Strengthening reliability in high hazard industries: reconciling tensions for impact

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Abstract

Purpose – Recent lapses in the management of high hazard organizations, such as the Fukushima event or the Deepwater Horizon blast, add considerable urgency to better understand the complicated and complex phenomena of leading and managing high reliability organizations (HRO). The purpose of this paper is to offer both theoretical and practical insight to further strengthen reliability in high hazard organizations.

Design/methodology/approach – Phenomenological study based on over three years of research and thousands of hours of study in HROs conducted through a scholar-practitioner partnership.

Findings – The findings indicate that the identification and the management of competing tensions arising from misalignment within and between public policy, organizational strategy, communication, decision-making, organizational learning, and leadership is the critical factor in explaining improved reliability and safety of HROs.

Research limitations/implications – Stops short of full-blown grounded theory. Steps were made to ensure validity; however, generalizability may be limited due to sample.

Practical implications – Provides insight into reliably operating organizations that are crucial to society where errors would cause significant damage or loss.

Originality/value – Extends high reliability research by investigating more fully the competing tensions present in these complex, societally crucial organizations.

Keywords Reliability, Qualitative, Nuclear, High hazard, Non-profit, High reliability organizations

Paper type Research paper

The intersection of high hazard industries, the high risk organizations that operate within them, and the stakeholders these organizations serve are a source of considerable debate spanning profit and non-profit arenas (Boudet *et al.*, 2014; He *et al.*, 2013; Lengefeld and Smith, 2013; Mancini *et al.*, 2014). Without question, high hazard industries, many of which are energy related, are a considerable source of economic output. For instance, in the USA alone, total energy expenditures was 6.8 percent of GDP in 2011 and that expenditure ratio is expected to continue through 2040 (US Energy Information Administration, 2013a, p. 57). In addition, the advent of new technologies, such as hydraulic fracking, are direct and causal factors explaining the US surge in global energy leadership. Specifically, the USA is now in a position to be a net energy exporter of natural gas (US Energy Information Administration, 2013c)

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and perhaps the world's largest oil producer by 2017 (Reuters, 2013). These economic benefits, however, do not arise without some costs and concerns. At the intersection of the management and operation of high hazard industries are profit and non-profit players that exact and expect sterling, if not perfect, safety and reliability records. When these expectations are not met, entire industries are at stake. For instance, after the Fukushima event, Germany's political leadership bowed to public activists and special interest groups to shutter its nuclear facilities by 2022. These energy facilities currently amount to 23 percent of Germany's electrical grid (Dempsey and Ewing, 2011). Thus, the purpose and aim of our research study and of mutual interest to both profit and non-profit players is to best understand what factors contribute to the safe operation of these high-risk organizations that demand high reliability. These high reliability organizations (HROs) are firms that ideally achieve low error rates in industries where an error could cause significant damage and loss (Roberts, 1990).

Despite the economic and societal impact of these special industries and the organizations that operate within them, the theoretical and empirical research focussed on them is surprisingly limited and not well understood. Existing research into HROs have mostly focussed on one of several industries: aircraft carriers (Rochlin *et al.*, 1987), air traffic control (La Porte, 1988; Weick, 1987), and nuclear power plants (NPPs) (Marcus, 1995; Schulman, 1993). Scholars argue that any high hazard industry occupies a special space within the public psyche because of the social tensions they create such as the economic benefits vs the potential safety costs described above (Carroll and Cebon, 1990; Carroll and Hatakenaka, 2001; Carroll *et al.*, 2002; Offstein *et al.*, 2013). Without question, the myriad of safety systems and the sheer number of interested stakeholders, to include the central role of public and non-profit stakeholders, make high hazard organizations, such as NPPs or oil refineries, particularly difficult to manage and lead (Carroll and Cebon, 1990; Offstein *et al.*, 2013; Perin, 1995, 1998). Ironically, these management challenges rarely arise from technology issues. For instance, across competitors, technology, the process and techniques of production and distribution, is relatively uniform and constant. Indeed, in oil refineries and, especially in NPPs, the technology is stable and uniform with several dominant manufacturers and vendors dominating market share (Carroll and Cebon, 1990). Importantly, with the technology and equipment close to uniform and consistent, the driving factors explaining success in strengthening reliability tend to be unrelated to technology and distal from equipment (Offstein *et al.*, 2013). Rather, the factors that tend to separate safe and reliable high risk organizations from those that are not are social, political, human-capital, and leadership related (Carroll and Cebon, 1990). Consequently, the purpose of our study, again, is to better understand these forces and how they strengthen or weaken performance and reliability.

This study recognizes the surging interest in the effective management of HROs. Indeed, these organizations are unique in that they demand a shared governance mentality that spans the public, non-profit, and for-profit sectors. Our core research addresses a practical problem with policy and strategy ramifications directly applicable to the organizations themselves, but also to government and quasi-government agencies and professional associations that maintain the most important of all public duties and charges: to regulate in a manner that keeps the public safe. Our penultimate purpose, then, is to seek and understand what forces exist that affects the management and safe operation of high hazard industries and HROs. Furthermore, we aim to ascertain how these forces can be proactively and adequately managed to strengthen reliability; thus, providing for the ultimate public good. We will discuss and draw upon decision making, strategy, organizational behavior, human resource management, organizational learning, political behavior, collaboration and conflict among public, non-profit, and private organizations. Also, we focus on integrating expertise from scholars, managers, and consultants to approach our research question. The setting of this study: energy firms and utilities, in general, and NPPs, in particular, is perhaps the best economic exemplar of the intersection of public, non-profit, and private enterprise. Indeed, given the historical regulatory ownership of these enterprises and, even its continued governmental focus amidst some growing trends toward deregulation, this setting and sample is ideal to explore the interconnectedness and tensions present in high hazard organizations.

Methodology

Our primary research question was to better understand the social, political, behavioral, and leadership forces that impact HROs. Given the tremendous richness, complexity, and contextual influences that span multiple levels of analysis within high hazard industries (Carroll, 1998; Offstein *et al.*, 2013; Perrow, 1984; Weick *et al.*, 1999), we employ research tactics closely aligned with the qualitative research tradition. Specifically, we follow some specific recommendations and traditions from organizational scholars (Gibson and Hanes, 2003; Sanders, 1982), in general, and HRO qualitative researchers (Klein *et al.*, 1995; Roberts *et al.*, 1994; Weick *et al.*, 1999), in particular, that suggest phenomenological studies as the best approach to capture the nuance and complexities of organizational life. While our phenomenological inquiry stops short of a full-blown grounded theory study, we do offer a combination of theoretical propositions and relationships, as well as, actionable insight for practitioners.

To address these research imperatives, we engaged in a unique research protocol that addressed several common refrains calling for better and more innovative research designs. First, we heeded a call from leading scholars to work directly in the field, with practitioners (Bartunek, 2007; Rynes *et al.*, 2001). Specifically, this study is the result of interplay between "boundary spanning" academic scholars alongside practitioners in the field (Bartunek, 2007, p. 1329). In particular, scholars accompanied energy consultants on project work over a contract period exceeding three years.

Second, our object of study included several NPPs spanning three major utilities. Two of the utilities are publicly traded enterprises and are Fortune 500 firms. The first utility has yearly revenue of more than $12 Billion, 1,550 employees, and is responsible for 2.2 percent of the USA's energy grid (US Energy Information Administration, 2013b). At the time of submission, this utility was involved in all spectrums of our nation's energy profile (e.g. natural gas, hydro, clean coal). At a global level, this utility's energy strategy involved generation, distribution, and billing from the midwest to the mid-atlantic to northeastern regions of the USA. Unique to this specific utility, a decommissioning of one of their fleet's NPPs occurred during our study, which involved massive involvement from a variety of players – profit, public, non-profit, governmental, and quasi-governmental. The second utility mirrored the first in terms of its energy profile and strategy. Unique to this utility, it underwent a controversial merger with another utility that engaged a myriad of diverse stakeholders to include state and federal regulators in both the energy spectrum but also in the finance and governance arenas. Our third utility occupies a different and storied present and past compared to the others. The third utility was created in the 1930s as part of the New Deal legislation portfolio aimed at driving economic enhancements – especially in rural areas along the Appalachian and Blue Ridge regions of the US (Tennessee Valley Authority, 2014).

This decidedly non-profit organization works alongside and competes against for-profit and publicly traded utilities. While the regulations were similar between this non-profit, government controlled utility, they were not exact. Over a three year period, we engaged three utilities responsible for 11.3 percent of our nation's energy grid on any given day.

Third, across five NPPs, we employed a purposeful sampling technique that aligned closely with the project work of the consultancy. Specifically, during a series of qualitative, semi-structured interviews, we captured all ranks/grades of personnel. These positions included, but were not limited to, shift managers, systems, components, and design engineering managers, managers and directors from the Safety and Licensing division, a variety of training and specialty training managers, unit shift supervisors (front line supervisors), a variety of maintenance and specialty maintenance managers, work control managers, chemistry managers, emergency management leaders, the plant manager, and the site vice president (the highest ranking employee/official) on site. In addition, we interviewed and observed hourly employees that included plant equipment operators (PEOs), sometimes referred to as auxiliary operators. We also faced, interviewed, and observed corporate personnel to include CEOs, chief nuclear officers, senior vice presidents of nuclear operations, and corporate oversight officers. We also observed and interviewed several key regulatory personnel primarily from the quasi-governmental oversight organization: the Institute of Nuclear Power Operations (INPO). INPO is regarded by the Nuclear Regulatory Commission (NRC) and also by the utilities as a major force in policy formulation and regulatory compliance, and a source of operational and leadership guidance for the nuclear industry. Most of the personnel we interviewed were veterans of the industry with many eclipsing 20 + years of nuclear service. A majority of the participants in our study were highly educated with at least an undergraduate degree with many carrying a graduate degree usually in a specialized field such as mechanical, chemical, or nuclear engineering. Importantly and, possibly a point of departure from other high hazard industries, approximately half of our participants had military service. In particular, a significant number of nuclear personnel have roots in the Navy as beneficiaries of the Navy Nuclear Power education program. While our interviews involved men and women and a mix of ethnic backgrounds, the preponderance of our participants were white males with an average age exceeding 50 years. This is in line with industry standards; the nuclear field has been characterized, for years, as dominated by an aging workforce (Nuclear Energy Institute, 2011). While the partnership and involvement in the study was not necessarily voluntary as it was part of larger, corporate funded consultancy projects, coaching and confidentiality agreements were brokered with the participants. We interviewed and/or observed over 175 leaders during this three year period. When combined with the consultancy's 12 executive coaches on staff and a review of their notes and coaching assessments, not a single complaint was lodged regarding our interviews and/or observation. In fact, high levels of trust occurred where several participants engaged either the scholar(s) or the consultants even after the contract period had ended.

Lastly, the scholar-practitioner partnership with the consultancy allowed unfettered access within the nuclear facility. The partnering agreement between the researchers, the consultants, and the leadership of the NPP retained a clause that allowed, and even encouraged, access to every department and all meetings at the NPP. These included such important meetings as Nuclear Safety Review Boards (NSRBs), Department Self-Evaluation Meetings (DSEMs), Metric Review Meetings (MRMs), Root Cause Evaluation (RCE) meetings, mid-shift briefs, crew hand-offs, and Corrective Action Review Boards to name just a few. Access of this type is uncommon and required social capital, trust, and, on occasion, debriefs to senior leaders on site and at corporate headquarters regarding our findings. We also had access to internal documents and some specialty industry reports. For instance, we reviewed strategic plans, continual improvement plans along with reports such as INPO exit briefs, Significant Operating Experience Reports, and several "Principles" documents from INPO such as *Principles for a Strong Nuclear Safety Culture* (2004).

Much of the research on high hazard industries focusses its attention on NPPs or military organizations (e.g. naval carriers). Thus, one of our key concerns was how well our findings would apply to other high hazard industries such as oil and gas firms or refineries. To better ascertain this, we presented our findings to key stakeholders with knowledge of best practices within the global energy industry. Specifically, we first approached a large, multi-billion private equity group with specialty knowledge in the energy sector to gauge external validity. We then spoke to a specialty engineering firm that focusses on equipment reliability issues within the oil, gas, and refinery sectors. Moreover, we accompanied this niche engineering firm to a sales call with an international client to also see how and what ways our findings correlated. Lastly, through a purposeful sampling technique that drew heavily on social media, we directly contacted and discussed some of our findings with two high-level managers at global oil and gas firms. It is important to note that none of the interviews were fully transcribed. A short-hand version of transcription usually occurred and was often sent back to the people who were being coached, interviewed, mentored, or developed via e-mail.

With the interviews, observations, and survey of many documents, we began a primitive sort of the data, which is often done within the nuclear industry via a practice called "binning[1]." Pursuing a method not entirely unlike the constant comparative method common in grounded theory research (Creswell, 1998; Glaser, 1992; Strauss, 1987), we created categories and attempted to link/connect categories. It was from this analysis and the open dialogue between the scholars and practitioners that several themes emerged. Keeping in mind that this study stopped short of a full-blown grounded theory research endeavor, we do offer several recurring and strong themes that emerged from our analysis and inquiry. It is these themes that we present now.

Findings

Tensions and the friction that result are common within organizations (Clegg *et al.*, 2002; Smith and Lewis, 2011). For example, tensions can emerge within a firm as the firm balances the pressures of exploration and exploitation where current operations may be harmed while seeking future opportunities (Birkinshaw and Gibson, 2004; Tushman and O'Reilly, 1996). Notably, tensions can cause mis-alignment issues where goals conflict (March, 1991; Margolis and Walsh, 2003). Also, tensions cause angst arising from formal and informal communications issues that emerge from these tensions. In addition, tensions and the oft-seen contradictions seemingly affect organizational functions such as role assignment and the role clarity that accompanies the assignment of roles (Pratt and Foreman, 2000). While the scholarly aim is to understand tensions and the practitioner aim is to resolve them, both are inherently difficult to do (Poole and van de Ven, 1989; Smith and Lewis, 2011). Perhaps, the best that organization scholars can do is to spotlight competing forces or tensions. This awareness may allow for profit and non-profit stakeholders to manage these tensions (Golden-Biddle and Rao, 1997; Quinn, 1988; Smith and Lewis, 2011). Thus, the goal of exposing organizational contradictions is to manage tensions – not to solve them. It is these tensions that we describe below.

Balance of regulation and simplicity; the signal and noise effect

High hazard industries deserve heightened attention due to their very nature; a hallmark of high hazard industries is the catastrophic impact that can unfold from equipment breakdowns or human errors (Rochlin, 1993). Given this inordinate and mammoth risk, there is an economic, if not purely rational impetus to revert to a heavily rule-oriented system (Roberts and Bea, 2001), where one senior leader remarked that sometimes "regulators confuse many regulations with good ones." Of course, regulators and non-profit enterprises come under particularly heavy public scrutiny after a "high-impact" event such as Fukushima or the Deepwater Horizon scenarios. For instance, we know of one facility that was facing enormous capital outlays to meet a coming rule change that required higher flood embankments/walls. This new NRC guidance, soon to become regulation, surfaced quickly after the Fukushima event (United States Nuclear Regulatory Commission, 2013). Capital outlays to meet the safety requirements of a 500 or 1,000 year flood posed significant challenges. However, we noticed that another unintended consequence was that interpretation and compliance with these new, upcoming rules taxed the cognitive and staffing capabilities of the site's engineering department. Ironically, it appeared that the new and increased regulations that impacted future safety could have negatively impacted current reliability. One systems engineer that we talked to estimated that he spent a full 40 hours in any given week fielding Fukushima and flood meetings, calls, and reviews of proposed regulations. He lamented aloud to us that:

> […] the intent of the new regulations are good, but at the very least, we need an engineer devoted entirely to Fukushima as my old requirements and my prior 55 h week isn't going away anytime soon […] instead, I've told my wife to be prepared for a 70 h week until these regulations are sorted out.

Keep in mind, the event detailed depicts an industry wide frustration. More of the same seemed to occur at a micro or case-by-case basis. For instance, we came to know of a plant that had a series of small performance lapses that culminated in a fairly egregious Human Performance (HU) event that directly impacted nuclear safety and reactivity. Due to this poor performance, the plant received heightened oversight from a variety of profit and non-profit stakeholders such as INPO, the NRC, corporate oversight, fleet help from other stations within the utility, more periodic and substantive executive oversight, along with visits from state regulatory agencies. This more emphatic oversight coincided with more media attention – both locally and regionally. A series of programs, corrective actions, and rules were instituted to deal with the declining performance. Ironically, however, given this more robust oversight, performance actually declined farther and faster over a six month period culminating in a reactor trip as a unit emerged from an outage and began to raise power. One of the authors queried several leaders about this phenomenon. Namely, how could one explain worsening performance in the face of heightened oversight? A common theme, from multiple levels within the organization, was that the added oversight, regulations, and programs caused an administrative burden and taxed an already fragile system. One PEO, with many years of service, suggested that when performance declines, individuals and departments actually need less regulation – not more:

> We should be focused on the blocking and tackling. We should be focused on solid operator fundamentals. We're not. We should revisit the basics. We're not. Instead, we're scrambling with new programs, new interventions […] all the while, it seems like we are on constant show as the number of visitors here has exploded tenfold in the last 60 days. What we need, more than anything, is focus. We crave for simplicity right now and we're just not finding it.

What we found here is that the most effective managers are successful in that they can focus in the midst of chaos. One senior VP of Nuclear Operations, sensing a tidal wave of oversight and feedback, chose to dial back into core, command priorities. He remarked that "every time I'm up here I double down on my three command priorities [...] hopefully this is cutting through some of the noise." One of our initial and strong findings centered on this paradox and contradiction. To repeat the dominant logic, poorly performing plants often lack requisite levels of focus. When their errors reach a trigger threshold, more regulation and oversight occurs, that further detracts from focus. Importantly, to break the chain, a courageous leader must often revert back to simplicity and core business, even if it means disregarding some programmatic improvement efforts.

Scholarly research informs us as to the danger of this phenomenon. *Post hoc* analyses of almost all of the major industrial catastrophes of the last 40 years (i.e. the Union Carbide event in Bhopal, NASA's Challenger disaster, and Three Mile Island) indicate that some warnings were present prior to the event (Marcus *et al.*, 1990; Weick *et al.*, 1999). These warnings, however, went either unnoticed or not detected and a major reason why was the preponderance of "noise" found in these organizations. Put simply, the more "noise" in a given organization, the more difficult it is to detect a danger "signal." To Carroll and Cebon (1990), a mainstay of truly superior performing industrial plants is to reduce the "noise to signal" ratio. Put differently, in any given organization, faint signals cannot be detected when there is too much noise. We found that this noise takes many shapes and forms, but all share a common theme; noise is often the result of managerial and regulatory overreaction. Thus, a core learning applicable to a myriad of profit and non-profit stakeholders is to not overreact whether that be in the form of regulations, new corporate rules, more fleet procedures, or leadership interventions. Rather, it seems that simplicity does, indeed, offer some of the best hope toward performance gains because simplifying, at its essence, reduces the noise to signal ratio (Figure 1).

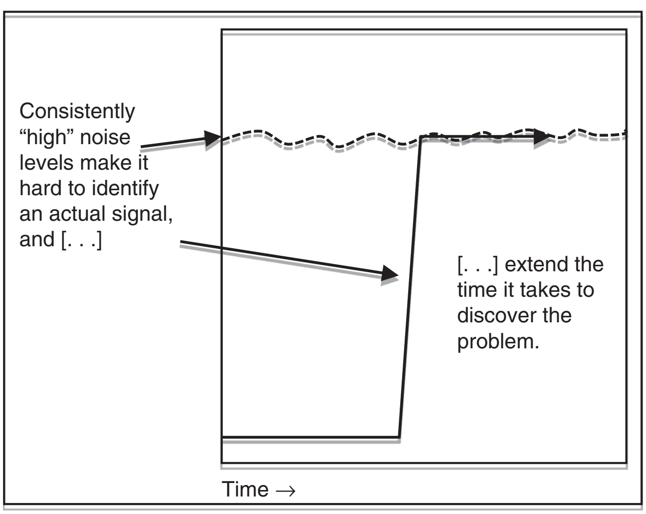

Figure 1.
Noise delay of problem identification

Balance of learning – rule based, systems knowledge, and internal and external operating experience (OE)

After Three Mile Island, the nuclear industry courageously revisited some long-held assumptions about industry performance (Carroll and Cebon, 1990; Kemeny *et al.*, 1979). One of the most enduring takeaways from this industry-wide debrief was an emphasis on how NPPs, as organizations, learn and share OE. Indeed, even the most cynical opponents of the nuclear industry agree that learning has been a focus for the greater part of four decades – a focus that rivals the airline industry and the Federal Aviation Administration in terms of sharing lessons and learnings across peer groups (Carroll, 1998). Of particular note, all plants – whether competitors or not – are not only expected to share learnings immediately, but they must share their learnings. For instance, we sat in on several Plan-of-the-Day meetings where events or incidents occurring over the last 24 hours at one of the 100 NPPs in the USA were discussed. This, of course, is indicative of learning in real time. Importantly, the centrality of learning is well chronicled in both academic and applied arenas; many contend that how organizations learn directly impact their competitiveness (Argyris and Schön, 1978; Nonaka and Takeuchi, 1995).

As we surveyed, observed, and interviewed the top operations managers, shift managers, unit supervisors, and senior reactor operators (SROs), we noticed a subtle, but significant, way in which they processed information, formed knowledge, and, then, disseminated their understandings.

The most basic and rudimentary, but important, knowledge attainment was rule based. In this sphere, operators and others that manipulated plant equipment were expected to know the rule or, as we heard hundreds or thousands of times, "what does the procedure say." Thus, at this level and a level which is hypothesized to predict the safety of the public, is a necessary mandate to know and follow the rules or follow the procedures. A common refrain that we heard is that "top performing organizations have great procedures." Without question, the willful or unintended choice to not follow the procedures often put a plant in an "unsafe" condition. We observed on several occasions where failure to adhere and use procedures, tripped the reactor. A tripped reactor is an unplanned outage and in this state produces no energy or electricity, which often causes the utility to pay market prices to pay a third party for electricity that they were contractually obligated to provide to a customer. Despite the meaningful consequences afforded to those that do and do not know or follow the procedures, we found this level of knowledge foundational, if not basic. In other words, we found this rule based or procedure-based learning to be a necessary but not sufficient condition for reliable plant operations.

Rule or procedure-based knowledge, we found, is much like single loop learning. It is a type of knowledge that is linear and driven by cause and effect orientations (Argyris and Schön, 1978; Nonaka and Takeuchi, 1995). Unlike our discussion above, we found that some plant operators used or fronted rule-based knowledge as cover for a poor operational judgment and decision. For instance, in one training simulator we witnessed a poorly performing crew argue during the simulator debrief that "we just followed procedure" and "that's where the procedure took us" or "that's what the procedure told us to do." Finding the fault lines in this reasoning is rather straightforward. Rule-based knowledge tends to work best when the problems that one or many face are structured in nature (Mintzberg *et al.*, 1976; Nonaka and Takeuchi, 1995). Structured problems are seen often, are usually not surprises, and have proscribed routines to deal with them. Rule-based learning, and certainly the procedure focus we observed, is akin to checklist models of learning and understanding. Without balance, nuance, and the blending of other forms of knowledge, a degraded plant condition can occur. This is based on two additional findings common to all organizations, not just high hazard operations. Notably, procedures account for the knowable or for events that have occurred before. Even the most comprehensive and well-written procedures cannot account for all possible contingencies within any organization – but especially the more complex HROs (Carroll and Cebon, 1990). It is in this gray space, in the face of unstructured problems as opposed to structured ones that rule-based knowledge exhibits its shortcomings. In addition, an over reliance of this type of knowledge without sophistication, without nuance, and without the balance of other forms of knowledge actually hampers and works against true learning. Notice the impersonal tone along with the lack of accountability and ownership that attaches to the simulator comments such as "that's what the procedure told me to do" or "I was just following procedure."

One of the RCEs of a significant plant event was that operators and their immediate supervisors did not fully understand plant systems and how following a poorly written procedure could or would impact other equipment systems within the plant. Two specific corrective actions followed this RCE. First, in licensing school and for requalification of licenses, operators would need to draw systems via flowcharts to demonstrate the understanding of different equipment systems such as circulation water systems and how these equipment groups interplayed with other plant systems. Second, during mid-shift briefs, front line supervisors were required to devote a portion of the mid-shift brief to "system knowledge." When this level of understanding is combined or allowed to co-exist with rule-based knowledge an interesting team, department, and organizational phenomena occurs. Specifically, Weick and Roberts (1993) found evidence of this phenomenon during their study of Navy aircraft carriers. They referred to it as a collective mind or a heedful understanding; it was the knowledge of how an individual's role and adherence to a procedure impacted and affected the larger system/organization (Weick and Roberts, 1993). Thus, we found that organizations and departments that embraced both rules-based and systems-based knowledge formation tended to outperform those that relied on one at the exclusion of the other.

Interestingly, the nuclear industry seems to understand the inherent dangers of blindly following rules or procedures at the expense of additional and contrary information. One of our more interesting findings is that higher performing groups, departments, and plants deployed procedures to ward against the dangers of procedures. More specifically, high performing units embraced the use of HU tools to challenge the rote following of procedures. HU tools took several forms but often were proceduralized in the form of heuristics. While most heuristics are meant to deal with structured or semi-structured problems in times of stress or panic and time constraints (Klein, 1998), the heuristics used by NPPs were meant to invoke not action, but, rather, deliberate and purposeful thought. For instance, a common tool that we observed was the use of the S-T-A-R heuristic. This decision-making tool was used during pre-job briefs (PJBs) and task preview evaluations. This heuristic stands for stop, think, act, and review. Again, the essence of employing this heuristic was to align or attach purposefulness, central processing, and intentionality alongside the demands of following procedures that often, without the above intervention, lead to thoughtless action. Thus, a major finding that separated highly performing teams and departments from others was this ability to marry purposeful thought with the necessity of following procedures. Importantly, under the auspices of the Think step, the very best operators and supervisors initiated intrusive questions that actually challenged the efficacy and legitimacy of the procedure. For instance, we heard one supervisor ask an operator "What is the worst that could happen from what you are about to do?" This question appeared to jolt the operator out of rule or procedure-based knowledge. After this line of questioning, the supervisor then offered "When you manipulate this valve, what do you expect to happen? And what will you do if what you see doesn't meet your expectations?" This last line of questioning invoked what scholars call double loop learning. Double loop learning looks at assumptions behind knowledge. As such, when this level of learning is triggered, individuals seem to get a better understanding of the why and the intent of a piece of given knowledge (Argyris and Schön, 1978). Here, we saw the operator struggle with the intent of the procedure. The supervisor cleverly pushed the operator to consider the why of the procedure – not just following the rule for the sake of the procedure. Again, the irony is that heuristics (a form of learning procedure), often used to drive action in difficult situations, were actually used to drive reflection; in high performing NPPs, these heuristics encouraged reflection in the face of constant action. Indeed, scholars such as March (1991) argue that one of the great tensions is striking the balance between knowledge for exploitation (procedure/rule based) and knowledge for exploration (reflection and systems based). In conclusion, reliability seems to be reinforced when rules and procedures co-exist with deeper learning and cognitive mechanisms; where exploitation and exploration are mutually encouraged and mutually reinforced.

Another ancillary, but important, finding revolved around the sheer abundance of information, feedback, and lessons learned and how that feedback is used to impact reliability. Notably, high hazard organizations are often under a deluge of information uncommon to normal organizations (Perrow, 1984; Weick and Sutcliffe, 2007). The sources of this information originate from a myriad of different sources to include corporate stakeholders, energy regulators at the state and federal level, and industry watchdogs to name a few. Managing this tidal wave of information and feedback is difficult and pushes against individuals' bounded rationality (Simon, 1957) and the absorptive capacity of the organization (Cohen and Levinthal, 1990). Namely, organizations face a learning paradox – as the amount of information increases, the individual and organization could actually learn less. Of course, the sheer abundance of information speaks to our earlier finding where noise drowns out important signals that could negatively impact reliability. Our purpose below, though, is to highlight learning effects.

Central to the high hazard industry, in general, and NPPs, in particular, is the fundamental drive to share lessons learned (Carroll, 1998). Much like airlines, when an accident or near miss occurs, there is an industry wide push to disseminate that information to every industry player as quickly as possible. The same is true for NPPs. However, we offer some critical findings that, to our knowledge, have yet to be discussed with the gravity they, perhaps, deserve.

First, lessons learned, feedback, or knowledge can be categorized along several dimensions. We offer the beginnings of a taxonomy below. Notably, knowledge and learning can either be technical, operational, or leadership/behavioral. The best performing departments and plants, not surprisingly, seemed to do two things well in regard to this classification scheme. Specifically, they would almost grossly accentuate the type of knowledge/learning under study so as to eliminate confusion and to make clear that the group was in leadership as opposed to operational space. At each station we engaged with, the beginning of every Plan of the Day meeting began with a safety message, and one station followed this with a leadership lesson of the day. Second, the best performing plants, often led by progressive training departments, balanced the technical, operational, and leadership/behavioral lessons. One successful training manager remarked:

> We must be technically competent. This is the atomic unit. If we aren't technically competent, we can't even get off the starting line. If we are technically competent, but lack systems knowledge and good operational decision-making, we can't keep the doors open; we can't keep the units running. If there's no leadership, at the very best, this place becomes an unpleasant place to work and we never optimize as a team. At its very worst, we have a Davis-Besse […] we have a nuclear safety culture issue. It's a three legged stool. Two without the other is a doomed plant. Too many organizations just devote their energy to one of these legs at the expense of the other.

Another categorization of knowledge involves internal vs external sources. OE is the moniker for lessons learned. OE can come from a variety of sources but there are three or four dominant sources. First, OE can be internal lessons learned that originated from that plant. An interesting finding or relationship surfaced between turnover, tenure, and OE. In particular, the plants with the lowest turnover and the longest tenure seemed to harken back, the most, to internal OE. In confronting one operational problem, an experienced operator mentioned "we have OE here from 2005 and 2002 and we've seen this before." We heard some personnel refer back to events as early as 1979. Of particular interest, this source of OE tended to exist primarily with hourly workers up through front line supervision. The next source of OE is considered fleet OE. Few high hazard industries occupy a single plant or refinery and the same applies to our nation's nuclear fleet. With few exceptions, many utilities own and operate multiple reactors spanning large swaths of geography (i.e. Exelon, Dominion, PSE&G, and TVA). Because the lessons of fleet OE are internal to the utility, they are often viewed as more accessible. In a best practice, we found that one utility would share OE and, in particular, safety lessons from all plants in the entire fleet to include coal fired, gas burning, or hydraulic plants. Not surprisingly and consistent with the essence of job rotation, we found that plants that shuffled more of its personnel between stations enjoyed more and better fleet OE. In a mutually reinforcing way, the relationships and social capital created from rotating leaders among jobs at different plants continuously reinforced fleet OE. Unlike internal OE, this form of OE tended to reside at the middle management level. Lastly, there is industry OE. These are lessons that occurred at one of the 65 commercially operating nuclear stations in the USA with 100 nuclear reactors located in one of 31 states in the USA. We found that plants that emphasize industry OE shared two common characteristics. Namely, they had leaders, usually fairly senior leaders, who were active in industry events such as benchmarking tours or did rotations at the INPO where they visited many sites to offer expertise. Also, plants that encouraged industry OE tended to institutionalize it. For instance, at one meeting called an Operations Tailboard, this daily, standing meeting began with Leadership OE from the industry – an event that occurred, usually, within the last 24 hours throughout the industry.

We found that great performance coincided with a purposeful and balanced embrace of OE. In particular, during plant meetings, mentorship, and prior to major plant evolutions, we found that safety and operational performance appeared to coincide with the right mix of internal, fleet, and industry OE. Because different organizational levels seemed to account for a specific OE domain, this was also a signal that the entire organization was engaged in the learning process. In addition, we found that OE was managed appropriately and avoided cognitive and absorptive overload by institutionalizing it as mentioned above and by embracing technology. Of particular note, we encountered an organization where a standing order was issued that OE germane to the task would be included in all PJBs. Moreover, we found that technology enabled such a feature. Database mining and management allowed a user to search for OE, internal or otherwise, that was relevant to the job at hand. As a consequence, this focussed OE was not noise and provided targeted and relevant information at the critical moment; this is not information or lessons that push against the limits of bounded rationality (Cyert and March, 1963/1992; Simon, 1957). In summary, we found that reliability was enhanced by adding structure, purpose, and focus to the abundant amount of information available to, and often thrust upon, NPPs.

Continual improvement vs building a positive culture

During the autumn of 2013, we had the opportunity to sit in and observe several monthly DSEMs. The purpose of these meetings, and when done well, is to expose technical, operational, and/or leadership/behavioral gaps that training may help to close. At this particular station, a recurring behavioral theme emerged that spanned months and also departments. More specifically, employee morale and employee satisfaction was low based on both anecdotal and survey data. What was more surprising, this sentiment moved inversely to performance. As plant performance began a steady and, rather, steep improvement trajectory, employee satisfaction and morale tanked. A plant operator, an hourly worker, offered this as a core reason:

> Nothing is ever good enough. We think we do a good job. But management or INPO comes or some regulator comes and doesn't even say "good job" or "you're improving". Instead, it's always the hammer and what we could've done different or better and what an INPO 1 (highest ranked organization) could do. We're just sick of working 50 hours a week only to hear every day how we don't stack up.

We pressed a senior manager on this sentiment. His response carries insight and informs us to the nature of high hazard organizations:

> We'll, I'm bothered to hear that. Everyone at this station should ask what can be done better or different to approach perfection. Within nuclear, and I'm sure in other organizations like refineries and airlines, I'm sure it's the same or similar. But we're dealing with perfection – not excellence. We can't have 1,000 hours of perfect runtime and 1 minute of screw-ups. It is has to be perfect, all the time. Every time. There's no margin. That's what the public and our regulators demand of us. 15 seconds of taking the eye off the ball can impact the safety of the public. Why can't people get that?

With all high hazard and high risk organizations, problems are caused by one of two forces: equipment reliability or human performance/error/decision making (Carroll, 1998; Weick *et al.*, 1999). In general, human errors are believed, some would say ironically, to be more preventable and more egregious than equipment failures. Also, there is a sentiment that all equipment reliability issues have a human decision behind it whether that is in work control, maintenance surveillances, engineering design, or post maintenance testing. In short, humans with all the variance accorded to them, are expected to decide and execute much like, even better, than equipment – consistently and perfectly. When this unrealistic standard cannot be met, individuals, teams, departments, and plants are met with streams of continual improvement feedback. Ironically and paradoxically, this lack of positive reinforcement/feedback in lieu of constant developmental feedback actually could make the organizational more vulnerable to reliability issues – not less.

One case that garnered attention and spurred some pro-union sentiment involved an automatic reactor shutdown. HROs have multiple redundancies, or "defense in depth," to protect and safeguard the station, employees, and the public (Weick and Sutcliffe, 2007). In this particular case, pressure to one valve was affecting a steam generator system, which is critical for nuclear safety. At a certain threshold, pressure decreased to the point that the reactor automatically tripped and was put in a safe condition. In the RCE, the crew was faulted. They had approximately 40 seconds to diagnose the problem and then implement the correct actions to prevent the reactor trip. If they could not control pressure within 40 seconds, they should implement manual, as opposed to automatic shutdown. The manual trip is a higher standard as it shows that humans – not technology, computers, or equipment, made the command and control decision to put the reactor in a safe condition. This crew, which had close to stellar operational performance over the previous year, received considerable developmental feedback. One operator remarked to us, "here we go again, we only get the bad, never the good. No wonder nobody likes coming to work. Sometime, anytime, people just like to hear good job. I've been here 29 years, and I can count the 'good jobs' on one hand. I've had it."

Again, a different senior leader responded:

> I refuse to give positive feedback just for the sake of positive feedback. The standards are high. So the performance has to be extraordinarily high to warrant positive feedback. And when I give positive feedback for just average performance or just meeting the standard, I'm, in essence, weakening that standard. The feedback is hollow and it's false and everybody knows it and it does more harm than good.

This serves as a launching point to discuss our next finding. The higher performing teams and departments tended to balance the competing forces of developmental feedback and positive reinforcement. It was done in such a way that it reinforced high standards while simultaneously building morale. The converse was true. Teams, groups, departments, or organizations that over-relied on one end of the spectrum suffered declined performance and low morale to include labor strife.

Here, the research is without dispute. Seminal research on job characteristics (Hackman and Oldham, 1975), goal setting (Locke, 1968; Locke and Latham, 1990), and recent leading research from applied scholars (Amabile and Kramer, 2011) overwhelmingly supports the practice of positive feedback and positive reinforcement to both dramatically affect job performance but also to build a sustainable, high performing, positive culture.

Perhaps, of all the balances, this was the most difficult for leaders and power stations to embrace or reconcile. Rather than balancing or holding this notion of performance improvement with positive feedback, some managers appeared to toggle between these two. As a consequence, some personnel viewed these managers/leaders with suspicion and perceived them as fickle and inconsistent and what one junior supervisor remarked "leadership by convenience." In high performing teams, we found leaders did not toggle between these two competing tensions, but, rather, held these seemingly contradictory forces simultaneously. For instance, one successful maintenance manager who arrested and then reversed declining performance of a large maintenance group purposefully inserted positivity into his communication mediums. We saw a weekly newsletter of his, which shared "small wins," possessed some humor, while also reinforcing and then raising standards. This approach was well received across the organization. In person, he would speak to the notion of "proud but not satisfied." In addition, we witnessed one operations manager ask an open question to his staff of 40 or so leaders, "are we sharing the positive stories with our people?" To that end, he directed that all unit supervisors (front-line supervisors) and above to read a *Harvard Business Review* article entitled the "Power of small wins". He then directed his leaders to comment on this paper on an e-mail thread. In a conversation with him, he explained his rationale:

> People, I don't care what industry, want to come to work and win at something every day. Doesn't have to be big. In industries like ours, we're very good at telling people how they can lose less and we're really good at telling people how they've screwed up. Our industry, with its goal of perfection, really doesn't do a good job of telling people when they're making progress. When they occasionally win. I wouldn't want to work in a place where I'm losing every day. Would you? We need to do better here. I really like "John's" proud but not satisfied mentality. That's a great launching point.

In conclusion, it appears that high hazard organizations can benefit from sharing successes and offering, even integrating, positive reinforcement with that of continual improvement. When that occurs, performance seems to improve along with many of the factors that make sustainable performance possible like job satisfaction.

Temporal balance and the production vs safety contradiction

Time pressures and the overall theme of the temporal within organizational theory and management remains a continued topic of important study. Indeed, the *Academy of Management Review* has devoted special issues to managing the temporal, rhythmic nature of organizational life (2001, Vol 26, No. 4). We found the push and pull of temporal forces at work in NPPs and, consistent with other findings and with our findings contained in this study, the better performing plants managed and, even, blended the tensions of the past, present, and future to enhance reliability.

Drawing again from the notion of organizational learning, the better performing plants consistently reviewed past OE and lessons to affect current and future performance. For instance, we observed one plant manager ask his subordinate leaders to convene a meeting to review the three main lessons from the last refueling outage and what the group was going to do "different or better" to "prevent us from reliving history." Those organizations that did not consult OE or strongly revisit the past to learn what went well and what did not, suffered declines in performance. Related to this, higher performing organizations highly emphasized preparation. For instance, we observed the following dialogue between a plant operations manager and a SRO who had some leadership duties during a refueling outage:

> Operations Manager: Are the tools staged at the job site now, before the job begins?
> Senior Reactor Operator: Yes.
> Operations Manager: **All** [with emphasis] the tools?
> Senior Reactor Operator: [pause]. Yes.
> Operations Manager: How do you know?
> Senior Reactor Operator: Okay, I will go put eyes-on.
> Operations Manager: Are the valve hoses there?
> Senior Reactor Operator: Yes. I know that.
> Operations Manager: Have you taken them out of their plastic and tried to tie them on?
> Senior Reactor Operator: [pause] [...] Uhhh. No, I didn't think about that.
> Operations Manager: How many hoses do you need?
> Senior Reactor Operator: Thirteen.
> Operations Manager: How many do you have?
> Senior Reactor Operator: I just said thirteen [with annoyance].
> Operations Manager: What if two or three split or tear as you're putting them all on. Didn't they do that two or three outages ago? Why would we put ourselves in the same position?

This exchange typifies the gravitas that higher performing managers and plants tend to put on preparation. Others used preparatory time, especially for higher risk tasks, to engage the training department or division to give just-in-time training to the operators.

Of course, the quality of past learning coupled with strong preparation, directly contributed to strong execution in the present. However, we offer some commentary on the work flow of the actual execution of work. In the highest performing stations, we witnessed a very uneven workflow where work was punctuated by starts, stops, fits, and pauses. While an argument can be made that this intermittent work flow jeopardizes rhythm and, maybe, efficiency, we found that it greatly enhanced reliability. For instance, we saw work groups take a "two minute time out" both right before work commenced and also during the work, itself. When one of the authors asked about this practice, we were told that two minute time outs allow operators to revisit the context of the workspace, in which they would be manipulating plant equipment. Another said that it provided situational awareness that helped with the safe (and efficient) execution of work. We also witnessed on several occasions unit supervisors coaching operators to "stop when unsure" if an element of work was not what was expected, contradicted the PJB or task preview, or did not make sense with the procedure. One shift manager applied heavy command emphasis on this point and one which we will touch upon in greater depth later. This senior and successful shift manager told his operators that the first priority was always to do work error free and safely. Finally, in regard to managing the temporal nature of work, the best stations had both a collective mind/strategic orientation as well as a tactical imperative to "look ahead." Put differently, at the tactical level, the better performing leaders have a "look ahead" mentality where they examined the work schedule approximately two weeks in advance. At the higher levels of the organization, the "look ahead" mentality tended to be measured in months or quarters. One shift manager suggested to us:

> Look at the worst performers. They all share the same flaw. They work completely in the moment. They never look ahead. When you don't look ahead, you can't prepare. I've seen shift managers that have been on their 7 day off without even caring or knowing the work schedule. They come in after their 7 day break and they're behind before they even get started. They spend the day in surprise mode. These are the ones that get blindsided. These are the ones that make mistakes. Because they go into work, into execution mode, without the forethought that only preparation can provide, they rush and make mistakes. [with emphasis] That's a loser's approach.

A major and growing tension that we saw involved a long held tension between safety and production (Boin and Schulman, 2008). In particular, when do economic factors reach such a level that they cause safety concerns to be ignored, minimized, or disregarded? In one RCE a major finding was that lower, middle, and higher levels of leadership put pressure on those performing the work, the operators, that production mattered more than safety.

Before we dissect this phenomenon a bit more, we feel obligated to legitimize some of the economic pressures that certainly exist in NPPs, and throughout the energy industry. As profit and non-profit stakeholders already know and understand, a variety of energy sources now compete against each other in markets that are more deregulated, which allows the market to pick winners or losers. One of the most significant technologies that has applied downward cost pressure is the recent advent of hydraulic fracking, which allows for clean burning natural gas to be captured and produced at historically low rates. This has caused enormous pressures on oil, oil sands, bio-fuels, wind, air, geo-thermal, and, of course, nuclear energy sources. Coal, in particular, has suffered dramatically due to the surge in natural gas production (Sober Look, 2012). Many think that nuclear plants that operate a single reactor are no longer cost competitive and either are or will be shut down (Tracy and Chaudhuri, 2013). Nuclear, compared to other energy sources, is characterized as having cheap fuel inputs and able to provide a constant, consistent baseline of energy in which energy grids prefer (whether the sun shines or not or whether the wind blows or not). These advantages are refuted by some significant drawbacks to include incredibly high fixed costs, tremendous ongoing maintenance expenditures, particularly for aging plants, and high regulatory costs. Thus, there is extraordinary pressure to keep "reactors running" and to spread this energy production over the tremendous fixed costs. In essence, this is an economic imperative – nuclear power stations must run and must have "up time," or capacity factors that approach 100 percent. We heard from a variety of sources that an out-of-service medium to large reactor (approximately 950 megawatts), as a rule of thumb, cost the utility $1 million a day in lost revenues. This could be conservative as the utility often needs to visit and purchase electricity off the open market spot prices to supply the energy that they are contractually obligated to provide. Put differently, they must pay a premium to buy energy to supply to consumers that they should be producing if the reactor is operational.

And this is where a significant rift can occur between profit and non-profit sectors to include regulators. At this fissure, mixed messages can trickle down to the operators who must, in work execution, decide whether the emphasis is on production or whether it should be on safety. To put this into greater perspective, we read an operations strategic plan in which two leadership behaviors were mentioned heavily in the first ten pages. More specifically, the strategic plan mentioned bias for action 13 times within the first 15 pages. In those same 15 pages, conservative decision making was mentioned nine times. From this apparent contradiction arises a fundamental question common to all high hazard industries – how do we manage two, seemingly, contradictory forces like bias for action and conservative decision making in a way that does not send mixed signals and confuses decision making. Taken at the extremes, we have problems. Conservative decision making, at its worst, looks like massive risk aversion where no work is even done as all work carries some risk. In contrast, bias for action, taken at its worst, could mean complete recklessness in the face of procedures, rules, or regulations in an effort to produce.

Unfortunately, there is no easy answer to this conundrum. To suggest otherwise would be to dismiss the incredibly powerful economic factors at play or the tremendous and catastrophic calamities that accompany disregards for safety in the high hazard industries. Top performing plants do two things considerably well. First, they acknowledge these tensions openly and then encourage, even, force dialogue on this issue. Bringing these tensions or assumptions into public consciousness creates some balance and research supports this (Weick *et al.*, 1999). Second, higher performing stations tend to the past, present, future (look ahead) aspects of work so as to reduce the likelihood that a station would be put in that position. This knowledge and best practices are of important significance to profit and non-profit sectors.

Discussion, implications, and future research

Our study and analysis focussed on a sector of unparalleled importance to the non-profit and profit stakeholders, alike. Namely, the purpose of our research agenda was to highlight factors that impact the reliability of the high hazard industries such as NPPs. When our data and findings were presented to energy executives outside of the nuclear arena, there was convergent validity; our findings apply to other energy producers and to other high hazard industries. Seasoned executives at the private equity firm suggested that some of these findings should/could apply to sectors where risk is systemic and catastrophic such as the finance industry. We thought this a new way to conceptualize high hazard industries. That aside, given the mammoth effects to society, both economically and from a public health and safety perspective, considerable more research focus needs directed at high hazard industries. We continue to be surprised at the lack of research efforts or dialogue aimed at understanding and improving organizations within high hazard industries.

We found that tensions exist within high hazard organizations. And compared to other, non-high hazard organizations, these tensions appear exaggerated. Left unmanaged or mis-aligned these tensions can impact financial and safety performance. Specifically, we found that stations can strengthen reliability by balancing complexity and simplicity in a way that allows for the detection of signals; balance and synthesize different knowledge domains to include rules based, systems based, single and double loop learning; maintain a healthy balance of continual improvement and positive reinforcement that produces a culture of "happy strivers" who are "proud but not satisfied"; and balance the temporal nature of organizational life, in general, and devote attention to closing the production vs safety divide. Again, we feel that these are lessons that all organizations, high hazard and others, could attend to for strengthened reliability.

One of the three stations we were engaged with intrinsically understood these tensions. This station experienced a significant event, which deeply impacted the culture, and recovery efforts were stalled. The Site VP told one of the authors:

> We just didn't get it, we thought we had all the answers; yeah, we smiled and said we would use the feedback, but we were just giving them lip service. Then one day I realized that I might be part of the problem, and I had to change my behavior and lead by example.

Then, starting at the top, leaders recognized the need to get back to basics and shield the workforce from excess noise. Engaging and challenging PJBs became the norm. Feedback and OE were truly appreciated and implemented. Additionally, every meeting started by celebrating two successes, or small wins. This reinforced the fact that every day, people were focussed on completing the right tasks, the right way. Every worker, at every level, understands the tension between production and safety, and knows the priority is safety. Taking a two minute timeout was not only encouraged, it is applauded.

Our research is exploratory and offers insight into the potency of the alignment between scholars and practitioners. Clearly, extending this study into a grounded theory project enhances confidence and future research should explore that. Moreover, although high hazard industries are often surveyed and audited heavily, the surveys are a-theoretical. There is promise of integrating scholars and theory into this survey process. Interestingly, within nuclear, the INPO surveys frequently. However, those surveys lack theoretical constructs, hypotheses, and are *post hoc* ventures. Much more could be gleaned, we believe, by adding intellectual and scholarly insight into process.

As for specific research threads, we offer the following guidance. We found, and probably rightfully so, high hazard organizations are "serious spaces." Humor, often, was conspicuously absent. All authors had exposure to a variety of organizations and had historical experience running from retail to supply chain to manufacturing to energy. The high hazard organizations that we experienced in this study differed in the amount and kind of humor introduced into the workplace. It may seem unimaginable to suppose or support the presence of humor within high hazard organizations. However, the research on this topic is growing and the findings suggest an impact on these factors of performance (Duncan, 1982; Duncan and Feisal, 1989). There is some preliminary evidence that we may be moving in that direction. For instance, one prominent high-reliability web site now contains links on how to introduce "comedy improv" to the organization to increase constrained improvisation (high-reliabillity.org, 2014; Bigley and Roberts, 2001). Related to this, creative human resource (HR) practices and creativity seem lacking in high hazard organizations, in general. In the beginning of each station partnership, the site leaders had little regard for HR, and they were seen as a corporate entity and did not have a seat at the leadership table. We know that creative and innovative HR practices and creativity positively impact all variants of performance (Ichniowski *et al.*, 1996). In particular, creativity and innovative HR practices seem to impact many of the tensions that we discuss here. Future research may wish to understand and begin the theory building process and hypothesis testing into how leveraging creative HR practices may enhance HRO performance. We counter that a major risk mitigation exercise in high hazard industries may to be more creative; that is, to imagine the unimaginable. In general, we feel that the force of creativity is minimized in high hazard organization and deserves more scholarly and applied inquiry.

Few industries mean as much to our national economic engine and our public safety as high hazard industries that supply our nation's power, transportation, healthcare, and defense needs. Because of this, we offer some initial and exploratory, but incredibly important, insights into the factors and forces that strengthen reliability in the organizations that operate in environments where errors cannot be accepted due to their disastrous impacts. It is a concern that demands shared governance. Moreover, it is a concern that sits at the sweet spot of public, non-profit, and private enterprise. As such, all actors and stakeholders are responsible and accountable for improving this industry. Our study offers appeal, then, to those groups whose mission is to reduce hazards in our HROs and to the public they serve.

Note

1. Binning usually occurs when managers are doing RCEs, Apparent Cause Evaluations, or DSEMs. To add more context, we recently observed a DSEM where approximately 300 field observations were shared with approximately seven to ten managers and operators. From these field observations, they binned the observations into several larger categories that included such bin labels as "procedure use and adherence," "failure to maintain high standards," and "lack of supervisory engagement." So, not unlike axial coding and the constant comparative analysis, binning involves creating bin labels and then placing observations and data into those bins.

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