety accepted as part of the individual identity of personnel in an organization.

The Micro-Organization of Safety Management and Structural Elements. In thinking about the relationship between organizational culture and structure in relation to safety it's important to realize that preventing system accidents requires not only macro-level design and structural integration but also task- specific micro-coordination[16]. As noted earlier, any structural configuration that organizes some values and properties in will organize others out. So too any structural configuration will promote some features of safety management and safety culture but not others. Consider organizational centralization of authority, accountability and decision-making.

Many consultants and regulators have stressed the importance of centralized structures, including a single safety officer in charge of and accountable for the safety management of an organization. Andrew Hopkins in his book *Organizing for Safety*, argues that "the lesson that has painfully emerged in recent decades for process industries is that, while personal or occupational safety can be appropriately managed in a decentralized way, process safety must be centrally managed." (Hopkins, 2019; 5-6).

Centralization allows for decisive actions at the highest level to organize positions for a safety management system – with formal overseers, (often specific safety officers), safety rules, reporting and record-keeping systems and managerial accountability at the highest level for a safety emphasis. These structures can also help create a bureaucratic structure for a formalized process of "safety work". But a recent analysis concedes that this "safety work" is not the same as the safety of work:

> "Even where it does not contribute to the safety of work, safety work may be necessary for organizations to make sense of safety in an uncertain world. If organizations did not perform safety work, they would be unable to convince stakeholders that they were doing enough for safety, which would in turn prevent them from pursuing their core business." (Rae and Provan, 2019)

Despite its external benefits to organizations, in its particulars. the organizational structure of safety work may not necessarily enhance, at micro levels, the process of safety performance. Safety officers may be trained in "safety work" – the management and reporting processes associated with authority and accountability – but not the technical work they are to oversee. They may or may not have the respect of people who actually do that work. Those workers may see the required safety rules and reports as pro-forma paperwork – add-ons to an already full plate of responsibilities. They may or may not integrate actual behavioral changes into the work itself.

Finally, the existence of a safety officer, a safety department and safety focused chain of command may well cause others in the organization to believe that safety is someone else's job and responsibility instead of internalizing it into their own identity and motivation[17].

The hierarchy associated with centralized positions may also be an important framework for comprehensive system-level decision-making and accountability as well as downward communication, but not necessarily for the fast and flexible responses and lateral communication important for micro-coordination of tasks, especially in emergencies[18]. The same hierarchical structure that positions top officials to plan, make decisions and issue commands, and to be held accountable for them, can also be an unreliable conduit for upward and lateral information flows and for the real-time coordination of activities. Organizational plans, strategies, decisions and commands are prone to error or distortion in design due to upward information lapses, and failures in execution if individual units or departments have developed their own sub-cultures, sometimes at variance with an "official" organizational position.

Here's where an effective safety culture can supplement the gaps in a centralized structural configuration. An effective safety culture, while it requires requires top level supports, can also bring an ability and

[15] An insightful organizational account of this accident can be found in Hayes (2015).

[16] A recent set of analyses of risk management in organizations that focuses on the "micro-sociology of risk management work" can be found in Michael Power, Riskwork (2016).

[17] As we have noted, "personal engagement" has been found to be one of the variables most correlated with safety performance (Nahrgang et al., 2011 and Wachter and Yorio, 2013). At the same time "moral disengagement" is identified by psychologists as a dynamic process that can lead to significant ethical violations by individuals, including the normative rules of process safety (Bandura et al., 2000 and Petitta et al., 2017).

[18] A more recent perspective now stresses the importance of flexible organizational adaptation and resilience as elements in effective safety management in periods of crisis. See Sutcliffe and Vogus (2003) and Weick and Sutcliffe (2015).

disposition of localized actors to supplement formal decisions and designs – adding safety margins, attending to safety issues not addressed by plans, commands and designs, and calling attention to and correcting errors in decisions, plans and procedures, if even in some cases by supporting those who, with or without formal authority, may refuse commands to carry them out.

In order to get a closer read on the relationship between structure and safety culture it is important to note that this relationship can vary depending on different stages in the life cycle of a safety culture and whether we are analyzing structure in relation to *changing* a dominant culture, *developing* a distinctive safety culture or continuously *maintaining* a safety culture.

The role of structure in changing an organizational culture. The California Public Utility Commission in its PG&E proceeding was reviewing structural options with the underlying assumption that structural changes could be an important, if not primary, factor in creating an organizational safety culture within PG&E. It is worth exploring this assumption – first in the larger context of the impact of structure on changing the culture of an organization.

All organizations have a culture, and probably sub-cultures, whether these support safety or not. There is clear evidence that high-level executives cannot simply order the dissolution of a deeply entrenched prior culture or sub-culture in their organizations, nor can they reliably order the implantation of a safety culture as a replacement. For example, efforts have been made in the U.S. to change the culture supporting abusive practices in some urban police forces in their treatment of suspects during stops and arrests. These efforts have often focused on structural elements such as orders by police Chiefs to precinct captains, mandated sensitivity training or even the creation of Civilian Review Boards. Yet these elements have often failed to change attitudes and resulting practices (Armacost, 2016).

As Schein's definition of organizational culture cited earlier indicates, an existing culture "has worked well enough" in an organization to be considered valid and taught to new members. Given the physical risks in policing, the discretion of police on the job (Wilson, 1978) and the socialization of new recruits by their partnering with more senior officers, existing policing culture often continues to work "well enough" for many officers on the job, and existing attitudes and practices have been very resistant to change.

In general, comprehensive structural changes in organizational leadership and strategy, jn job descriptions, procedures and rules, and accountability standards, as well as rewards and punishments, can indeed function to reduce the likelihood that the elements of an existing culture will still work "well enough" to support its continuance. In this way structural changes can certainly help to change cultural attitudes and related practices. But the role of informal leaders is likely to be important as well, and the change will hardly happen overnight. It may take a generational turnover to eliminate entrenched attitudes and assumptions, values and practices of some middle and lower-level managers and employees.

Developing a safety culture. Formal leadership is also a necessary, if not sufficient, factor in the development of a safety culture within an organization. A chief executive can elevate, and symbolize as well, a commitment to safety as a top, if not the top, priority in an organization. This can be done though budget allocations and investments, personnel hired or fired, new rules and procedures, and new lines of accountability and authority for safety officers. Top-level executives can also institute incentives for managers and employees, both positive and negative, and corrective-action programs.

At the same time, formal incentives can be risky elements to use in promoting a safety culture. There is significant evidence that formal safety performance incentives, such as bonuses or punishments, can be problematic in promoting safety behavior, especially if tied only to lagging performance metrics such as incidents, accidents or injuries, instead of safety process measures which can serve as leading indicators but don't have to be connected to high stakes rewards or punishable failures. High stakes, in both rewards or punishments, can and has led to falsification in performance reporting in order to appear in compliance with or fulfillment of formal safety performance goals (Moller et al., 2018). This has actually happened recently within Pacific Gas and Electric Company's gas operations where employees falsified compliance records regarding a state legal and regulatory requirement to locate and mark its near-by gas distribution pipelines within 48 hours of a request for this information by contractors prior to planned construction work that would entail dig-ins.

A significant falsification of completion records occurred during the period from 2012 to 2017, ironically a period beginning not long after the San Bruno pipeline explosion described earlier. This violation is the subject of yet another California Public Utilities Commission investigatory proceeding. In its own report to the Commission concerning this proceeding[19] PG&E noted that it has over the years since the San Bruno explosion been working on many improvements to its safety management system including "*a revised compensation program that bases an industry-leading 50% of employees' short-term incentive compensation on safety metrics*" [PG&E, 2019; P. 13 (emphasis added)].

Yet as its own report concludes "As the Company's workload increased, some L[ocate] &M[ark] employees were given directives that they viewed as making zero late tickets the only acceptable outcome—which in turn led them to take inappropriate steps not to eliminate late tickets, but to eliminate the *appearance* of … late ticket reports." [PG&E, 2019; pp. 72–73]. While the Director of the Locate and Mark Program at PG&E, in testimony to the Commission, did concede that zero-late tickets was one among many of the Short-Term Incentive Program performance goals for the him as Director, he denied that financial compensation was directly tied to this particular performance item. Of course, failing to reach this public, legislatively mandated performance goal certainly at the same time carried negative implications for him and his employees.

Further, financial incentives for safety may not actually add positive motivation for safety performance if they actually undermine an individual's normative identity as a safety professional. Classic organizational research in compliance theory suggests this possibility. One compliance model (Etzioni, 1997) differentiates three distinctive motivational foundations for members to comply with orders and rules in organizations: coercive (with physical punishments for non-compliance e.g. military organizations), utilitarian (with financial motives for compliance among employees in commercial organizations) and normative foundations for compliance (based on internalized values embracing objectives in the organization). The model then argues that it can be difficult to mix these compliance foundations in a single organization in an effort to gain additive compliance effects because they can be mutually undermining. Adding financial incentives (a utilitarian motivation) to employees for safety performance , for example, can challenge their normative self-identity and the respect accorded them by higher executives and others in their organization as safety professionals.

Given the complexity of factors associated with safety incentives and their impacts on safety-related behavior, one analysis has suggested that "there is not an absolute answer to the question of whether incentives are impactful. Rather, their use is an empirical question that must be examined for given tasks, in particular contexts, and managed so as to avoid the potential for unintended consequences" (Maslen and Hopkins, 2014). This is an important cautionary statement and points again at the complex, multivariate connections between structure, safety culture and safety outcomes.

Paradoxically, as an element of formal structure, incentives, in order to be effective may well *require* a safety culture to already be in place in

[19] PG&E (2019), *90-day Response Report to the CPUC OII 18.12.007* (file:///C:/Users/schul/Downloads/LocateandMarkOII_Report_PGE_20190314_556371%20(2).pdf).

order to prevent the distortion of information about performance, or to at least allow some employees to feel comfortable in reporting instances of such distortion. The PG&E locate and mark case noted above is an illustration of this problem and suggests that elements of structure and safety culture have a mutual dependency upon one another for their development and ultimate effectiveness in the promotion of safety.

Perhaps among the most important factors a top leader can offer in safety culture development is persistence. Just as old cultures cannot disappear overnight, safety cultures cannot be instilled overnight – they can take a long and unpredictable time to develop. Top leaders must demonstrate and other structural features must reinforce that a "safety push" is not a fad and that resistant members cannot simply wait it out.

Finally, it is also likely that a safety culture can also grow from the bottom up in an organization. One organizational unit may develop a safety culture closely tied to the risks of its specific technology and elements of that culture may spread outward by example, through peer pressure or by informal leadership to other units. The development of safety norms and values in one maintenance or control room crew, for example, can spread to others, especially if these norms convey a professional identity and status to the adopting units and their members. In one historical example the development of a shared safety culture and safety practices among anesthesiologists, including a commitment to learning through careful record-keeping across many cases (Gaba, 2000), had an impact on the evolution of safety norms and practices among surgeons in their hospitals.[20]

Maintaining a safety culture. One of the findings from HRO research is that high levels of reliable and safe management are not synonymous with invariance in behavior. High reliability organizations, including elements of their safety culture, are not established once and for all in their creation. High levels of attention, trust between departments and units, rich communication across multiple information channels, continuous scanning for system implications of specialized work, maintenance of mindfulness[21] and warding off complacency in routine tasks all are hard to sustain and subject to erosion under the press of time, heavy workloads and intense pressures for service outputs (Schulman, 1993).

Instead, a key to high process reliability and safety management is the close monitoring and management of fluctuations in key components of both management and culture. A successful safety management system has to ward off drift toward lapses in its integrity, integration and energy[22]. It has to take its own temperature in regard to precursor conditions not only in operations but also in management and culture themselves. One strategy to avoid drift into complacency is an embrace of a constant search for improvement. This may be reflected in formal practices but is also grounded in culture.

In one well-managed nuclear power plant formal procedures were taken very seriously throughout the organization and none were disregarded in actual work. But at the same time, procedures were continuously reviewed for clarity and relevance and employees were encouraged to submit suggestions for revisions that would improve procedures. As a consequence, many procedures had undergone multiple changes through a formal revision process. Because many of these revisions had originated at the operations and shop levels, the employees came to "own" the procedures – they took them seriously as custodians and they, among others, were always on the lookout for improvements to them. The procedures were, in effect, a living document capturing the current plant knowledge base and state of the art in operations and maintenance (Schulman, 1993).

Finally, as noted earlier, reliability professionals can also be watchful guardians against safety drift in their organizations, whether it be from operational complacency or growing parochialism with respect to system risks. While occupants of formal leadership roles can be important forces for the establishment of a safety culture, they can also undermine it by changing organizational policies that can shift the balance in organizational priorities away from safety in relation to other objectives. Here a strong safety culture, embedded in the norms and identities of personnel throughout the organization can lead to resistance – speaking up, filing complaints, whistleblowing or even, as in the case of control operators, refusing to operate under shifting conditions that undermine safety. The prospect of this resistance can itself be a deterrent to higher level policy shifts away from safety.

Conclusion: The Safety Culture and Organizational Structure Relationship. From this analysis it should be evident that both safety management structures and reinforcing culture are necessary for reliable, effective and continuing safety performance in an organization across the scope and time frames required for safety performance. Macro-level design and strategy, including long-term commitments, resource investments, planning, and integrated decision-making across an extended time-frame and system-wide scope are necessary. But micro-level communication and coordination, error signaling, and personal engagement with safety applied down to specific actions in real-time are also required. Both structure and safety culture, in other words, are important elements in enabling the effectiveness of one another.

In summary, upon closer inspection, it turns out that:

)1) The concepts of both safety and safety culture are under-developed in organizational analysis. This has led to ambiguity and confusion in our understanding of the causal relationship between safety culture and specific elements of organizational structure.
)2) There is more overlap between structure and culture as features of organization than might be supposed. The actual content of structural elements such as roles and rules, functional lines and limits of authority, accountability and communication can themselves be cultural artifacts and require closely supporting cultural norms of acceptance to actually function as formally described. The formal organization chart can offer a misleading picture of actual transactions occurring within a functioning organization.
)3) But the relationship between structure and culture can vary across the different phases of initial cultural *change*, subsequent safety culture *development* and the continued *maintenance* of a safety culture.

Future Research and Regulatory Implications

This essay began with a set of questions posed by a regulator looking for advice on structural options it could impose to promote a safety culture within one of its regulated utilities. It is important to draw some practical implications from this review of findings and uncertainties in our understanding of the relationship between organizational structure and safety culture, for the purpose of helping to answer some of these questions.

While often frustrating to those looking for decisive regulatory "solutions" to increase safety and prevent accidents, it is important that safety researchers highlight that both structure and culture are part of multi-variate relationships, not only between themselves but also in the production of safety outcomes. Many variables, such as the character of technology, the scale and geography of systems being operated, the public risk tolerances surrounding these systems and the regulatory competence applied to them intervene in culture, structure and safety relationships.

It is essential that safety researchers do not ignore the ambiguities and complexity in our knowledge base relative to the promotion and management of safety but instead keep alive questions, even as we try to resolve them through careful research. Otherwise questions about

[20] For an insightful description of these surgical norms and their role in the training of surgeons see Charles Bosk, *Forgive and Remember* (2003).

[21] An insightful psychological analysis of the difficulty of maintaining constant mindfulness is Ellen Langer, *Mindfulness* (2014).

[22] A description of this process can be found in Dekker, *Drift Into Failure* (2018).

these relationships and any ambiguities and uncertainties concerning them will simply be "resolved" by legislators, regulators, and lawyers in single factor "solutions" as needed to reach closure in formal proceedings[23]. An artificial simplification through normative or legal prescription is the opposite of a high reliability approach to safety.

But what research can we undertake to be able ultimately to offer empirically tested and validated answers to questions such as those posed by the California Public Utilities Commission? What practical advice can we currently offer regulators and infrastructure managers given the current state of our findings?

Research Requirements. Currently many organizational and managerial "pathologies" have been described in case studies comprising much of accident research. But these pathologies – such as the "normalization of deviance"; rigidification; "brittleness" (as opposed to "resilience"); practical drift; a culture of punishment and blame; ambiguity in authority or accountability; decision bias; "groupthink"; goal-displacement; communication blockages; information silos, etc. – are expressed in natural language with all of its ambiguities and imprecision. As insightful and useful as the case studies of accidents have been[24] these concepts have not been standardized in their definitions and descriptions, let alone been translated into measurable variables.

That means that those management or organizational conditions tied to accidents are described in terms that do not allow careful additive or comparative measurement across cases. It is difficult to learn about the impact of organizational and managerial factors both positive and negative with respect to safety across organizations if these factors are expressed simply as binary nominal categories (present or absent) without standardized definitions and without some ordinal, if not interval, variables that can describe *more or less* of them.[25]

We cannot aggregate findings in a way that could allow us to discover the causal contribution of these organizational factors, at their current level of specification, as independent variables in relation to given safety outcomes. Nor can regulators measure what level of improvement an organization may be making in relation to these pathologies.

It would therefore seem that a first step to clarifying current ambiguities in our understanding and findings concerning relationships between structural options and safety culture promotion is through clearer conceptual specifications and the development of measurements for both. Then, it is also important to develop a set of safety performance metrics that are in effect *leading* indicators of safety as an organizational process – to supplement the traditional lagging performance metrics of incidents or accidents.

There is always a danger in imposing a false precision by a number that ignores the ambiguity or complexity in a phenomenon. But there are leading metrics that have been offered to cover safety practices such as employee training hours, corrective action reports, and budget investments in safety improvement. Questionnaires have been used to survey employees in order to uncover assumptions and attitudes related to safety culture. Metric development should be undertaken as an experimental process – with a view to continually re-assessing the reliability of measures and their validity in relation to safety behavior and outcomes. There should also be multiple metrics for each feature of management and culture to avoid single high-stakes metrics which might invite distortion, gaming or goal-displacement. Collecting multiple metrics can actually help organizations identify safety precursors that might not yet have been understood. Further, metrics can establish baseline levels of safety management and culture against which future progress or possible regression can be tracked over time.

Regulatory Requirements. One of the factors that seems to mediate the effects of structural variables such as public or private ownership on safety performance is regulatory quality. The development of an effective safety management system, including a safety culture within an organization, seems to depend at least partly on the competence and effectiveness of its regulator. Does the regulator promote the development of safety metrics among its regulated organizations, for example? These should include measures of process safety practices in operation as well as measures of precursor management – the degree to which an organization has defined and recognizes precursor conditions, and the corrective action processes it has in place with respect to them.

Does a regulator promote improvement in safety management among its regulated organizations or does it simply assume, as one regulatory inspector stated: "as long as they follow our rules they're safe"? As a basic inspection requirement, the National Academy of Engineering has asserted that "One challenge for all regulators is changing the mind-set of inspectors from inspecting for compliance to advocating for safety culture." [26]Do a regulator's inspectors have any training in safety management and safety culture?

Finally, is a regulator pushing for excellence in safety management or simply adequacy? As one regulatory analyst has observed: "If [utility regulators] award a secure profit stream [to organizations] for adequacy instead of excellence, they will operate to adequacy and not excellence, and the inevitable slippages will be departures from adequacy rather than excellence."[27] It can further be noted that there will likely be far fewer performance lapses from excellence because excellence in safety management includes self-monitoring and continual system improvement.[28]

The CPUC Challenge Specifically. Given the state of our understanding in how to "grow" a safety culture and the role of structural features in this process, any structural options chosen or promoted by the California Public Utilities Commission for PG&E will inevitably constitute "risky bets" in relation to its safety objectives. To put it another way, any structural strategy the Commissions prescribes for PG&E will be a hypothesis and should be treated as one.

Therefore, the CPUC will need to continually inspect, evaluate and review progress being made by PG&E in developing a safety culture. It can expect this process to have its ups and downs and to take years, not months. It will not happen on a pre-planned timetable.

Yet currently, the CPUC doesn't even have an adequate inspection force to monitor the many units and assets of PG&E. Its inspectors can only make periodic visits to regulated organizations and do not have time to closely observe specific operations.[29] Nor do its current inspectors have training in safety culture. The CPUC does not currently regulate for either safety culture or safety management.

One obvious and practical suggestion is to recommend to the CPUC

[23] A very insightful discussion of how this process can occur can be found in Johan Bergstrom (2020).

[24] An insightful account of the importance of case studies to our understanding of accidents can be found in Jan Hayes, "Investigating Accidents" (2020).

[25] This has also been a problem in high reliability organizations research in which "high" reliability as an identifying concept has been left as a nominal category with no way to identify "higher" or "lower" reliability organizations. This has also undermined the formulation of developmental models that could describe how organizations might become HROs.

[26] National Academy of Engineering, *Strengthening the Safety Culture of the Offshore Oil and Gas Industry* (Washington, DC: The National Academies Press, 2016), p. 5. https://doi.org/10.17226/23524.

[27] Scott Hempling,"Effective Regulation of Public Utilities." (https://www.scotthemplinglaw.com/essays/competition-for-monopoly)

[28] A description of the self-monitoring and correcting features of excellent safety management systems can be found in Institute of Nuclear Power Operators (INPO), *Traits of A Healthy Safety Culture* (2013) (https://www.nrc.gov/docs/ML1303/ML13031A707.pdf) and also in FAA, *Safety Management Systems* (https://www.faa.gov/about/initiatives/sms/) see the elements in the Safety Assurance pillar.

[29] By way on contrast since 1978 the Nuclear Regulatory Commission has had a resident inspection force of 150 persons with 2 full-time resident inspectors on site at all the nuclear power plants and nuclear fuel production facilities it oversees.

that it significantly beef up its inspection force. This upgrade should not only be in the number of inspectors, but also in their training in safety management and safety culture.

Secondly, the Commission should begin to work with PG&E and its other utilities, in an ongoing R&D process, on the development of metrics on safety management and culture as leading indicators of how well they are putting in place a system of safety based in organizational processes, both structural and cultural, that create "dynamic non-events". This as opposed to the Commission's current approach of looking only at lagging indicators which do not allow it to differentiate safety in a utility from the statistical good fortune of so far "failing to fail".

Finally, the Commission should look to its own "regulatory reliability" with respect to safety. This would entail recognizing and listening to its own reliability professionals with respect to deficiencies in its current safety regulations. It would also entail a constant search for ways to test and improve its own effectiveness in safety regulation – starting, of course, with measuring and monitoring the impacts of its own regulatory decisions concerning the restructuring of PG&E.

In this way the process of safety regulation can become its own research and learning process. The CPUC as well as other regulators can and should, in their regulatory practice, be making their own contributions to the advancement of safety science.

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