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A capacity index to replace flawed incident-based metrics for worker safety

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Abstract. Shortcomings of incident-based metrics such as Total Recordable Incident Frequency Rate (TRIFR) are well-documented, including the lack of standardization, construct validity, statistical power, and predictive power. A low TRIFR is also no assurance against legal liability. There is considerable overlap between the research literature on safety as the presence of capacities to make things go well, and jurisprudence in labor and workplace safety law. In this paper we suggest an index that merges the two, measuring the capacities to acquire and maintain safety knowledge; to understand the nature of operations; to resource for safety; to respond to risks; to demonstrate engagement and compliance; and the capacity for assurance.

Keywords: legal compliance, assurance, capacity index, TRIFR, incidents

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1. A 'measure' that doesn't work

The use of incident-based metrics for worker safety is still widespread, (e.g., Collins 2013). It is carried in part by a misunderstanding of the legal requirements placed on directors of corporate boards to exercise due diligence and ensuring compliance with safety obligations. Some organizations use only a single metric (such as the total recordable incident frequency rate or TRIFR) as a putative safety measure to monitor performance, assess trends and enable comparison against other organizations or industries. The presumed advantageous properties of this single measure, however, have been disproven, or are easy to disprove. Comparison between industries or business units, for example, is impossible because the measure says something about shifts, not people or jobs; because it is a rate (meaning it requires a denominator, which is a malleable choice); and because the definition of 'injury' is both variable and gameable. There is little consistency in what is registered as an injury and what isn't. Supervisors, often in coordination with health & safety professionals, will make their own call on whether to record a worker's injury or not.

Deriving trends or changes from the measure is meaningless because of its considerable lack of statistical power. With injury numbers relative to hours worked (i.e. injury *rate* or any other rate) as low as they are, it becomes easy to show that the requirements of statistical significance are never met. In other words, managers or boards saying that they have seen a significant reduction in injury rate, or a significant difference between

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their injury rate and someone else's injury rate, actually have no statistical basis for their claims. In addition, because of the low power, statistical variations in injury rates from year to year or between companies or business areas, are completely random and cannot be provably related to a manager's or board's actions or inactions (Muller 2018).

Due diligence is concerned not only with receiving information in relation to incidents, hazards and risks but, importantly, considering and responding to that information (Tooma & Johnstone, 2012). Data in relation to total recordable incidents as a proportion of work performed provides little if any insight for that purpose since it masks the consideration and understanding of the actual incidents, hazards and risks that sits behind that number which is the essence of the due diligence exercise. By its very nature, TRIFR is ill suited for that insight in that its purpose is to show a trend in lost production time and not the safety conditions that led to the injury or the potential from the incident that led to that injury. Furthermore, TRIFR is a record of injuries and not incidents. An incident may have significant potential but result in no injury. In that respect, TRIFR would fail to facilitate due diligence.

A low TRIFR provides no assurance of legal compliance with local safety requirements (Tooma and Johnstone 2012, Tooma 2017), nor does it provide a defense against legal liability as shown in jurisprudence.[1] Low numbers of injuries are not predictive of fatalities or accidents, so they do not constitute a safety measure (indeed, LTI and its derivations are originally productivity measures). Outcome measures are not the

[1] See e.g., *United States of America v. BP Exploration & Production Inc. et al., Civ. Action No. 2:10-cv-04536 in the US District Court of Louisiana* – the US Department of Justice suit against BP under the US *Clean Water Act* arising from the Deepwater Horizon Disaster despite a period of prolonged operation with no reported injuries.

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variables an organization should set out to control to achieve higher quality or safety outcomes (Deming 1982). In fact, in many fields this would be taken as fraud. Instead, control of the input variables (such as the capacities reported here) should be encouraged. Even so, because TRIFR and similar measures are productivity measures and not safety measures, they do not offer an index of the suffering caused to, or experienced by, the worker (Dekker 2017, Ullstrom et al. 2013). The use of TRIFR and similar measures, and the kinds of rules that have sprung up around work designed to manage these numbers, have unsurprisingly generated widespread cynicism among workers (Collins 2013, Heather and Kearns 2018, Leplat 1998, Bieder and Bourrier 2013).

In sum, personal injury rates are not a good indicator of the effectiveness of an organization's safety and risk management (Long 2016), offer no protection against liability, and are not predictive of fatalities, accidents or disasters (Saloniemi and Oksanen 1998, Salminen et al. 1992, Sheratt and Dainty 2017). In fact, while not proving a causal relationship, a lack of injuries and incidents in already safe organizations (Amalberti 2001) has repeatedly been linked with increased risk of process safety disaster and fatalities (Michaels 2015, Baker 2007, Hopkins 2010, CSB. 2007, Elkind, Whitford, and Burke 2011). Similarly, the pursuit of 'zero harm' has been shown to be correlated with *greater* rather than smaller company fatality risk (Sheratt and Dainty 2017). This is an important reason why such measures provide no protection against liability. At best, they are not indicative of legal compliance, and at worst, they may be indicative of a culture of non-compliance (Tooma and Johnstone 2012, Tooma 2017).

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The use of inappropriate metrics itself of course does not cause fatalities or disasters, as pointed out above. Those causes are found in working conditions, the state of repair of assets, corporate strategic choices, organisational design, structural complexities, goal conflicts, lack of resources, and more (Le Coze 2020, Hopkins 2019). That said, a singular focus on metrics can function as a decoy, taking organizational attention way from the build-up of risks and a possible drift into failure in other areas. Underlying risks can then be left to grow misconstrued or unnoticed, as has been recognized by models of organizational safety since the 1970s (Turner 1978, Vaughan 2005). Connecting financial bonuses or other incentives or rewards to low injury numbers exacerbates this (Hopkins 2015), likely because it tends to encourage cultures of risk secrecy (Dekker and Pitzer 2016, Sharpe 2004, Edmondson 1999). Injured workers, supervisors or even safety managers can feel pressured not to report injuries because it will negatively impact the company's statistics and future contracts (Derango 2013, Frederick and Lessin 2000, GAO 2012). A link between a lack of transparency and openness to employee voice on the one hand, and organizational disaster potential on the other, was recently demonstrated (Blanton and Peksen 2018). Pursuing a low TRIFR becomes, in Lofquist's words (2010), 'the art of measuring nothing.' It seduces organizations into what is known as the fundamental regulator paradox: Achieving zero, control theory cautions, could be a foolish aspiration in dynamic systems. Once you achieve zero, there is no longer any basis to correct or regulate system behavior on, no 'error' in the system to work off, and the regulator (manager, board) literally 'goes blind.'

2. A capacity index as alternative

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Consistent with moves to what is known as Safety Differently or Safety II (Hollnagel 2018, 2014, Dekker 2015), organizations are encouraged to see safety not as the absence of negative events (i.e. a low TRIFR score) but as the presence of capacities to make things go well, even under variable and sometimes messy conditions (Roe 2013). The potentially measurable and certainly demonstrable capacities elaborated below are not only consistent with existing and emerging research in safety and resilience engineering, they also exhaustively cover the due diligence requirements under typical work safety legislation in many western countries (e.g., Bahn 2012, Peace, Mabin, and Cordery 2017). Because of the financial (and human) impact of safety accidents on companies, leadership and stewardship on safety issues is part of the care and diligence that directors are expected to demonstrate in the performance of their role. Failing to do so has led to shareholders to sue directors and senior management to recover losses in shareholder value in the aftermath of major disasters. The Deepwater Horizon case, for instance, was settled by a payment of US$175m to the plaintiffs. In a number of jurisdictions around the world the duty of directors and senior managers expressly requires the exercise of reasonable care or due diligence to ensure compliance on safety matters either as a defense to liability for breach of a personal duty under safety laws (Canada, UK, HK, Singapore, Malaysia) or expressly as a proactive duty (Australia and New Zealand) (Tooma 2017).

TRIFR is a great example of organizations and boards counting what they can count, but not what actually *counts*. But what are the things that do count? A review of the jurisprudence reveals that 'due diligence' has been recognised to have a number of components: (1) an active and ongoing interest in a baseline of knowledge in relation to

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safety matters to enable effective decision-making; (2) understanding the nature of the operations that the director is responsible for and the risks arising from those operations; (3) a commitment to addressing those risks through provision of resources and processes for managing those risks; (4) a proactive approach to receiving information in relation to incidents, hazards and risks and considering and responding promptly to that information; (5) a commitment to the provision and implementation of processes for meeting relevant duties and obligations; (6) vigilantly verifying the implementation of processes and resources deployed to address risks and ensure compliance.[2]

A capacity index that captures the requirements of exercising such reasonable care and diligence would more readily reflect the legal requirements expected of directors and managers of companies and represent a better guide to compliance with such duties. It is not, of course, that knowledge of incidents and injuries do not provide managers, board members and other stakeholders with some insights into their knowledge, their capacities and their understanding. The point that has been made repeatedly in the past two decades, however, is that the experience base of what goes well—and an understanding of the capacities that make it so—is (potentially) so much larger than the few instances of failure. The simplest reason for this is that much more goes well than goes wrong (Hollnagel 2014), though what makes work go well is often subtly different (in the sense of work-as-done versus work-as-imagined) from what managers, supervisors or boards believe or think is responsible for operational safety and success

[2] *R. v. Bata Industries Ltd*., [1992] O.J. No. 236, C.C.C. (3d) 394 p: R. v. Syncrude Canada Ltd., 2010 ABPC 229, [2010] A.J. No. 730; *R v Brisbane Auto Recycling Pty Ltd & Ors* [2020] QDC 113. In Australia and New Zealand this definition is codified in the legislation: for Australia see section 27 of the *Work Health and Safety Act 2012* (Commonwealth) for example and for New Zealand see section 44 of the *Health and Safety at Work Act 2015* (NZ).

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(Hollnagel 2012b). Building one's understanding of safety mainly on injuries and incidents is akin to trying to understand how to have a happy, life-long marriage by only studying a few cases of divorce. It misses much of the interesting data. So included in the index proposed here are the capacity to acquire and maintain safety knowledge; the capacity to understand the nature of operations and its risks; the capacity to adequately resource for safety; the capacity to respond to risks and unsafe events; the capacity to demonstrate engagement and compliance; and the capacity for assurance. These are not just capacities that any organization might desire to possess. They are, indeed, the hallmarks of due diligence.[3] The index aims to track the following:

1. the building of capacities in people so that things go well even under variable conditions (Know);
2. the capacity to anticipate through risk competence and risk appreciation at all levels of the organization (Understand);
3. the capacity to make resources available and goal conflicts visible (Resource);
4. the capacity to monitor and identify issues through effective communication channels (Monitor);
5. the capacity to assure the effectiveness of this monitoring (Comply);
6. the capacity to learn from both failure and success (Verify).

We have examined the research literature on safety, resilience and cognitive engineering to shed more light on these six aspects that have emerged from the jurisprudence (see above), after which we develop the index in the following section.

[3] As shown by jurisprudence, e.g., Inspector Kumar v Richie [2006] NSWIRComm 323.

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2.1. The capacity to acquire and maintain safety knowledge

One of the functions of this capacity is the anticipation of future failure paths. This means monitoring conditions and threats associated with future scenarios that may happen within or around the organization. Anticipation is the expectation of what might happen in the future, which of course depends on how we think about the future—and in turn on how we leverage our knowledge of the present and past to inform us about it (Hollnagel 2017). In its simplest form, anticipation is the use of pattern recognition and the application of recognition-primed scenario responses to actual or emerging situations (Klein 1993). Recognition of course requires sufficient similarity between features of known (past) situations and future or present ones, so that any deductions or inferences have current validity. This may be impossible in complex systems (Cilliers 2010). Also, predictable kinds of errors intrude into this kind of anticipation, including so-called cognitive garden-pathing or fixation errors (De Keyser and Woods 1990), where courses of action are continued as if the scenario is what people anticipated it was, when it has in fact subtly changed (Orasanu, Martin, and Davison 1996).

Another possibility for anticipation is the deliberate construction of future scenarios and the preparation of responses to them, sometimes with the use of simulations of various levels of fidelity (Dahlström et al. 2009) which can help people and organizations 'plan for surprise' (Weick and Sutcliffe 2007). Anticipation through scenario construction, however, is easier said than done. There is a considerable literature and case corpus on so-called fantasy planning (Hutchinson, Dekker, and Rae 2018) and fantasy documents (Clarke 1999). Fantasy documents are artefacts (e.g., response plans, risk assessments) that make optimistic and unrealistic claims (e.g.

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based on positive audit findings) about how the organization can control highly uncertain risks, in an effort to convince stakeholders that the uncontrollable (or at least the very difficult to control) can be anticipated and bridled (Downer 2013). Fantasy plans are not usually written to purposefully deceive, although they may have that effect through selective assumption-making. Nevertheless, sometimes documents may be written in full knowledge that the stated claims are not true or have little chance of being successful. Such claims may be produced by safety departments to persuade a regulator or external auditor, or by organizations to persuade public stakeholders. The existence or demonstration of contingency plans, then, is not in itself sufficient evidence of the presence of relevant knowledge. A Board's ability to track and demonstrate that capacity is a critical component of demonstrating that they are discharging their due diligence duty. Indeed, acquiring and maintaining knowledge of work health and safety matters is an express requirement of the law in some jurisdictions (see for example Australia and New Zealand).

2.2. Capacity to understand the nature of operations and their risks

Understanding the nature of operations and their risks comes, unsurprisingly, from the place where operations actually take place and where the risks arise and get managed every day (De Carvalho et al. 2009, Havinga, Dekker, and Rae 2018). Learning from normal work, and learning that from the people who actually do that work, is key to building this capacity. There is always a gap between how work is imagined and how work is done (Hollnagel 2012a), since real work has to deal with surprises, with unanticipated variations, complications and unpredictable demands, with goal conflicts

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and resource constraints. People closest to the actual work environment have the most intimate understanding of where the gaps, messy details and operational nuances are, and they encounter the most opportunities on a daily basis to generate and congeal ideas about what can be done to bridge the gaps (Nemeth et al. 2005, Woods et al. 2010). Aggregate measures about work that boards and managers typically get to see tend to hide the normal ebbs and flows of strains and shortages that parts of the system are locally under. As a result, when evidence of local adaptations to deal with this first comes to the fore in, for instance, a post-incident investigation, it tends to get characterized as non-compliance, which is singularly unfruitful to learn about how quotidian operations actually take place and their risks get managed.

Learning from normal work requires boards and managers to provide opportunities for frontline employees to speak up about their ideas for where, when and how that work can be improved. This can be done or facilitated through for example learning teams or learning reviews—independent of whether work has gone badly, well, or routinely (Pupulidy and Vesel 2017). Having these activities and processes for learning about normal work in place represents one key way of demonstrating the presence of this capacity (understanding the nature of operations and their risks). Intended targets of this understanding are ultimately the improvements to the design and organization of work and work environments. These need to happen and be implemented in ways that align with the work as it actually gets done, and they have to deal with the obstacles that normally get in the way of people getting that work done (e.g., Pew, Miller, and Feehrer 1981). Such improvements represent a second source of demonstrating the presence of this capacity.

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It is becoming apparent that worker fatalities are not predicted by (higher) injury rates, but rather by a failure on part of the organization to understand how success is normally created by them, and what sacrifices are necessary to get the job done. Failure to gain that insight has been at the heart of many major disasters, including the 2010 Pike River disaster in New Zealand (where 29 miners tragically lost their lives when a coal mine they were working in exploded). The capacity to gain an understanding of the nature of the business operations and the risks associated with those operations, is a fundamental component of any Board strategy designed to minimize the risk of safety disasters in their business and of shareholder class actions arising from any such major disasters. In New Zealand it has directly led to the adoption of a due diligence duty on directors that expressly includes that requirement. However, it arguably implied in the duty of directors to shareholders and the duty of directors under numerous industrial safety laws globally.

2.3. Capacity to adequately resource safety

Most organizations don't exist to be safe: they exist to provide a product or a service. Safety may be a precondition for doing so commercially, legally or ethically, but it is always one of the many goals that needs satisfying and achieving. This means that resource battles for safety are likely to be present. As Woods (2003, 4) explained, "goal tradeoffs often proceed gradually as pressure leads to a narrowing focus on some goals while obscuring the tradeoff with other goals. This process usually happens when acute goals like production/efficiency take precedence over chronic goals like safety. If uncertain "warning" signs always lead to sacrifices on schedule and efficiency, how can

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any organization operate within reasonable parameters or meet stakeholder demands?" These goal conflicts work their way down to operational frontlines, where multiple, simultaneously active goals are the rule rather than the exception for virtually all domains where safety plays a role. Workers must cope with the presence of multiple goals, shifting between them, weighing them, choosing to pursue some rather than others, abandoning one, embracing another. Many of the goals encountered in practice are implicit and unstated (despite stated priorities for safety). In fact, as Hollnagel (1993, 94) commented, "If anything is unreasonable, it is the requirement to be both efficient and thorough at the same time – or rather to be thorough when with hindsight it was wrong to be efficient." Like efficiency versus thoroughness or safety, goals often conflict (Hollnagel 2009).

Sometimes these conflicts are easily resolved in favor of one or another goal, sometimes they are not. Sometimes the conflicts are direct and irreducible, for example when achieving one goal necessarily precludes achieving another one—which could indeed be safety (Woods et al. 2010). Understanding the nature of these goal conflicts and interactions is crucial if safety is to be resourced adequately in an organization. Having a clear line of sight of that trade-off at a Board level is crucial to proper decision making. Resources for a safety organization should ideally be independent of economic performance of the organization, and no-jeopardy access to relevant decision-making levels should always be assured (Woods 2006b). However, rather than resourcing the work of safety (i.e. the administrative OHS apparatus, paperwork, processes and systems), resourcing the *safety of work* (see 2.2.) is a much stronger demonstration of commitment to this capacity (Rae and Provan 2019). It is also a legal requirement in many jurisdictions globally.

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2.4. Capacity to respond to risks and unsafe events

Research suggests that a capacity to deal with risks and unsafe events doesn't typically come from centralized, directed responses, but rather from pushing or devolving decision authority down to the points of action and interaction with the safety-critical process (Loukopoulos, Dismukes, and Barshi 2009). The adaptive capacity required to deal with risks and unsafe events as they emerge from actual operations, can per definition barely be captured in standard protocols or pre-written guidance (Rochlin 1999). Monitoring that capacity offers a key insight into safety resilience and is an important component of the role of Boards in overseeing safety. When coupling tightens and interactive complexities escalate (as the saying goes: in a crisis, all correlations go to one), devolving decision authority is known to yield better results in real-time—even where horizontal co-ordination is key to preserving overall system safety and integrity (Snook 2000). Research shows that adaptive capacity can be grown by emphasizing a diversity of voices of influence and decision making (Janis 1982, Page 2007); by letting decisions gravitate toward expertise, not power (Farrington-Darby and Wilson 2006, Deming 1982, Weick and Sutcliffe 2007); by instituting and rewarding a willingness to say 'stop' even in the face of acute pressures to continue (Edmondson 1999, Woods 2003, Rasmussen 1997); by allowing operational and design improvements to grow on the frontline without relying on audits or inspections to trigger them, and by encouraging a concomitant pride of workmanship (Deming 1982). These all constitute measurable or at least demonstrable capacities.

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Another aspect of demonstrating the capacity to respond is what an organization does in relation to the people who were involved in the unsafe event. It has long been known that sanctioning and learning are mutually exclusive; that organizations can do either, but not both at the same time (Dekker 2016). Retributive responses that are organized around rules, violations and consequences have a way of impeding openness, honesty and learning. They also don't get to the deeper causes of trouble and tend to fight symptoms instead. The alternative of restorative approaches, where all stakeholders impacted by an incident or safety event are involved so that they, together, can figure out what should be done, by whom, to repair the harm done and prevent recurrence (Dekker and Breakey 2016, Barton 2003). Because restorative responses ask about the various impacts that an incident or safety event has caused, and the needs that arise from those impacts, and whose obligation it is to meet those needs, the kind of accountability it generates is *forward-looking (Sharpe 2004)*: what needs to be done by whom, by when, and how will we know that it is being done? People involved in, and affected by, the incident collaboratively decide on what needs to be done. This can help restore trust between stakeholders, empower victims, and reintegrate practitioners. Restorative justice deals with consequences and causes of an event. It isn't just between the 'offender' and 'judge,' and doesn't pursue narrow facts to secure, for example, a dismissal. This kind of response facilitates a dialogue to identify the many sides of an event and its complex causal web. With a deep understanding of how success is normally assured, and how a negative event could come about, it can create a fair response and identify improvements.

2.5. Capacity to demonstrate engagement and compliance

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One of the biggest obstacles in demonstrating compliance is the extent of ill-calibration in boards and management (and often even supervisors and workers) about what needs to be complied with (and by whom). Complying with applicable legislation is actually a minor part of all the compliance demands organizations typically put on themselves and their people. The majority of compliance demands are internally generated and enforced, or expected from business to business (e.g. in a client-contractor relationship), without the relevant regulator even knowing or caring (Saines et al. 2014). Many of these rules typically have no correlation with actual legal obligations or safety outcomes but contribute significantly to worker frustration, productivity declines and, in fact, non-compliance at the front end (Dekker 2018). Their amount and putative authority, however, tends to muddle the organization's ability to demonstrate compliance with legislation, because people inside the organization (including boards and executives) have a hard time knowing what they are actually complying with, and for whom. Board attention should be on processes that facilitate engagement and on compliance with rules or precautions that matter to safety outcomes. For example, unlike the numerous self-imposed rules, there are risk based processes mandated by regulations that have evolved through bitter experience on these issues – rules around working in confined space, working at heights or working with hazardous chemicals. These are the matters that should command attention.

2.6. Capacity for assurance

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Practical experience and research on resilience dictate that neither the control of critical risks, nor the control of human behavior, nor the control of incident or injury numbers are sufficient to assure safety in a complex system. Safety in complex systems clearly doesn't arise from centralized control and standardization (which, in the extreme, would outlaw variability), but from acknowledging that variability is inevitable. Guided adaptations to local conditions and challenges is likely to generate greater safety improvements than greater centralized control will. It depends critically on organizations that manage to grow and expand their adaptive capacity so as to handle unknown (or even unknowable) disruptions, are those who are capable of recognizing, absorbing and adapting to harms that fall outside of its experience or knowledge base (Roe 2013, Woods 2006a, Sutcliffe and Vogus 2003). The control of adaptive capacity, in other words, is critical: it is the ultimate demonstration of assurance.

Large organizations contain so many interacting components that the number of things that can go wrong is huge. Small events can trigger larger failures: outages, leaks, poor performance, and other undesirable outcomes (Dekker 2011). In practical terms, the most effective legal strategy for risk minimization remains avoiding serious incidents in the first place. While controlling critical risks and preventing all possible failure modes is a rather hopeless endeavor in these complex systems, it is actually possible to rigorously identify at least some (if not many) of the weaknesses in the system before these are triggered by small failure events. This can provide the kind of assurance that the system is resilient, or find the places where it isn't yet. Chaos Engineering has been developed as a method of experimentation (in computer infrastructures) that brings systemic weaknesses to light (Rosenthal et al. 2017). It is an empirical process of

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verification that can lead to more resilient systems, and builds confidence in the operational behavior of those systems. Chaos engineering can be as simple as failing one component (even if in a simulated setting) and testing how its failure cascades through the organization. But it can be much more sophisticated: designing and carrying out experiments in a production environment against a small but statistically significant fraction of live operations in a safe-to-fail way. Engagement with these novel kinds of pathways to assurance, let alone their testing and implementation, represents a strong demonstration of the presence of the capacity.

3. A Capacity Index

The translation of the insights above into an index is a collaborative work in progress, but the research is already suggesting that:

1. In order to acquire and keep up to date knowledge on health and safety matters, organisations and their leaders need to instil an abiding desire for learning. There is a need to get closely involved in the organisation's health and safety capabilities and challenges as well as the suitability of its approach at a systems level when compared to the reality of work in practice. The very best way to learn about those matters is to listen directly to workers performing the work, and their supervisors and their managers. They are best placed to understand the hazards and risks in the organisation's work and as a result, they will also be best placed to tell the organisation whether its approach is working and provide practical and innovative solutions where needed to address any challenges not yet resolved. This may well lead to the discovery of safety clutter—unnecessary

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rules, procedures and processes that increase the burden of the 'work of safety' but do very little to enhance the 'safety of work' (Rae et al. 2018, Rae and Provan 2019).

2. Leaders of organisations need to understand how operations are performed in their organisations in order to be able to determine what critical hazards and risks follow. These again provide and important context for the appropriate resourcing of health and safety in an organisation. Traditionally, health and safety system designers will set out what they believe to be the case in that regard. Little emphasis or assurance is placed on whether the assessments are accurate or what real-world view has been considered in determining critical hazards and risks. Learning teams enable the engagement and continuous learning outlined for Item 1 of the capacity index. They bring operational personnel together with technical experts to look at both how work is designed and performed and build better connections between the two. In that way, they can be powerful mechanisms to inform the organisation and its leaders on how work is done and the hazards and risks faced in those operations as well as how work design and work methods may be improved given the insights from those who perform the work day to day. Learning teams provide more focused and detailed types of worker insights enabling greater understanding of the operational context.
3. Better-performing organisations have a range of capacities that contribute to those better outcomes. Resources and proactive processes for health and safety risk management require organisational capacity. That is, having the right resources, training, skills and capability to meet the organisational demands. Organisations and their leaders need to understand the organisational capacity

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in that regard which is why Item 3 of the Capacity Index requires organisations to invest in undertaking capacity assessments. Building from the guidance in Item 2 of this index, to enable more things to go right, organisations need to invest in the capacity of people and processes to achieve desired outcomes. Measuring the organisation's capacity building capabilities is therefore of use to one's organisational leadership in obtaining assurance as to organisational resourcing and any areas where further capacity must be created.

4. Monitoring health and safety performance is not about simply looking at failure. Indeed, much more powerful lessons can be derived from investigating success. In fact, success in operations happens far more frequently than failure and organisations typically take this success for granted, paying little attention to how or why that success is achieved. Reflecting on work undertaken in a successful manner can provide opportunities to understand the true health and safety capacity and performance in the organisation as it does not wait for the *absence* of health and safety (that is an incident) before reporting. It is a truer picture of health and safety performance in practice in day to day operations than relying on the minority of instances when an incident occurs for the purpose of understanding such performance
5. A requirement for leaders of organisations to ensure that there are processes in place to comply with all health and safety legal obligations is essentially a requirement to resource the conduct of health and safety legal compliance audits. That is why the measure under Item 5 requires reporting on the number of health and safety legal compliance audits. Health and safety legal compliance is not a bureaucratic exercise. There are good reasons from a health and safety perspective to ensure legal obligations are met. This is because specific health

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and safety regulations essentially codify the health and safety control measures that have been identified through lessons learnt in industry practice as being the control measures that prevent negative (particularly fatal) health and safety outcomes and can ensure success (particularly in relation to matters of high / known risks). Health and safety legal compliance audits are not the place to start: building effective health and safety systems and processes should begin with engagement and trust in workers and solutions derived by and with workers who must implement them (as is the focus of the metrics in Items 1 to 4 above). However, verification processes to ensure that those worker and operationally driven solutions are legally compliant can provide additional support to enabling health and safety.

6. As element 6 of the due diligence obligation is essentially a verification element, it is prudent to measure the extent to which the organisation and its leadership is taking into account the lessons learnt from the mechanisms established to learn from its people. As such, the KPI measure for verification for Capacity Index Item 6 is linked to the KPI measure for Capacity Index Item 1 as Item 1 captures worker insights and I the broadest measure of the Capacity Index relevant to operational learning. Item 1 assesses the establishment of mechanisms for gaining insights from workers and Capacity Index Item 6 enables an assessment of the extent to which learning occurs through the worker insights provided.

The translation of the due diligence jurisprudence and research insights is of course, as indicated above, a work in progress. One of the things to be constantly aware of is that it is easier to measure the 'work of safety' (the bureaucratic, back-office busywork associated with counting and tabulating) than it is to measure the 'safety of work' on the

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frontline (Provan et al. 2020, Rae and Provan 2019). This is where initial measures are progressively being replaced by developing measures, such as a resilience control score and resilience state score, and assessments of implementation and improvement of controls. Severity rate (something never included in traditional TRIFR metrics) is a straightforward and relatively easy-to-develop metric, as is the significant event rate. The cost of loss is of course more difficult to agree on and standardize, but is an important data point for management and boards to use for, e.g., adjusting their resourcing decisions. Measuring worker engagement and asking for a net promotor score in relation to safety are both straightforward too and can easily be added to the capacity of verify. The table below shows the capacities, due diligence requirements, initial measures and developing measures.

Capacity	**Matching due diligence requirement**	**Initial measure**	**Developing measures**
Know The building of capabilities in people so that things go well even under variable conditions	Acquire and keep up-to-date knowledge of health and safety matters respectively to role and responsibility	Number of worker insights per million hours worked	
Understand The capacity to anticipate through risk competence and risk appreciation at all levels of the organization	Understand the nature of the operations of the organisation and generally the risks associated with those operations	Number of learning reviews per million hours worked	Resilience control score Control implementation assessment Control improvement assessment
Resourcing The capacity to make resources available and goal conflicts visible	Ensure the organisation has appropriate resources and processes in place to eliminate or minimise risks to health and safety	Number of capacity assessments per million hours worked	Resiliscore – measurement of resilience state

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Monitor The capacity to monior and identify issues through effective communication channels	Consider information regarding incidents, hazards, and risks. Measure critical control performance.	Number of investigations of success per million hours worked	Severity rate Significant event rate Cost of loss
Comply The capacity to assure the effectiveness of this monitoring	Ensure the organisation has processes in place to comply with all work health and safety duties and obligations under legislation	Number of legal compliance audits per million hours worked	Safety plan implementation
Verify The capacity to learn from both failure and success	Personally and proactively verify the provision and use of the resources and processes outlined in the other steps	Percentage of worker insights effectively closed out per million hours worked	Engagement rating Safety Net Promotor Score

Table: Capacities, due diligence and metrics

4. Discussion

Each of the above capacity measures are capable of being numerically represented by capturing the productive activities that underpin them. Take the capacity to understand the nature of the operations and the risks. An effective way of building that capacity is for directors and officers to engage in leadership insights where they speak to line workers and get their perspective on how work is done and the state of safety in the company. Those insights must be meaningful. That can be measured through a double feedback loop from both the director *and* the worker. The frequency of those insights must be commensurate with the work activity. That can be done by measuring the insights as a percent of work hours. The net result is a frequency rate that reflects

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quality activity aimed at providing directors and officers with the capacity to understand the nature of the operations and the risks arising from those operations. Similar measures can be developed for each of the capacities with the aggregate of these being reduced to a measure – the safety capacity index.

Because the index is engaging with how work is done and the state of safety of that work rather than measuring injuries, it better reflects the objective of due diligence which is to gain an insight into how to make work safe. The consistency of the definition and the objective nature of the measures allow comparability between companies. The objective is not to monitor changes in data and adjust behavior but rather to promote an increase in positive activity. In that respect, the safety capacity index aligns directly with the legal obligation to exercise due diligence.

The problems with injury- and incident-based metrics are insurmountable and increasingly undeniable. The capacity index suggested as a replacement here is a small step in a direction that tries to make Safety II, or Safety Differently more measurable. The measurements it taps into are to an extent still about the 'work of safety' rather than the actual 'safety of work' as it gets done on the frontline, and the same sorts of numbers games that organizations typically engage in around incident- and injury metrics are not impossible with some of these capacity measurements too. These are substantive and significant challenges that are common to early stages of adoption and development. What speaks for a capacity index of the kind suggested here, though, is its low bar: much or all of the measurements that make up the index are already routinely conducted by organizations, and many of them actually are relevant to the safety of work as actually performed. Because the capacity index couples known due diligence

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requirements with the literature on Safety II and resilience, it could be an achievable step in the right direction.

5. Conclusion

Law and the threat of legal liability has played a major part in the propagation and elevation of injury data such as TRIFR in board reporting, cross-organizational and sectorial comparisons, and in (impossible) attempts to predict accident- and worker fatality risks. These measures have the veneer of simplicity and comparability, which is in part responsible for their dubious but continued popularity. In reality, though, they offer no useful insight to the state of safety in the organization. They also offer no assurance of legal compliance or liability protection. This paper has put forward a comprehensive measure of capacities that at once provides insight into the state of safety within an organization, based on:

1. the building of capabilities in people so that things go well even under variable conditions (Know);
2. the capacity to anticipate through risk competence and risk appreciation at all levels of the organization (Understand);
3. the capacity to make resources available and goal conflicts visible (Resource);
4. the capacity to monitor and identify issues through effective communication channels (Monitor);
5. the capacity to assure the effectiveness of this monitoring (Comply);
6. the capacity to learn from both failure and success (Verify).

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It is the hope that further developing this index will provide better data for boards, and their regulators, to enable the achievement of legal compliance, and a safer workplace.

References

Amalberti, R. 2001. "The paradoxes of almost totally safe transportation systems." *Safety Science* 37 (2-3):109-126.

Bahn, S. 2012. "Work health and safety act 'due diligence:' Will our current safety systems be compliant?" *Journal of Health & Safety Research and Practice* 4 (2):8-13.

Baker, J. A. 2007. The report of the BP U.S. refineries independent safety review panel. Washington, DC: Baker Panel.

Barton, C. K. B. 2003. *Restorative justice: The empowerment model*. Sydney, NSW: Hawkins Press.

Bieder, C., and M. Bourrier, eds. 2013. *Trapping safety into rules: How desirable or avoidable is proceduralization?* Farnham, UK: Ashgate Publishing Co.

Blanton, R. G., and D. Peksen. 2018. "Pro-Market Policies and Major Industrial Disasters—A Dangerous Combination?" *Sociological Forum* 33 (1):5-29.

Cilliers, P. 2010. "Difference, identity, and complexity." *Philosophy Today* (Spring):55-65.

Clarke, L. . 1999. *Mission Improbable: Using Fantasy Documents to Tame Disaster*. Chicago, IL: University of Chicago Press.

Collins, R. 2013. "Losing faith in lost time injuries." *ASM*, 4-5.

CSB. 2007. Investigation report: Refinery explosion and fire, BP, Texas City, Texas, March 23, 2005 (Report No. 2005-04-I-TX). edited by U.S. Chemical Safety and Hazard Investigation Board. Washington, DC: U.S. Chemical Safety and Hazard Investigation Board.

Dahlström, N., S. W. A. Dekker, R. D. van Winsen, and J. M. Nyce. 2009. "Fidelity and validity of simulator training." *Theoretical Issues in Ergonomics Science* 10 (4):305-315. doi: 10.1080/14639220802368864.

De Carvalho, P. V. , J. O. Gomes, G. J. Huber, and M. C. Vidal. 2009. "Normal people working in normal organizations with normal equipment: system safety and cognition in a mid-air collision." *Applied Ergonomics* 40 (3):325-340.

De Keyser, V., and D. D. Woods. 1990. "Fixation errors: Failures to revise situation assessment in dynamic and risky systems." In *System reliability assessment*, edited by A. G. Colombo and A. Saiz de Bustamante, 231-251. The Netherlands: Kluwer Academic.

Dekker, S. W. A. 2011. *Drift into failure: From hunting broken components to understanding complex systems*. Farnham, UK: Ashgate Publishing Co.

Dekker, S. W. A. 2015. *Safety Differently: Human factors for a new era*. Boca Raton, FL: CRC Press/Taylor and Francis.

This article is protected by copyright. All rights reserved.

Accepted Article

Dekker, S. W. A. 2016. *Just Culture: Restoring trust and accountability in your organization*. Boca Raton, FL: CRC Press.
Dekker, S. W. A. 2017. *The end of heaven: Disaster and suffering in a scientific age*. London: Routledge.
Dekker, S. W. A. 2018. *The Safety Anarchist: Relying on human expertise and innovation, reducing bureaucracy and compliance*. London: Routledge.
Dekker, S. W. A., and H. Breakey. 2016. "'Just culture:' Improving safety by achieving substantive, procedural and restorative justice." *Safety Science* 85:187-193.
Dekker, S. W. A., and C. Pitzer. 2016. "Examining the asymptote in safety progress: A literature review." *Journal of Occupational Safety and Ergonomics* 22 (1):57-65.
Deming, W. E. 1982. *Out of the crisis*. Cambridge, MA: MIT Press.
Derango, J. 2013. "Safety manager receives jail sentence for falsifying records." *OSHA Net: Workplace Safety*, 12 April. Accessed 2 October 2014. http://washingtonexaminer.com/article/feed/2088502.
Downer, J. 2013. "Disowning Fukushima: Managing the credibility of nuclear reliability assessment in the wake of disaster." *Regulation & Governance* 7 (4):1-25.
Edmondson, A. 1999. "Psychological safety and learning behavior in work teams." *Administrative Science Quarterly* 44 (2):350-383.
Elkind, P., D. Whitford, and D. Burke. 2011. "BP: 'An accident waiting to happen'." *Fortune*, 24 January, 1-14.
Farrington-Darby, T., and J. R. Wilson. 2006. "The nature of expertise: A review." *Applied Ergonomics* 37:17-32.
Frederick, J., and N. Lessin. 2000. "The rise of behavioural-based safety programmes." *Multinational Monitor* 21:11-17.
GAO. 2012. Workplace safety and health: Better OSHA guidance needed on safety incentive programs (Report to Congressional Requesters, GAO-12-329). Washington, DC: Government Accountability Office: Government Accountability Office.
Havinga, J., S. W. A. Dekker, and A. J. Rae. 2018. "Everyday work investigations for safety." *Theoretical Issues in Ergnomics Science* 19 (2):213-228.
Heather, S., and G. Kearns. 2018. *Poll: mining OHS rules polarise the industry and risk friction*. Perth, WA: Mining People.
Hollnagel, E. 1993. *Human reliability analysis: context and control*, *Computers and people series*. London ; San Diego, CA: Academic Press.
Hollnagel, E. 2009. *The ETTO Principle: Efficiency-Thoroughness Trade-Off. Why things that go right sometimes go wrong*. Aldershot, UK: Ashgate Publishing Co.
Hollnagel, E. 2012a. "Resilience engineering and the systemic view of safety at work: Why work-as-done is not the same as work-as-imagined." Gestaltung nachhaltiger Arbeitssysteme, 58. Kongress der Gesellschaft für Arbeitswissenschaft, pp. 19-24, Universität Kassel, Fachbereich Maschinenbau, 22-24 February.
Hollnagel, E. 2012b. "Resilience engineering and the systemic view of safety work: Why work-as-done is not the same as work-as-imagined." 58. Arbeitswissenschaftlichen Kongress GfA (Hrsg.) Gestaltung nachhaltiger Arbeitssysteme: Wege zur gesunden, effizienten und sicheren Arbeit, Kassel, Germany, 22.02.-24.02.2012.
Hollnagel, E. 2014. *Safety I and Safety II: The past and future of safety management*. Farnham, UK: Ashgate Publishing Co.

This article is protected by copyright. All rights reserved.

Accepted Article

Hollnagel, E. 2017. *Safety-II in Practice: Developing the Resilience Potentials*. London: Routledge.
Hollnagel, E. 2018. *Safety-II in practice: Developing the resilience potentials*. London: Routledge.
Hopkins, A. 2010. *Failure to learn: The BP Texas City refinery disaster*. Sydney: CCH Australia Limited.
Hopkins, A. 2015. *Risky rewards: How company bonuses affect safety*. Farnham, UK: Ashgate Publishing Co.
Hopkins, A. 2019. *Organising for Safety: How structure creates culture*. Sydney, NSW: CCH Australia.
Hutchinson, B., S. W. A. Dekker, and A. J. Rae. 2018. "Fantasy planning: The gap between systems of safety and safety of systems." Australian Safety Critical Systems Association Conference, Melbourne, Vic, May 23-25.
Janis, I. L. 1982. *Groupthink, Second Edition*. Chicago, IL: Houghton Mifflin.
Klein, G. A. 1993. "A recognition-primed decision (RPD) model of rapid decision pmaking." In *Decision making in action: Models and methods*, edited by G. A. Klein, J. Orasanu, R. Calderwood and C. E. Zsambok, 138-147. Norwood, NJ: Ablex.
Le Coze, J. C. 2020. *Post Normal Accident: Revisiting Perrow's classic*. Boca Raton, FL: CRC Press.
Leplat, J. 1998. "About implementation of safety rules." *Safety Science* 29:189-204.
Lofquist, E. A. 2010. "The art of measuring nothing: The paradox of measuring safety in a changing civil aviation industry using traditional safety metrics." *Safety Science* 48:1520-1529.
Long, R. 2016. "The social psychology of risk, safety and leadership maturity." *The AusIMM Bulletin* 12 (5):26-28.
Loukopoulos, Loukia D., Key Dismukes, and Immanuel Barshi. 2009. *The multitasking myth: Handling complexity in real-world operations*, *Ashgate studies in human factors for flight operations*. Farnham, England ; Burlington, VT: Ashgate Pub. Ltd.
Michaels, D. 2015. "Proper protections could have saved four DuPont workers killed by gas." *Occupational Safety and Health Administration Document OSHA News Release; Labor Department Documents and Publications* 15-0912-NAT (5):1-2.
Muller, J. 2018. *The tyranny of metrics*. Princeton, NJ: Princeton University Press.
Nemeth, C. P., M. Nunnally, M. O'Connor, P. A. Klock, and R. I. Cook. 2005. "Getting to the point: Developing IT for the sharp end of healthcare." *J Biomed Inform* 38 (1):18-25. doi: S1532-0464(04)00155-8 [pii] 10.1016/j.jbi.2004.11.002.
Orasanu, J. M., L. Martin, and J. Davison. 1996. "Cognitive and contextual factors in aviation accidents: Decision errors." In *Applications of naturalistic decision making*, edited by E. Salas and G. A. Klein. Mahwah, NJ: Lawrence Erlbaum Associates.
Page, S. E. 2007. "Making the difference: Applying a logic of diversity." *Academy of Management Perspectives* 11:6-20.
Peace, C., V. Mabin, and C. Cordery. 2017. "Due diligence: A panacea for health and safety risk governance?" *Policy and practice in health and safety* 15 (1):19-37.
Pew, R. W. , D. C. Miller, and C. E. Feehrer. 1981. *Evaluation of proposed control room improvements through analysis of critical operator decisions*, *Applied Ergonomics*. Palo Alto, CA: Electric Power Research Institute
Provan, D. J., D. D. Woods, S. W. A. Dekker, and A. J. Rae. 2020. "Safety II professionals: How resilience engineering can transform safety practice." *Safety Science* 195:1067-1080.

This article is protected by copyright. All rights reserved.

Accepted Article

Pupulidy, I., and C. Vesel. 2017. "The learning review: Adding to the accident investigation toolbox." 53rd ESReDA Seminar, Ispra, Italy.

Rae, A. J., and D. J. Provan. 2019. "Safety work versus the safety of work." *Safety Science* 111:119-127.

Rae, A. J., D. E. Weber, D. J. Provan, and S. W. A. Dekker. 2018. "Safety Clutter: The accumulation and persistance of 'safety' work that does not contribute to operational safety." *Policy and practice in health and safety* 16 (2):194-211.

Rasmussen, J. 1997. "Risk management in a dynamic society: A modelling problem." *Safety Science* 27 (2-3):183-213.

Rochlin, Gene I. 1999. "Safe operation as a social construct." *Ergonomics* 42 (11):1549-1560.

Roe, E. 2013. *Making the most of mess: Reliability and policy in today's management challenges*. Durham, NC: Duke University Press.

Rosenthal, C., L. Hochstein, A. Blohowiak, N. Jones, and A. Basiri. 2017. *Chaos Engineering: Building confidence in system behavior through experiments*. Boston: O'Reilly.

Saines, M., M. Strickland, M. Pieroni, K. Kolding, J. Meacock, N. Nur, and S. Gough. 2014. Get out of your own way: Unleashing productivity. In *Building the Lucky Country: Business imperatives for a prosperous Australia*, edited by G. Vorster, C. Richardson and D. Redhill. Sydney, Australia: Deloitte Touche Tohmatsu: Deloitte Touche Tohmatsu.

Salminen, S., J. Saari, K. L. Saarela, and T. Rasanen. 1992. "Fatal and non-fatal occupational incidents: Identical versus differential causation." *Safety Science* 15:109-118.

Saloniemi, A., and H. Oksanen. 1998. "Accidents and fatal accidents: Some paradoxes." *Safety Science* 29:59-66.

Sharpe, V. A. 2004. *Accountability: Patient safety and policy reform*, *Hastings Center studies in ethics*. Washington, D.C.: Georgetown University Press.

Sheratt, F., and A. R. J. Dainty. 2017. "UK construction safety: A zero paradox." *Policy and practice in health and safety* 15 (2):1-9.

Snook, Scott A. 2000. *Friendly fire: The accidental shootdown of US Black Hawks over Northern Iraq*. Princeton, NJ: Princeton University Press.

Sutcliffe, K., and T. Vogus. 2003. "Organizing for resilience." In *Positive Organizational Scholarship*, edited by K. S. Cameron, I. E. Dutton and R. E. Quinn, 94-110. San Francisco: Berrett-Koehler.

Tooma, M. 2017. *Safety, security, health and environment law (2nd Ed.)*. Annandale, NSW: The Federation Press.

Tooma, M., and R. E. Johnstone. 2012. *Work health and safety regulation in Australia: The model act*. Annandale, NSW: The Federation Press.

Turner, B. A. 1978. *Man-made disasters*, *The Wykeham science series 53*. London: Wykeham Publications.

Ullstrom, S., M. A. Sachs, J. Hansson, J. Ovretveit, and M. Brommels. 2013. "Suffering in silence: a qualitative study of second victims of adverse events." *BMJ Quality and Safety* Nov 15 (doi: 10.1136/bmjqs-2013-002035).

Vaughan, D. 2005. "System effects: On slippery slopes, repeating negative patterns, and learning from mistake?" In *Organization at the limit: Lessons from the Columbia disaster*, edited by W. H. Starbuck and M. Farjoun, 41-59. Malden, MA: Blackwell Publishing.

This article is protected by copyright. All rights reserved.

Weick, K. E., and K. M. Sutcliffe. 2007. *Managing the unexpected: Resilient performance in an age of uncertainty*. 2nd ed. San Francisco: Jossey-Bass.

Woods, D. D. 2003. *Creating foresight: How resilience engineering can transform NASA's approach to risky decision making*. Washington, D. C.: US Senate Testimony for the Committee on Commerce, Science and Transportation, John McCain, chair.

Woods, D. D. 2006a. "Essential characteristics of resilience." In *Resilience Engineering: Concepts and Precepts*, edited by E. Hollnagel, D. D. Woods and N. G. Leveson, 21-34. Aldershot: Ashgate Publishing Co.

Woods, D. D. 2006b. "How to design a safety organization: Test case for resilience engineering." In *Resilience Engineering: Concepts and precepts*, edited by E. Hollnagel, D. D. Woods and N. G. Leveson, 296-306. Aldershot, UK: Ashgate Publishing Co.

Woods, D. D., S. W. A. Dekker, R. I. Cook, L. J. Johannesen, and N. B. Sarter. 2010. *Behind human error*. Aldershot, UK: Ashgate Publishing Co.

Accepted Article

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