The tangible-intangible dilemma

abstract.the pivotal dilemma, that safety culture is an intangible that purports to account for the tangible, for human performance in general and organizational accidents in particular. This paper takes a closer look at this dilemma. The aim is briefly to chart the chequered history of safety culture, to focus on the fundamental intellectual dilemma and to suggest a modest solution.

Keywords: safety culture, tangible, ages of safety, intangible, Safety Culture Ladder, Bradley curve,,Nietzschean anxiety, resilience, systemic potentials, incremental safety.

Introduction

So much has been written about safety culture, that even an AI endowed search engine does not know the number of published books , but a conservative intelligent human estimate is at least several hundreds, to say nothing of tens of thousands of journal papers and conference proceedings with no end in sight. Few of these efforts have, however, addressed Throughout most of the history of safety, the ages of technology and of human factors, according to (Hale & Hovden, 1998), cf., Table 1, safety practitioners were satisfied with using a single cause (either a technical failure and malfunction or a quirk of the human factor) to account for why and how accidents happened (technically called *proximal monocausal attribution*) but the 1970s and 1980s saw several large accidents such as the explosion at Flixborough (1974), The nuclear reactor accident at Three Mile Island (1979), the explosion of the space shuttle Challenger (1986), the accident at the Chernobyl nuclear power plant (also 1986), the capsizing of the Herald of Free Enterprise (1987) and the King's Cross Underground fire (also 1987), where were no obvious proximate active failures, but instead a combination of active failures and long-standing (latent) distal systemic pathogens, that suddenly resulted in an accident. This ushered in the age of safety management (Table 1) which required a combination of active failures and latent system conditions or pathogens, hence a transition to *distal multicausal attribution* that challenged established linear cause-effect reasoning It also threatened conventional monocausal reasoning and called into question traditional Newtonian methods of safety analysis and management. (Dekker, Cilliers & Hofmeyr, 2011). Out of this turmoil arose the idea that safety culture, as a single cause or factor perhaps could be used to explain what happened. This salvaged the convenience of monocausal thinking but at the cost of reduced veracity. The concept of safety culture maturity, using the analogy of human psychological development soon became so popular as a way to account for third age accidents, that it itself required further elaboration. The primary contribution of safety culture was to meet the psychological and socio-cultural need for simple explanations of accidents in cases where *proximal monocausal attribution* was inadequate. Safety culture has never demonstrated any practical value or ability to improve safety by reducing the number of unexpected and unacceptable outcomes. Safety culture is a *social construct* (Searle, 1995), and also a *counterfactual conditional*. There are no recognised psychological, sociological, or organizational theories that support safety culture, and no known methods effectively to establish, manage, maintain, or improve it. Safety culture came out of nowhere to relieve the anxiety in the wake of organizational accidents. Safety culture achieved that but has otherwise done nothing to reduce or prevent such accidents from occurring much work and many serious efforts notwithstanding.

Table 1: Three ages of safety (Hale & Hovden, 1998).

AGE OF SAFETY THINKING	TYPICAL (DEFAULT) CAUSE	TYPICAL (DEFAULT) RESPONSE	ASSUMED MODE OF CAUSALITY	BEGAN YEAR
I:Technology	Failure of technology	Replace, repair and improve	Active failure, monocausal	1769 (steam engine)
II: Human factors	Human factors human error	Blame, train, design, automate	Active failure, monocausal	1979 (TMI)
III: safety management	Organisational failure lack of safety culture	Audits, standardisation regulation	Latent conditions, multicausal	1986 Challenger, Chernobyl

Safety culture was first invoked as a counterfactual cause or explanation when the International Nuclear Safety Advisory Group (INSAG) from the International Atomic Energy Agency (IAEA) released its report on the causes of the accident that had happened at the Chernobyl Nuclear Power Plant on April 26, 1986. (INSAG-4, 1991), although (Reason, 1988) had already attributed the accident to a combination of an inadequate test plan and *Group Think*. Safety culture from the beginning denoted something that was absent but which might have prevented an accident if only it had been present, or in other words as ***a counterfactual conditional***.

In the INSAG report introduced the concept of safety culture to the common safety vocabulary, safety culture was defined as:

> "that assembly of characteristics and attitudes in organizations and individuals which establishes that, as an overriding priority (nuclear plant) safety issues receive the attention warranted by their Significance" (INSAG-4, 1986, p. 5). *This is, however, in philosophy known as an analytic proposition, that is true solely by virtue of its meaning.*

Safety culture was therefore from the very start left undefined. The INSAG is a group of senior experts in the field of nuclear safety appointed by the DG of the IAEA and usually serve for a period of 3-4 years.It is,however, difficult to say with any kind of certainty who contributed the idea of safety culture, as no one has come forward to claim the honour. Educated guesses, nevertheless, suggest that Mr. Brian Edmondson from the Central Electricity Generating Board (CEGB) in the UK may have been the one. The term safety culture appears to have originated privately in the post-Chernobyl analytical work by the British Central Electricity Generating Board (CEGB) (likely authored by Mr.Brian Edmondson) and was carried into IAEA discourse through professional collaboration, and eventually formalised anonymously in the INSAG-4 report. .Brian Edmondson was one of the 14 experts in the first INSAG constellation in 1985. All 14 expertts of the INSAG supported to suggestion of safety culture, as they presumably shared the same Nietzschean anxiety.

We do know for certain that when Jim Reason wrote his paper on the Chernobyl errors (Reason, 1987, p. 203-204), he pointed to the problems of coping with complexity, and elements of 'groupthink'. Groupthink is in many ways the essence of safety culture, but differs from safety culture by being a genuine psychological phenomenon, (Turner & Pratkanis, 1998).

Reason concluded that "we would be wise to extend the causal analysis beyond the limited scope of individual information processing to take account of the social aspects of the situation". (Ibid p. 204. Groupthink is a psychological phenomenon and cognitive bias where the desire for group harmony or conformity strongly influence or even determine individual decision-making. This

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The INSAG report also contained the following important passage, which has received very little attention:

> "The definition relates Safety Culture to personal attitudes and habits of thought and to the style of organizations. A second proposition then follows, namely that such matters are generally intangible; that nevertheless such qualities lead to tangible manifestations; and that a principal requirement is the development of means to use the tangible manifestations to test what is underlying." (INSAG-4, 1986, p. 1, emphasis added).

Much has been written about safety culture since then, but few authors seem to have noticed the above passage with the *second proposition*, which was cleverly tucked away on page 1 of the report. This passage nevertheless precisely identifies the fundamental problem with safety culture, namely how the intangible (safety culture) determines the tangible (what people do at work particularly when it does not go well) or tangible=*F*(intangible), and whether this can actually be regulated. Without having a clear and practical solution to The tangible—intangible dilemma it is a fool's errand to rely on safety culture.

Throughout the ages of safety (Table 1) it has every now and then, but rarely been necessary to introduce a new cause to explain a hitherto unknown type of accidents. The best known case is the world's first commercial jet airliner, the de Havilland Comet aircraft. During its first year of operation (1949) three Comets were lost in highly publicised accidents after suffering catastrophic mishaps mid-flight. Following these accidents the Comet was withdrawn from service, but a redesigned version flew again in 1958. The aircraft was finally retired in 1997. To provide passengers with a better experience, the Comets

had large rectangular windows, which eventually induced metal fatigue. Metal fatigue is the weakening of a metal part due to repeated cyclical movement such as bending or twisting Metal fatigue was obviously not considered when the Comet were designed, even though the phenomenon can be traced back to Hoooke's law and had been known, and named, since 1839 to explain broken train axles. Metal fatigue was seen as just another failure of technology hence did not introduce a new age of safety.

In other sciences it has also from time to time been necessary to introduce something new, because it was required by the underlying theories. The best known example is that the Standard Model of particle physics required specific elementary particles, most famously the Higgs Boson, predicted by Peter Higgs, Francois Englert, and others in 1964, and confirmed to exist by experiments using the Large Hadron Collider (LHC) in 2012. (Higgs and Englert shared the Nobel prize in physics in 2013). A similar inference in cosmology is the existence of **dark matter**, a mysterious, form of matter that supposedly makes up altogether 85% of the known universe although it is yet to be found, perhaps because it by definition is invisible. Safety culture differs from both of these. There is first of all no compelling physical evidence, such as crashed airliners that requires safety culture as a cause, neither are there any strong theories about human or organizational behaviour that predict its existence. So like ***dark matter*** safety culture remains invisible. The reasons why safety culture became necessary are instead purely psychological. Whenever something unexpected and unacceptable happens there is an *insatiable psychological need of explanations.*

Behaviour Based Safety (BBS)

behaviour Based Safety aims to improve safety by focusing on employee actions, identifying unsafe behaviours, providing real-time feedback, and reinforcing safe practices to prevent accidents, rather than just focusing on equipment or conditions. This is practically an analytic truth, since it is the outcome of how people act or perform that becomes the manifestation of the presence or absence of safety, although we mostly notice the latter, but neglect the former. Behaviour is the tangible, and the essential question that BBS is unable to answer is what determines the tangible – what determines human behaviour, whether safe or unsafe. Psychology has here made significant contributions, not least the Tversky and Kahneman research on Judgment under Uncertainty (Tversky & Kahneman, 1974). It is also the central issue addressed by the tangible—intangible dilemma: How does the intangible, safety culture, determine the tangible, what people actually choose to do in a specific situation. Safety research has for some reason skirted that central issue, perhaps because it is too difficult, and calling the intangible for nominating safety culture is no more an answer than error proneness once was. To make progress we therefore need a way to make the intangible tangible that is more practical than behaviour based safety, which actually does not explain anything. By itself behaviour based safety is just a fancy name that denotes the obvious and explains absolutely nothing. behaviour based safety completely misses the point, that safety **is** behaviour. Simply acknowledgning that explains nothing at all. . It as meaningful as saying "I can see because there is light".

The Need Of Safety Culture

New causes or constructs can become necessary for different reasons, as explained above: (1) for practical, technical or tangible reasons when a new type of accidents happens, as illustrated by metal fatiguethe de Havilland Comet, or (2) for theoretical or intangible reasons as illustrated by the Higgs boson. Safety culture, however, had its own and equally compelling inangible reason: (3) psychological necessity, as pointed out by many philosophers.

First of these was the Andalusian Muslim polymath, Ibn Hazm of Cordoba (994 – 1064) who explains all human activities and emotions as stemming from anxiety and the attempts to dispel it. (Abu Laylah, 1998, p. 114).

Half a Millennium later, the English philosopher Thomas Hobbes (1588 - 1679) in his great book ***Leviathan*** wrote that:

> "Ignorance of remote causes, disposeth men to attribute all events, to the causes immediate, and Instrumentall for these are all the causes they perceive". (Hobbes, 1651, Chapter XI).
>
> This by the way elegantly explains the problem of organizational accidents, namely that we cannot perceive the causes. Latent conditions, by definition, stay latent because they are not noticed.

In the late 19th century The eminent German philosopher, Friedrich Wilhelm Nietzsche (1844-1900), was even more explicit, when he wrote:

> "to trace something unfamiliar back to something familiar is at once a relief, a comfort and a Satisfaction, while it also produces a feeling of power. The unfamiliar involves danger, anxiety and care -the fundamental instinct is to get rid of these painful circumstances. ***First principle - any explanation is better than none at all***." (Nietzsche, 1997, Chapter 5, emphasis added). I will refer to this as the Nietzschean anxiety.

But most eloquent was Count Leo Tolstoy (1828-1910), who in his great book *War And Peace* discussed how the Muscovites tried to make sense of the conflict when Napoleon was marching toward Moscow. Tolstoy astutely noted that:

> "Man's mind cannot grasp the causes of events in their completeness, but the desire to find those causes is implanted in man's soul. And without considering the multiplicity and complexity of the conditions any one of which taken separately may seem to be the cause, he snatches at the first approximation to a cause that seems to him intelligible and says: This is the cause." (Tolstoy, 2007, Book 13, Chapter 1)

The famous German-US psychoanalyst Erich Fromm (1900-1980) was more blunt when he wrote: "The quest for certainty blocks the search for meaning."(Fromm, 2002, p. 45).

The numerous unexpected and unacceptable outcomes that happened in the third age of safety - and which still happen, created an urgent need for a new type of explanation that the counterfactual social construct safety culture appeared to meet. Safety culture literally came as a *deus ex machina*.

Given that safety culture for the reasons mentioned above was necessary to restore the peace of mind where simpler explanations had failed, the obvious next question is how a safety culture can be established and maintained. This is the essential problem the INSAG identified when they wrote "the development of means to use the tangible manifestations to test what is underlying." This is where an articulated theory of organizational culture would have come in handy. Such a theory is unfortunately nowhere to be found. A good approximation is Edgar Schein's proposal that an organizational culture has three main parts. According to (Schein, 1992) an organizational culture comprises **artefacts**, [the visible, tangible elements of an organization's culture] that are easy to perceive, **shared basic assumptions** [the deeply embedded, taken-for-granted behaviours which are usually unconscious], but constitute the essence of culture, hence essentially Reason's *Group Think*, and the **espoused values** [the organization's stated values and rules of behaviour]. The artefacts represent and complement the union of espoused values and the basic assumptions. There are several renderings of this model (often as three layers of a pyramid with artefacts at the top and underlying assumptions as the bottom layer. Cultures are, more generally, "systems of (socially transmitted behaviour patterns) that serve to relate human communities to their ecological settings (Keesing, 1974, p. 75), presumably also when these settings are intentionally created, such as the places of work that are of concern for industrial safety and which today totally have replaced natural work environments, with the possible exception of fishermen, farmers, loggers, and miners.

Schein's model is, however not a proper scientific model according to the definition by (Coombs, Dawes & Tversky, 1970, p. 2). These authors define a model as:

> "... the representation of some aspects of the world by a more abstract system. In applying a model, the investigator identifies objects and relations in the world with some elements and relations in the formal system." (Coombs, Dawes & Tversky,1970, p. 2).

Schein's model does describe three essential parts of an organizational culture (artefacts, basic assumptions an espoused values, but does not account for their mutual relations. The intangibles are obviously the espoused values and the shared basic assumptions but Schein's model contains nothing that corresponds to the tangibles, to human performance. It is therefore of little help to clarify the intangibles and to use safety culture actively to improve system performance., how, for instance, does a change in artefacts affect the espoused values? And what should be done effectively to change the basic assumptions, if and when needed?

The tangible—intangible dilemma is the essential issue that the INSAG report identified. There are two well-known candidates or frameworks that address that: the HSE Safety Culture Ladder and the Bradley curve.

As soon as safety culture and safety culture maturity became important issues proposals were made about how to manage the intangible in order to ensure the desired tangibles, to wit the absence of organisational accidents. But all such attempts immediately ran into problems with the first paradox of reason.

Twenty five years ago Jim Reason published a paper on "Safety Paradoxes And Safety Culture", which received surprisingly little attention. In this paper Professor Reason described four paradoxes of safety. The **first** paradox was that safety is defined and measured more by its absence than its presence. That means that what is supposed to be the tangible outcome of the intangible safety culture actually is not there, which, of course, is a major problem for the intangible-tangible dilemma. While there are many well-known manifestations of the absence of safety there are practically none for the presence of safety, that can serve as evidence for the presence of the intangible safety culture. It is therefore essential to define which tangible manifestations the intangible is supposed to produce. Another consequence of the first paradox is that while there are numerous models of how accidents occur there are practically no models of performance when there are few or no unexpected or unacceptable outcomes, even though these happen nearly all the time and are the rule where accidents are the exceptions and also is the kind of performance that is highly desired and necessary for companies to sustain their existence.

Examples

Examples Of The Tangible

Examples of the tangible, are relatively easy to find. The simplest is probably the adage"Safety First", which in a slightly expanded form becomes S.T.O.P: Stop, Think, Observe, Plan, in some cases supplemented by Communicate.

An even better example from the world of healthcare is Jeff's rule:

which encourages practitioners to 'reflect, review, rethink' if a patient presents three times with the same or escalating symptoms. (Spencer, et al., 2025).

Examples Of The Intangible

Examples of the intangible are in the nature of things harder to come by. Because they require an available definition of culture, or at least organizational culture.

What Is Culture?

Culture can be defined as the complex whole of a group's shared beliefs, customs, values, and ways of life, including both tangible elements and intangible aspects like language and traditions. Culture includes both tangible elements and intangible aspects like language and traditions. The concept of an organizational culture, can be found as far back as the *esprit de corps* of the Napoleonic Grande armée (1805-1815), possibly even the *agoge* of the Spartan Army more than two Millennia ago, Another expression is provided by the individual or collective level of aspiration for performance, or the *anspruchsniveau* (Chapman & Volkman, 1939) and (Lewin, et al., 1944), and, of course, more directly in the model of organizational culture described by Schein, 1992):the **artefacts**, [the visible, tangible elements of an organization's culture] that are easy to perceive,the **shared basic assumptions** and the **espoused values**. There are several renderings of this model (often as three layers of a pyramid with artefacts at the top. Cultures are, more generally, "systems of (socially transmitted behaviour patterns) that serve to relate human communities to their ecological settings (Keesing, 1974, p. 75), presumably also when these settings are artificial, such as the places of work that are of concern for industrial safety and which today totally have replaced natural work environments, with the possible exception of fishermen, farmers, loggers, and miners.

The problems in defining the intangible safety culture were clearly laid out by (Borys, 2019) who concluded:

"The literature review revealed that there is no agreed definition of the term 'safety culture,' and no definitive model of safety culture. In short, the body of literature is large, diverse, fragmented, confusing

and ambiguous. There is little evidence supporting a relationship between safety culture and safety performance. In a practical sense, it is fruitless to continue to attempt to define safety culture. Rather than trying to change something as nebulous as 'safety culture,' the focus should shift to changing the organisational and management practices that have an immediate and direct impact on workplace safety. Organisational culture, however, is a useful concept if understood as a metaphor rather than a variable. Organisational culture informs changes in organisational practices that focus on safety, and may evolve as the culture learns and grows over time. While they do not inform culture change, safety climate surveys may be a useful measure of the perceived effectiveness of changes in organisational practices focused on safety. This view of organisational culture has implications for practice, both for OHS professionals and management." Borys, 2019. p. 29)

The HSE Safety Culture Ladder

One of the best known frameworks for managing and improving safety culture is Patrick Hudson's HSE Safety Culture Ladder, even if it does not directly address or solve the tangible-intangible dilemma. The HSE Safety Culture Ladder represents the intangible by five levels or steps (Figure 1.) An obvious question is, of course, where the five named levels come from and what their theoretical or empirical basis is.

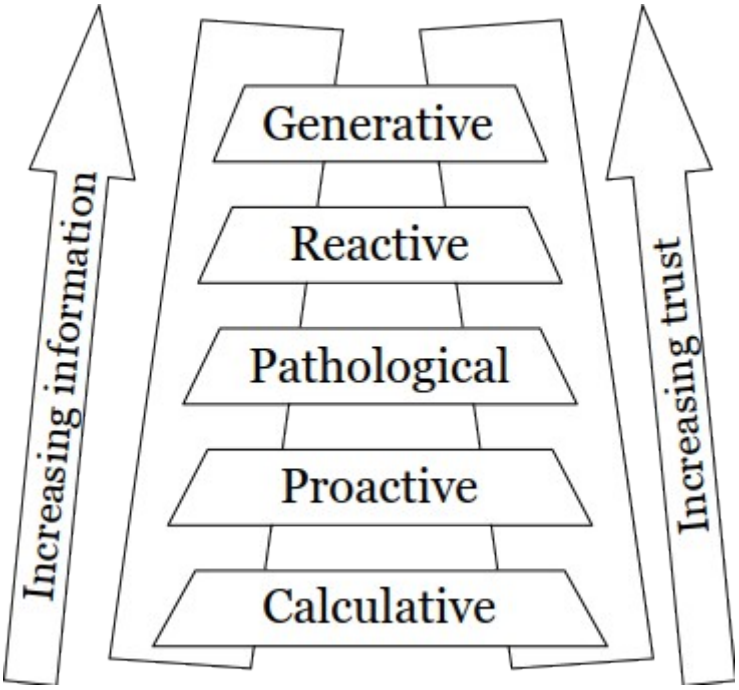

Figure 1: The HSE Safety culture ladder (Hudson, 2007)

(Lawrie, Parker & Hudson, 2006), proposed a framework for understanding the development of organisational safety culture, where the five levels were introduced and explained (Lawrie, Parker & Hudson, 2006, p. 267). The three authors in turn listed two sources for their proposed levels of safety culture, namely (Westrum, 1996) and (Reason, 1997), where (Westrum, 1996) provided the idea of various levels, although in relation to safety climate rather than safety culture:

"One useful indicator of the overall climate is the way that information is handled in the organization. It might be useful to suggest a range of climates, using information flow as the indicator. One such range is the pathological, bureaucratic and generative scheme" (Westrum, 1996, p. 7) (Table 2).

Table 2: Westrum's (1996) types of organizational climate

PATHOLOGICAL	BUREAUCRATIC	GENERATIVE
Information is hidden Messengers are "shot" Responsibilities are shirked Bridging is discouraged Failure is covered up New ideas are crushed	Information may be ignored Messengers are tolerated Responsibility is compartmented Bridging allowed but discouraged Organisation is just and merciful New ideas create problems	Information is actively sought Messengers are trained Responsibilities are shared Bridging is rewarded Failure causes inquiry New ideas are welcomed

The origin of the HSE Culture Ladder is not in research on *safety culture*, but rather in research on *safety climate*. (Westrum, 2004). Whereas the HSE Culture Ladder pretends to be a model of safety culture maturity, accounts of Safety Climate (Westrum, 2004) are less pretentious. Climate represents patterns in information handling, and therefore at best espoused management values, completely different from the safety culture of the organization as such, as management is a subset of the organization. To make matters worse,neither the HSE Safety Culture Ladder (Figure 1), nor the Bradley hypothesis (Figure 2) are actually models in a scientific sense (Coombs, Dawes & Tversky,1970). They are both seductive graphical renderings of the popular idea, that safety culture can gradually mature or improve through a number of distinct phases, either five levels or four stages but neither rendering provides the three types of knowledge needed to control a change, described below [The Knowledge Needed To Control A Change].

The analogy with a ladder immediately triggers the idea that safety culture is improved by climbing the ladder, just as we physically can reach higher if we use a ladder. The critical question is, how a simple and familiar movement in the tangible world can be represented as a movement in an intangible world, Hudson, of course, understood that a movement in the intangible world must take place in the minds of the people who do the work, because their actions constitute the tangible manifestations that express the safety culture. Hudson "solved" the problem in the following way:

"But it was clear that simply pointing out which direction to go would not be enough to actually induce progress up that ladder, for that some way of creating lasting change was necessary. The next stage in the project therefore required the development of a process model that defined how people could be brought to change and, it was felt, it would be best if this change was what people wanted, not one that they felt had to take place because they are told to. There are a wide variety of change models available, but most of these (e.g. Kotter, 1996; Kotter and Heskett, 1992) tend to concentrate on the details of project management in a change environment; we selected one model from psychology, the transtheoretical model of (Prochaska & DiClemente, 1983) and (Prochaska et al., 1998), because it covered the elements felt essential to cover the requirement that people should want to change. In particular this model laid much more emphasis on getting those involved to have an active personal desire to change rather than a passive requirement to meet the goals of management. (Hudson, 2007, p. 704) presents the five main stages of the change model, with its special emphasis on acquiring awareness and, once behaviour change has been effected, of maintaining that change."

Hudson chose the so-called transtheoretical model of (Prochaska and DiClemente, 1983), which became marketed and widely known as the *hearts and minds method*.

This solution is, however, quite problematic. The transtheoretical model of change, was so named because it is not based on a specific articulated theory of how changes can be made but rather is a hodgepodge of different theories from psychotherapy, it may well be useful to understand how a personal choice such as to stop smoking takes place. Yet we know practically nothing about how the decisions we make determine the actions we take. An organisation is anyway not a single sentient being, and does not as such choose to change or improve its safety culture, responsible managers perhaps do but they do not by themselves constitute the safety culture of a company. While the transtheoretical model possibly may be appropriate for understanding how a management decision is made, it is singularly unsuitable for

understanding how to implement a change in the workforce, once the management's choice has been made. the *hearts and minds* method therefore does little to explain the tangible-intangible dilemma.

Another peculiarity of the Safety Culture Ladder is that Pathological is the name of the third step, half way to optimal maturity. In common parlance pathological is the worst possible and not the third best. The worst is here calculative, which most people would rank better than pathological, since it at least suggest there is some kind of underlying principle.

Hudson's Mistake.

The above long quotation from (Hudson, 2007, p. 704) exposes the main problem with the *hearts and minds* method for all to see. Regardless of whether safety culture is defined as Group Think (Reason, 1988), as ancestry and social environment (Heinrich, 1959) as an *esprit de corps,* as a collective level of aspiration for performance in a task, as a socially transmitted behaviour pattern or as the shared basic assumptions or the espoused values, of (Schein, 1992), it is obviously not something a single individual can decide to change, neither is it something that can be changed from the outside by a single factor ***leadership***, for instance. A person may choose to adopt an artefact, such as a MAGA Cap, but cannot in the same way choose to change the shared basic assumptions or the espoused values of the organization where that person works, even if that person is aware of them? It may happen after a while of socializing with others that also wear a MAGA cap, but then as a result of social pressure, as described by social judgement theory (Sherif & Sherif, 1968) rather than as a personal choice. It actually contradicts the very idea of culture to assume that adherence to the culture that influences what we do is a discrete individual choice, that can be changed in the same way as breaking a bad habit. To suggest that reveals a fatal misunderstanding of whatever culture or safety culture is. Performing in accordance with the safety culture or with the local organizational culture in general, is not an individual choice or an isolated act, like lighting a cigarette. This is also evident from the popular definition of safety culture as "the way **we** do things around here". The analogy that is the justification for the *hearts and minds* method is therefore misleading, irrelevant and inappropriate and the supporting reasoning is illogical and seriously flawed. Seen from this perspective the choice of the *hearts and minds* approach is a rather desperate efficiency-thoroughness trade-off (Hollnagel, 2009), due to Hudson's urgent need to come forward with some sort of method that could be used to change people's mindset (Hudson, as cited above).

It must be mentioned that the original transtheoretical model, in both the original version, and Hudson's interpretation thereof represents hypothetical stages of an individual's mindset, rather than of a safety culture. It can therefore not be claimed to be a model of safety culture maturity in the way that Schein (1992) is a model of organizational culture. Developing or maturing a safety culture must address the shared basic assumptions, espoused values, and artefacts, if, indeed, an artefact can represent safety culture maturity? And this cannot be replaced by addressing individual characteristics and attitudes. Group Think is neither the sum, nor the average of how a set of individuals think or of their readiness to behave safely, nor are there many artefacts that naturally represent basic assumptions and espoused values.

The Bradley curve

Another popular suggestion for solving the tangible-intangible dilemma is the Bradley curve. It differs from the HSE Culture Ladder (Figure 1) by showing a a continuous curve divided into four sections of apparently equal size instead of five discrete stages or steps.

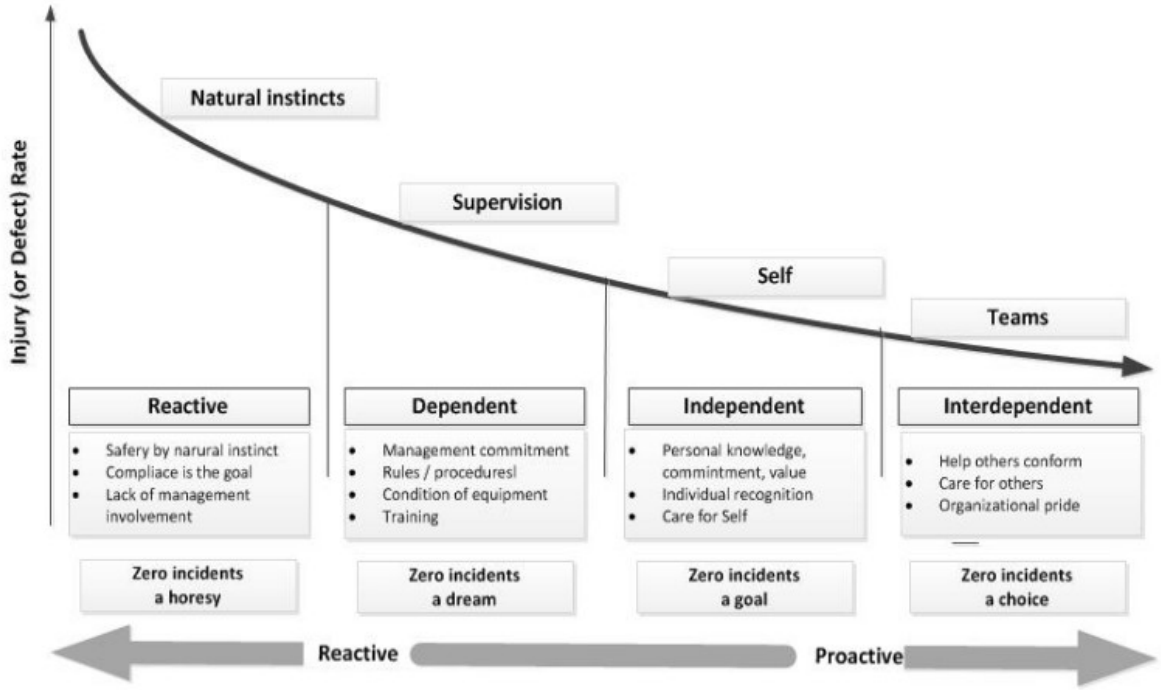

Figure 2: The Bradley curve from (Jasiulewicz-Kaczmarek, M., Szwedzka, K. & Szczuka (2015).)

The curve illustrates imagined steady improvement, measured by a diminishing number of occupational accidents, precisely what management wants. The smooth curve is, a manager's wet dream with neither data nor theory to support it. In the 1990s, Ed Woolard the CEO of DuPont chartered a so called DuPont Discovery Team to develop a system that would allow sustainable and lasting improvement in organisational safety (unsurprisingly defined in terms of the Zero Accident Vision, Woolard had apparently adopted the myth of safety culture). The best (and also the only) known, outcome of that team effort was the Bradley Curve (proposed in 1994 and named after a team member: Vernon Bradley (sometimes wrongly named Berlin Bradley, who was Manager of a DuPont plant in Canada). Empirical support is out of the question because continuous measurements of occupational accident rates are unaffordable and therefore practically impossible. In the best cases a occupational accident rate may be calculated weekly, monthly, or quarterly, but most likely only as part of an annual report. A proper rendering of the Bradley curve would therefore be a staggered graph or a histogram rather than a smooth curve. The Bradley curve anyway does not describe a system that will bring sustainable and lasting improvement in organisational safety, but only the imagined outcomes should such a system ever be specified and realised. The Bradley curve appears in many promotional materials from companies that either claim they use it or (worse) offer to teach others how to do so, but there are few if any scientific papers that either describe or support it, although several make opaque reference to it. (The names of the four stages were apparently borrowed by Mr. Bradley from Covey (1989) who himself seems to be taken them from the famous Swiss developmental psychologist Jean Piaget, hence not related to safety culture at all.) The curve is only possible if it is supported by a method to bring about a steady reduction of occupational accidents. Such a method did not exist in the 1990s and does not exist today. If wishes were horses, beggars would ride, and occupational accident rates would be under steady control.

The Bradley curve does not in any way explain how safety culture maturity can be controlled, CEO Ed Woolard's intentions notwithstanding. Unlike a ladder, there is no natural affordance for a curve or a slope, except, perhaps to slide down along it. Yet, the further you move along the slope as it is rendered in Figure 2, the further you get away from being in the best position, which in the natural rank order usually is the leftmost, The common renderings of the Bradley curve, but not the version seen in Figure 2 includes an ordinate scale named Safety Culture Self Assessment but it is not actually defined, and it would anyway not be reliable, if it was based on self assessment. Neither is it intuitive that moving further to the right represents improved safety culture maturity. The leftmost position is usually

considered to be better than any of the following. The further you move to the right the lower you also are on the abscissa. The Bradley curve therefore represents a counter-intuitive relation in every way and seems to be based on wishful graphics rather than systematic thinking. The curve is divided into four regions or segments of apparently equal size, named (reactive, dependent, independent, and interdependent), the names have no obvious connotations unlike the names of the five steps of the Safety Culture Ladder. And it is not reasonable that an interdependent safety culture is more mature than an independent one. From a simple reliability point of view, the opposite may actually is more reasonable, since a system where functions are independent is more reliable, and therefore preferable to a system where function are interdependent or coupled, as the latter is more likely to experience the normal accidents that (Perrow, 1984) brought into to the safety debate. the order of the two stages independent and interdependent therefore ought to be reversed. Neither does the Bradley curve in any way support how to determine the current position. Since the curve also represents the occupational accident rate it would in principle have been possible to define threshold values for each of the four stages, at least as percentages. The affordance of a ladder is that it brings you higher for each step you take. The Bradley curve does not offer any knowledge of how the movement along the slope, the so-called safety journey can take place (the **means**). The Bradley curve (Figure 2) does show a rough correlation with the occupational accident rate, but in this case it seems more reasonable to assume that the decreasing rate is a function of the postulated maturity of safety culture, rather than the other way around, since the latter raises the fundamental question of how the occupational accident rate effectively can be reduced, something the safety legacy so far has been unable to provide.

Similar to the HSE Safety Culture Ladder, the Bradley curve indicates a default **goal**, namely the fourth and rightmost stage (interdependent) but with no definition of what interdependent means in practice, nor how it can be determined, except by the above mentioned subjective safety culture self assessment.

Altogether the Bradley curve may appear appealing to a manager or a CEO, but is woefully underspecified and therefore impossible and inadvisable to use in practice.

The Reason Decomposition

That Jim Reason was aware of the tangible-intangible dilemma, can be seen from the following question:

“By what means can we set about transforming an average safety culture into an excellent one? The answer, I believe, lies in recognising that a safe culture is the product of a number of inter-dependent sub-cultures, each of which – to some degree – can be socially engineered. An informed culture can only be built on the foundations of a reporting culture. And this, in turn, depends upon establishing a just culture. In this concluding section, we will look at how to build these two sub-cultures. The other elements of a safe culture – a flexible culture and a learning culture hinge largely upon the establishment of the previous two. They have been discussed at length elsewhere (Weick, 1987), and (Reason, 1997) and will not be considered further here. (Reason, 2000, p. 12).

This decomposition defines a pyramid of subcultures as shown in Figure 3.

Figure 3: The decomposition of safety culture (Reason, 2000).

Reason's suggestion triggers three comments, **First**, how is it possible to decompose an intangible safety culture into four subcultures. **Second**, each of the four proposed subcultures will presumably be intangible themselves. **Third** if two of the proposed subcultures an informed culture and a reporting culture can be managed independently, as the quote suggests, then why can the same operations not be done for to the larger safety culture. The relative order of Flexible Culture and Learning Culture are not specified. Neither is it described how it can be determined that either of the four safety culture components are present. Reason's suggested decomposition is thus even less of a model than Schein's. Additionally neither(Weick, 1987), or (Reason, 1997) describe how a culture can be managed. Reason's decomposition is therefore not a viable solution to the tangible-intangible problem, nor does it clarify what safety culture is.

Resolving The Tangible—intangible Dilemma

The tangible—intangible dilemma is a serious impediment for the safety legacy and for established approaches to safety management. The obvious way to get rid of the tangible-intangible dilemma is, of course to replace the intangible with a description of the tangible, not as the accidents because they represent the absence of what we seek as the first paradox of Reason makes clear, but as behaviour, as what people actually do when they carry out their work, especially when it goes well as it does nearly all the time.

In the

Despite the several attempts described above, the tangible—intangible dilemma has not to find a solution. But a solution is actually fairly simple. Namely to replace the intangible with something tangible. The tangible replacement is in this case resilience, not in the sense of a wholesale substitution of safety culture by resilience culture, but by realising that resilience is tangible because it denotes what a system **does** rather than what it **has**. The question therefore becomes what characterises resilient performance. An early definition was

> "a resilient system is defined by its ability effectively to adjust its functioning prior to or following changes and disturbances so that it can continue its functioning after a disruption or a major mishap, and in the presence of continuous stresses." (Hollnagel, 2008, p. x).
>
> This was later defined more explicitly as follows:
>
> "Resilience is defined as the intrinsic ability of a system to adjust its functioning prior to, during, or following changes and disturbances, so that it can sustain required operations under both expected and unexpected conditions. Since resilience refers to something a system does, to a capability or a process, rather than to something the system has, to a product, the measurement cannot be based on counting specific outcomes such as accidents or incidents." (Hollnagel, 2011, p. 275).

The intangible is made tangible by expressing it in terms of the four potentials for resilient or systemic performance: The potential to respond, the potential to monitor the potential to learn and the potential to anticipate. The rather abstract problem of how to improve safety culture is in this way

transformed into a problem of how to establish and maintain the four potentials, for which a practical method is available, described in (Hollnagel, 2026) on the www.incrementalsafety website, and by (Hollnagel, Licu & Leonhardt. 2021). Since the latter source is freely available, the concrete details of how the four potentials and thereby also resilience can established will not be repeated here. The challenge is not to describe work as it actually will be done, since we are constrained by the inevitable difference between Work-as-Imagined and Work ~~as-~~Done (Hollnagel & Clay-Williams, 2022; Hollnagel, 2017). But in its place we can describe the abilities or potentials that are necessary for resilient performance, for work to go well.

the INSAG version of the tangible = F(intangible) relation is a dilemma, because the dependent variable tangible is the manifestations of the *absence* of safety or safety culture, while the independetvariable intangible ammot be manipulate, hence makes it impossible ever to determine that safety cultur as an independent varaiable actuallyhas empirical cosequnts.by virtue of being intangible does not support. In the alternative resilience version, the tangible = F(tangible) relation, the dilemma has been resolved, and the dependent variable tangible represents the manifestations of the *presence* of safety, hence work that goes well, while the independent tangible represents the four systemic potentials, that can be assessed in terms of their facets.

The Four Systemic Potentials.

The potential to respond. In order to manage anything,or even just to exist it is necessary to be able to respond to whatever happens and to know both **what** to do and **when** to do it. This either requires that a set of responses already exists (and that the necessary resources are available) – or that a response can be developed before it is too late. An inability to respond can be fatal, whether it concerns two moving vehicles, two business initiatives on a potential collision course, or a rapidly spreading wildfire. A good example was the evacuations due to Greek forest fires in on the Island of Rhodes in the summer of 2023), to say nothing of the wildfires in Los Angeles at the beginning of 2025 another example is a new pandemic (such as Covid-19), or an outbreak of measles in an unvaccinated population in Texas all of which will eventually lead to a loss of control. Quite apart from that, no person or company likes to be in a situation where they cannot respond to what happens.

While it is essential to be able to respond, it is a decided advantage to be ready to respond whenever something happens. In our societies only few types of responses maintain a constant readiness, the fire fighters, and the ambulance services, for instance. Readiness is, in principlepossible, if future events are so regular that they are predictable, yet in the Nordic countries people are still surprised when the first ice and snow appears. . The ability to predict something that is less regular than the sunrise every morning, depends on the ability to monitor to interpret early signs correctly and to identify trends.

The potential to monitor. In order to be able to keep an eye on what happens and be ready to respond quickly and effectively it is necessary to know what to look for (signals, signs, and symbols), (Rasmussen, 1983) and also to know to know **where** to look, and to know **how frequently to loo**k– which means knowing how to monitor (looking too often may be a waste of resources, not looking often enough may miss an important event or change). Although it sometimes may be possible to respond to unexpected events just as they happen, this strategy, known as "fire-fighting" is not viable in the long run. (Bohn, 2000). Learning must happen faster than the changes that require it.

The potential to learn. Neither responding, nor monitoring can or should always happen in the same way. In most systems prepared or built-in responses are based on Work-as-Imagined embedded in a World-as-Imagined. But actual demands and conditions will always be different from what was imagined or experienced previously, because internal or external conditions never are perfectly stable, it is therefore inadequate always to respond in the same way. The 2008 financial crisis demonstrated clearly that no company is too big to fail, so it is unwise to disregard what happens externally and to fail to adjust both the intangible and the tangible to that. It is a serious risk for any kind of dynamic system always to respond in the same way and to rely on the same signals, signs, and symbols. To do so may provide a short-term gain in efficiency but it is paid by a loss of thoroughness and attention to detail. The only way to avoid this is by learning. Learning enables a system (or a company) to change how it responds to whatever happens, by strengthening effective responses, by suppressing or eliminating ineffective responses, and by learning new responses. The purpose of learning is not the simple acquisition or accumulation of

knowledge (or data or information, but the effects on performance, on the potential to respond – as well as the potential to monitor, and ultimately also on the potential to learn. Learning must be at least as fast as the rate of change of the environment. The dinosaurs were limited to learning at en evolutionary pace, and that was clearly insufficient (Fremlin, 1979, p. 250-251). To achieve full efficiency, learning cannot be limited to actual experiences, but must also make use of anticipation, just as anticipation itself must be flexible and improve with experience. Without the potential to learn, responses will be limited to a fixed and pre-defined set as in a standard procedure or set of instructions, based on whatever system developers and designers were able to imagine once upon a time. Even learning itself must change and develop. It is imprudent always to respond, to monitor, to learn, and to anticipate in the same way, unless everything is perfectly stable, which entropy makes impossible. Always responding monitoring, learning, and anticipating in the same way is only feasible if conditions **never** change, if the world is fixed and perfectly stable. But entropy makes that impossible, as we all know. Things will never happen in the future the same way in the future as they happened in the past, which we have known since the time of as we know from the teachings the famous Greek philosopher Heraclitus (c. 500 BCE), who taught us that *panta rhei*, or "everything floats" The same argument, of course, goes for monitoring. It is unwise to always rely on the same signs, indicators and measurements. Learning can furthermore not be limited to what **not** to do (**avoidance learning**). It is equally important, if not more so, to learn from what works well (**reinforcement learning**), in order to *strengthen* effective responses. Learning is necessary to make performance more efficient, as in the progression from knowledge via rules to skills (Anderson, 1980; Vicente & Rasmussen, 1988). The gradual automation of responses, the development of patterns, habits, and routines, and the recognition of important weak signals (Hollnagel, 2025) are essential parts of how performance becomes attuned to the prevailing conditions – with all the risks that such increased effectiveness and reduced thoroughness involve. Learning is a *sine qua non* for both monitoring and responding, *and ultimately also for learning itself*. A strategy for learning cannot be stable, but must be heuristic and not algorithmic. Life is experienced backwards, but must be lived forwards, as the famous Danish philosopher Søren Kierkegaard pointed out.

The potential to anticipate. Since the environments and surroundings in which work takes place and where companies exist are not perfectly stable, it is necessary to acknowledge both that they **can** change and also to imagine or think about **how** they may change, which means the potential to predict and anticipate. (Prediction and anticipation are not synonymous. Prediction is focused on a specific future event, whereas anticipation involves preparing for potential scenarios or even just taking something into consideration. (Prediction can be used to prepare the readiness of a specific response, while anticipation can become the basis for a class of similar responses (consider the difference between a prediction of rain and the anticipation of inclement weather). Where monitoring focuses on the current situation and the near term developments, anticipation looks beyond the near term to the more distant future. It is, of course, difficult to predict what may happen in the future. "It is difficult to make predictions -— especially about the future" because it is nearly impossible to know how other people think, and to predict what they may do and also because the rate of changes, even of physical phenomena may be too rapid to follow, and sometimes paradoxically also so slow that it is difficult for us to notice them, climate change illustrates that well. It is also necessary to consider which resources, skills, and competences a company will need in the future? This is necessary in order to ensure that responding remains possible. A simple example is that fires in Electrical Vehicles (EV), for instance, cannot be extinguished in the same ways as fires in fossil fuel vehicles, since both water and foam conduct electricity, that may possibly hurt the fire fighters. New extinguishing equipment and new working procedures are therefore required. Likewise roof fires under solar panels do not dissipate heat as “normal” roof fires do.

The levels are defined by the relative fulfilment of each of the four potentials, and this also defines the practical way in which resilience culture can be established. A resilience culture thereby ceases to be intangible, and the intangible-tangible dilemma is transformed to a tangible-tangible relationship, where (tangible performance)=*F*(tangible systemic potentials).

Systemic Potentials Management(SPM)

Even though the details of Systemic Potentials Management are readily available elsewhere as already mentioned, it is only reasonable to provide a brief summary here. SPM was developed as a means to

operationalise resilience rather than as framework to resolve the tangible-intangible dilemma. The basic idea is illustrated by Figure 4.

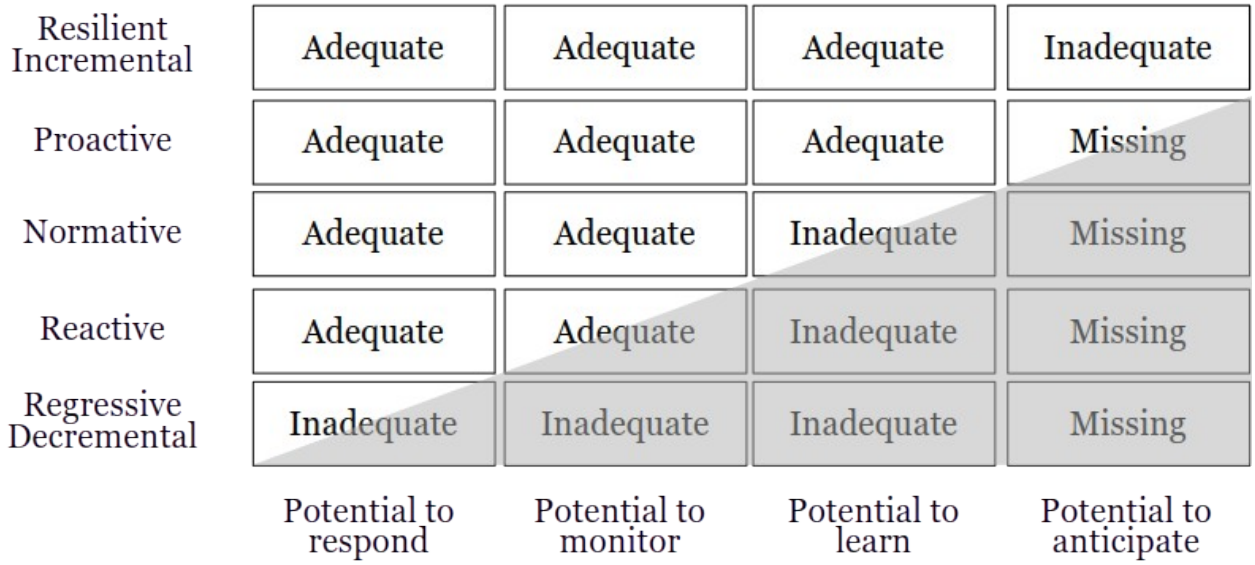

Figure 4: The four systemic potentials

Figure 4 (coincidentally also has five levels. But in this case each level is defined by the relative fulfilment of the four potentials. There is therefore a logical progression through the twenty steps that goes from a regressive or decremental safety culture to a fully develop resilient or incremental safety culture. The four systemic potentials thus provide a clear and practical way to determine the current **position** and of defining the **goal**. The relative fulfilment of each potential is achieved by assessing them using context specific seta of questions that address the facets of each potential.

Assessing The Systemic Potentials

The main practical issue of the systemic potentials is how they can be assessed in order to determine the current position. This is not done directly by assessing each potential as a single quality. That would be as mindless as assessing resilience or safety *eo ipso*. Each potential can, however, be described as comprising a number of more specific facets or functions that are common to many types of activity and domains. So instead of assessing each potential as a whole, the potentials may better be characterised in terms of the several facets each represents. This can be used as a concerted approach at both the blunt and the sharp ends to ensure that resilient performance is possible here and now as well as in the foreseeable future. The same cannot be done for safety because there is no theory of potentials for safety, other than safety culture. Which because it is a counterfactual condition does not live up to the requirements for a theory! The questions used in the assessment must fulfil three criteria:

- The questions must be ***specific*** and refer to the system or company in question. The questions should be about operational aspects, about how something is being done rather than about how someone thinks about it or likes/dislikes it.
- The questions must also be ***diagnostic*** and concerned with problems or issues that are known to be relevant (perhaps representing past problems) and therefore are meaningful to assess.
- The questions must finally be ***formative*** in the sense that the answers either can be used directly to choose an appropriate intervention or serve as a starting point for proposing specific actions or changes to improve – or maintain – the conditions revealed by the surveys.

If the questions fully meet these criteria, the replies can be used to provide the three types of knowledge needed to control a change as defined by (MacKay, 1951). Examples of concrete questions can be foundin(Hollnagel, Licu & Leonhardt. 2021).

The Knowledge Needed To Control A Change.

According to (MacKay, 1951) three types of knowledge are required to control or manage a change, whether a physical journey driving from your home to a holiday resort or metaphysical journey such as a safety culture journey:

1) Knowledge about the **current position,** where you are at any moment
2) Knowledge about the target, destination, or **goal**. Where you want to be at be at the end of the journeyYou need both in order to know when or whether you have completed the journey and arrived at the goal
3) Knowledge about the **means**. You need this in order to be able to change your position to get closer to the goal.

The three types of knowledge are necessary in order to be able to change the intangible with predictable consequences for the tangible for what people chose what to do in response to arising situations and unexpected changes in conditions.

Conclusion.

The inevitable conclusion from this analysis is that safety culture is a social construct that serendipitously and conveniently solved an urgent psychological need and thereby got rid of the distressing uncertainty that follows the novel, the unexpected and the unknown. Safety culture does, however, not represent or refer to an articulated theory about human performance, either individually or collectively, or even about safety. Indeed there are no articulated theories about safety, and hardly any about human performance either (there actually are no theories about safety!) The only known tangible consequences of safety culture are due to its absence rather than its presence, safety culture has never been proven to have any practical use, or in any way to be controllable or manageable, it is wishful thinking that safety culture is able to increase the number of expected and acceptable outcomes. Safety culture has practical value mostly for those who innocently promote and thereby perpetuate the social construct as if it was a practical solution to an acute problem. To make matters worse, the popular approach to change safety culture through the *hearts and minds* method, is based on a fundamental misunderstanding of what culture is, and what the method can do.

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