Civil Engineering and Environmental Systems
Vol. 27, No. 3, September 2010, 211–217

Taylor & Francis
Taylor & Francis Group

Systems thinking, culture of reliability and safety

Nick Pidgeon*

School of Psychology, Cardiff University, Cardiff CF10 3AT, UK

(*Received 1 March 2010*)

The paper reflects upon the intellectual contribution of both David Blockley and the late Barry Turner to contemporary thinking about organisational accidents and safety cultures in hazardous systems. When they first worked together in the 1980s, events such as the Chernobyl and Challenger accidents highlighted the fact that in seeking the causes of many modern large-scale accidents we must now consider the interaction between technology and organisational failings. Theoretical models also moved on at that time from descriptions of accidents and their causes, in an attempt to specify 'safe' cultures and 'high-reliability' organisations. Recent research has shown us that while effective learning about hazards is a common assumption of such attempts, organisations can still be very resistant to learn the full lessons from past incidents and mistakes. This paper discusses the ways of addressing barriers to learning in high-risk socio-technical systems.

Keywords: man-made disasters; safety culture; organisational learning; safety imagination

1. Introduction

I first met David Blockley in 1983 when I was fortunate enough to join the project that he and the late Barry Turner co-directed investigating the socio-technical causes of failures in the UK construction industry. It was a brave step both personally and professionally – a psychologist moving to work as a research assistant with a civil engineer and an organisational sociologist. But as a team, we worked well together – the trick, if there was one, was to always listen with care to the arguments and concepts from the perspective of the other discipline, however unusual they might seem at first. In that way the disciplinary language barriers, which often impede progress, could almost always be overcome, a lesson I have kept firmly with me throughout my own academic career since that time. It was also clear to me that in devising their joint project ideas, David and Barry had hit upon the other essential ingredients of successful interdisciplinary research – a problem which was real, was worth studying and potentially tractable, but which could not be easily solved working within any single discipline alone.

Barry Turner had devised his pioneering *Man-made Disasters* theory in the mid-1970s (see Turner 1978) but recognised that its real value would be to engineers and risk managers outside of his own discipline of sociology and that civil engineering would be as good a test bed as any for applying some of the ideas. David Blockley in turn, in his equally innovative analysis in the *Nature*

*Email: Pidgeonn@cardiff.ac.uk

ISSN 1028-6608 print/ISSN 1029-0249 online
© 2010 Taylor & Francis
DOI: 10.1080/10286608.2010.482660
http://www.informaworld.com

of Structural Design and Safety (Blockley 1980), had hit upon a similar set of ideas. Recognising with very great foresight that civil engineering failures were primarily human and organisational phenomena as much as they were technical failures, David sought out the concepts and ideas from social sciences that might help engineers to order, classify and ultimately predict the factors that contribute to major failures. David and Barry also shared other important intellectual common ground: in their concern for uncertainty and the unintended consequences of human actions, and their firm belief that major failures, in the construction industry as elsewhere, could only be understood through adopting systems thinking.

Again with hindsight, the project – which in itself produced well-regarded publications on failures in design practice (Pidgeon *et al*. 1986) and contaminated land (Pidgeon *et al*. 1988) – occurred at a key juncture in safety history and allowed all three of us working together, along with our colleague Brian Toft, the opportunity to reflect upon and take forward our ideas about the nature and place of uncertainty and safety in a contemporary high-risk world. When we commenced our own project, the now very well-known risk writings by sociologists Perrow (1984) in America and Beck (1992) in Germany had yet to be published, while the British psychologist Reason (1990) only began to think through some of the implications of adopting an organisational-level analysis to accident analysis during the latter half of the decade.

The period of our project, from 1983 to 1988, also saw a string of major industrial accidents – the catastrophic fire on the Piper Alpha oil rig, the Zeebrugge ferry disaster, the King's Cross fire, NASA's Challenger and perhaps the most devastating of all the Chernobyl nuclear accident in the former Soviet Union. On each occasion, and as details eventually unfolded, it became clear to us all that the systems approach to accidents had much to offer the analysis of these events. Developmental processes are central to this way of thinking about major failures. In a wide range of empirical case studies, we had seen how there are always very many preconditions to any major systems failure, some originating years prior to the actual event. Turner's model in particular described a process of increasing underlying system vulnerability, in which a chain of concealed errors and other partially understood events build up in a way that is at odds with the existing beliefs and norms about hazards, which he labelled the disaster incubation period. The theory also highlights how system vulnerability often arises from unintended and complex interactions between contributory preconditions, each of which would be unlikely, singly, to defeat the established safety systems (a point later elaborated extensively by Perrow in his 1984 book).

2. Safe systems and safety cultures

The 1980s were important not only for crystallising and disseminating the new theories of organisational accidents but also served as an intellectual turning point. By 1990, it was clear that the cutting edge intellectual focus was less on analysing how past accidents had occurred (important though that issue still was) and more towards the question of how safe organisations might be encouraged or even designed – under the rubric of work on *safety culture*. That is, researchers and practitioners became concerned to specify the organisational preconditions that might enhance crisis management, safe performance or risk-handling in complex and hazardous situations. Of course, in a straightforward sense, the two must always be considered as connected, and the goal (often undeclared) of all disaster and crisis researchers is to move from one to the other – from risk to safety, from organisational vulnerability to corporate resilience. But it was also clear even then that understanding how vulnerability to failures and accidents arises does not automatically confer predictive knowledge to prevent future catastrophes. In effect, many of us began to ask whether a theory of vulnerability to error and failures could be transposed into one of practical resilience.

Interest in the term safety culture itself can be traced to the accident at Chernobyl in 1986 and the response of the Western nuclear industries to the human preconditions to that event. The errors and violations of operating procedures which contributed in part to the disaster were described by the Western nuclear agencies to be evidence of a poor safety culture at this plant and within the former Soviet nuclear industry more generally (OECD Nuclear Agency 1987, INSAG 1991). Since that time, interest in the topic has burgeoned, as engineers, risk managers and safety analysts have attempted to both define and operationalise the concept, to judge its significance and in a number of empirical projects to search for 'it'. Our own response at the time was a mixture of both puzzlement and inquiry – we certainly did not know of any fundamental academic work on this topic, and despite our collective backgrounds in organisational accident theory, we would not have been able to define what a safety culture might be characterised by. Hence, we pondered at length where the comments of the OECD Nuclear Agency might have originated and upon what evidence they were based!

Our own response to this set of unanticipated developments was to convene a small internal seminar series at Exeter University during 1988, where a group of us debated the question of the postmodern turn, corporate symbolism and (safety) cultures. Initially, an exercise primarily in taking the time and space to think quite widely about a problem for an afternoon each week (a rare occurrence in the university even in those days), the informal notes of those meetings were to form the foundation of a number of important publications and lines of thought on the topic over the ensuing 10 years, including Blockley's (1992) next important book *Engineering Safety* and the final chapter to the second edition of Turner's book published after his death in 1995 (Turner and Pidgeon 1997). In seeking to address this issue more systematically, we recognised one critical facet of Turner's model, and one in which it differed clearly from that offered by Perrow. By Turners's account, organisational and professional cultures lie at the core of the failure issue – in effect our cultures (in groups, professions, organisations or nations) help us to see the world in a certain way but often also blind us to emerging hazards that are at the margins of our expertise. Implicit in the man-made disasters model was a view of culture in terms of the exploration of meaning and the symbols and systems of meaning through which a given group or profession (including that of engineers) understands the world (Turner 1991, 1995, Pidgeon 1991). A *safety* culture is in turn the set of assumptions and their associated practices, which permit beliefs about danger and safety to be constructed. Such a culture is itself created and recreated as members repeatedly behave and communicate in ways that seem to them to be natural, obvious and unquestionable and as such will serve to construct a particular version of risk, danger and safety. In exploring safety cultures as a route to resilient socio-technical systems, we need to go beyond individual attitudes to safety and, therefore, to the level of shared cognitions and the administrative structures and resources which support, rather than constrict, the development of organisational understandings regarding risk and danger. A 'good' safety culture might both reflect and be promoted by at least four facets (Pidgeon and O'Leary 2000, Jeffcott *et al*. 2006):

- *senior management commitment* to safety;
- *shared care and concern* for hazards and a *solicitude* over their impacts upon people;
- realistic and flexible *norms and rules* about hazards;
- continual *reflection upon practice* through monitoring, analysis and feedback systems (organisational learning).

Since Chernobyl, the study of safety cultures has progressed within a variety of diverse methodological approaches – both quantitative and qualitative – some of which may well ultimately prove complementary (Cox and Flin 1998, Guldenmund 2000). What is common to many accounts, however, is their emphasis upon *organisational learning* as a key component of appropriate safety cultures and institutional designs (Pidgeon 1997). Organisational learning as an

objective of institutional design also unifies a number of other recent attempts to specify safe or resilient socio-technical systems, including high-reliability and 'mindful' organisations (Weick and Sutcliffe 2001) as well as safety cultures more generally (Guldenmund 2010).

However, in the safety domain, learning is no easy matter, and in particular it can be blocked by known difficulties in handling information (too much information, the wrong channels, incomplete or inappropriate information sources or failure to connect available data). For example, critical errors and events may initially remain latent, or are misunderstood, during the incubation period because of wrong assumptions about their significance. This leads to a selective problem representation at the level of the organisation as a whole, a situation which in turn structures the interpretations and decisions of the organisation's individual members. Such a representation may arise through organisational rigidity of beliefs about what is and is not to be counted a 'hazard'. For example, prior to the 1966 Aberfan coal tip slide which buried a South Wales school, killing 116 children and 28 adults, the pervasive set of beliefs and practices within the UK coal industry was almost solely oriented towards hazards underground and not to the behaviour of waste tips on the surface. Dangerous preconditions may also go unnoticed because of the inherent difficulties of handling information in ill-structured and constantly changing situations. Here, the problem may become so complex, vague or dynamic – and the information that is available at any one time dispersed across many locations and parties – that different individuals and organisations can only ever hold partial, and often very different and changing, interpretations of the situation. What is more, the costs, whether material or political, of gathering the information to generate a definitive account may be prohibitive.

3. Addressing system learning

Is effective organisational learning a realistic goal of the safety professional? I wish to argue that before this goal can be met, we need to explicitly address some of the common barriers to learning. A problem arises immediately over the status of 'warnings'. Our foresight is always limited, and as such, the identification of warning signals of an impending major failure during the incubation period is doubly difficult. But just how limited is our knowledge of future events? If the identification of system vulnerability in foresight sets an impossible task, then proactive safety management might never be achieved under any conceivable circumstances. At a more pragmatic level, however, it is clear that careful observation and measurement of theoretically relevant events (unsafe acts, known barriers to communication, diffusion and fragmentation of responsibilities, financial constraints, etc.) will have some success in diagnosing when systems might or might not be vulnerable to failure.

A useful concept here from the social sciences is that of 'sensemaking' – the constant search by individuals and groups for meaning in the information they have – something which brings multiple possibilities for safety (Weick and Sutcliff 2001) and suggests avenues to counter the barrier to learning of *information difficulties* – for example, through argument and logical analysis of competing accounts, arbitration of power struggles within organisations (which might serve to conceal 'bad news') and psychological strategies to counter overly rigid problem-solving through the exercise of what might be termed *safety imagination* (Pidgeon and O'Leary 2000).

The idea of safety imagination is based upon the principle that our understanding and analysis of events should not become overly fixed within prescribed patterns of thinking, particularly when faced with an ill-structured incubation period. Prescribed patterns of thinking about hazards are, of course, critically important for safety much of the time in that they define ways of dealing with anticipated or well-understood hazards. However, as Weick (1998) notes, an organisation is of necessity defined not so much by what its members attend to but by what they choose to

ignore. As Vaughan (1996, p. 392) succinctly puts it about the Challenger Space Shuttle disaster, NASA's culture 'provided a way of seeing that was simultaneously a way of not seeing'. That institutionalised assumptions and norms have the capacity to simultaneously illuminate some hazards while shifting attention away from others is a fundamental paradox of any organisational safety culture (Pidgeon 1998). The man-made disasters model emphasises that events which are at variance with the assumed view of the world and its hazards are the most difficult to deal with in the incubation period. Avoiding disaster therefore involves an element of thinking both within administratively defined frames of reference (to deal with well-defined hazards that fall within an organisation's prior worldview) and simultaneously stepping outside of those frames to at least consider the possibility of emergent or ill-defined hazards that have not been identified in advance – or which perhaps fall outside of an organisation's strict administrative or legal remit. This is a critical and self-reflective process, in that one seeks to challenge the default assumptions about the world and its hazards, and then to use this interrogation to interpret the significance of external warning signs and events.

Although its originators do not directly use the term, Table 1 illustrates one of the best characterisations of safety imagination I have yet to come across. The list is derived from a set of teaching programmes, developed over the past 15 years, for training US firefighters in the federal forestry service (Thomas 1994). The majority of fire service training quite rightly revolves around a military style of command, emphasising hierarchical organisational structure and proceduralised responses, since many of the hazards involved in firefighting are well known (e.g. losing track of personnel) and relevant precautions or procedures can accordingly be specified and trained for in advance (strictly monitored entry and exit to a fireground). However, there are some hazards that are far less well understood by firefighters on the ground, such as the effects of changed wind strength/direction on fire propagation in an unfamiliar geographical location. Founded upon the premises of man-made disasters theory, the points in Table 1 provide a useful checklist for any practitioner faced with a potentially ill-structured risk system. The intention is to counter several of the information difficulties and rigidities of thinking known to be common to many hazard incubation periods by (a) extending the scope of potential scenarios that are considered relevant to the risk issue at hand (elicit varied viewpoints, play the 'what if' game, visualise near misses becoming accidents), (b) countering complacency and the view that it will not happen to us (fear the worst, consider the worst case scenarios), (c) forcing the recognition that during an incubation period the most dangerous ill-structured hazards are by definition surrounded in ambiguity and uncertainty (tolerate ambiguity) and (d) perhaps most critically, attempting to step temporarily beyond, or even suspend, institutionally defined assumptions about what the likely 'hazard' and its consequences will comprise (suspend assumptions about how the safety task was completed in the past).

The exercise of safety imagination will not always in and of itself ensure that effective learning takes place, something which Toft and Reynolds (1997) call active learning. To achieve this, a second institutional barrier, noted above, of *organisational power and politics* also needs to be

Table 1. Guidelines for fostering 'safety imagination'.

- Attempt to fear the worst
- Use good meeting management techniques to elicit varied viewpoints
- Play the 'what if' game with potential hazards
- Allow no worst-case situation to go unmentioned
- Suspend assumptions about how the safety task was completed in the past
- Approaching the edge of a safety issue a tolerance of ambiguity will be required, as newly emerging safety issues will never be clear
- Force yourself to visualise 'near-miss' situations developing into accidents

Source: Adapted from Thomas (1994).

addressed. What seems to lie at the heart of this issue is the institutional dilemma of *blame*. As Douglas (1992) reminds us, danger and blame have been ubiquitous features of societies over the years. For this reason, she argues that they underpin many contemporary discussions of risk and safety too. Ironically, the concern with risk management and its assessment also brings with it new possibilities for blaming, for despite the inherent complexity and ambiguity of the environments within which large-scale hazards arise, and the systemic nature of breakdowns in safety, myths stressing our ability to control affairs ensures that a culprit must be found after a disaster or crisis has unfolded. Blame does of course itself bring positive, as well as negative, possibilities for safety. The knowledge that responsibility brings accountability and that blame for accidents and disasters will be laid, and possibly legal sanctions invoked, may be needed to motivate organisations and individuals to examine their activities and act in good faith. On the other hand, if a 'culprit' has to be found whenever an error has occurred, the processes of sensemaking will emphasise avoidance of blame rather than critique and honesty. Hence, efforts to motivate people to act safely through sanction may be self-defeating, resulting in the very state of poor or incomplete information which is a precondition to vulnerability.

The obstacles which organisational politics place in the way of learning cannot be expected to yield to simple solutions. What is clear is that solutions are required which go beyond efforts to merely improve 'imagination' or problem-solving. More pointedly, we can ask what political, cultural, symbolic and institutional arrangements *support* the generation of organisational intelligence and safety imagination over corporate myopia? At the macro-level, we may require arbitration of the power struggles and parochial interests which block learning, with legal guarantees given to 'whistleblowers' who fear the consequences of speaking openly outside an organisation about safety concerns (Pidgeon and O'Leary 2000).

4. Concluding comments

The insights that have been derived from over 30 years of accumulated research on complex systems failures have highlighted organisational factors as presenting the most critical mechanisms in the generation of accidents and disasters across a wide variety of settings. It is a great sadness that our colleague Turner did not live to see some of the ways these ideas have been developed. Both he and Blockley are owed a great debt by the safety management communities for contributing to an intellectual tradition that is increasingly important in bridging European and North American approaches to risk management, high-reliability organisations, the investigation of past accidents and the prevention of future large-scale failures through improved safety cultures and other forms of institutional intervention and design in civil and structural engineering as well as vulnerable human–technical systems more generally. The increasing globalisation of many systems of production and finance, and our dependence upon large risk-bearing systems, also means that these issues are of increasingly wider relevance, both in traditional high-risk industrial systems, such as aviation and the energy sector, and in a variety of other modern complex settings (including food production, finance, health care and environmental problems such as climate change). We have yet to resolve all of the difficult questions that surround the attempt to translate the findings from organisational accidents research into properly theorised frameworks which will better inform safety management for the future. What is clear, however, is that the questions of organisational learning and design remain central to the safety management agenda both today and well into the future.

I have also argued in the paper that organisational learning is a critical facet of an effective safety culture and one which is common to a number of the contemporary models and approaches in the safety management field. However, there remain a number of social and institutional barriers

to effective organisational learning and the paper has highlighted some of these. It is only by explicitly recognising the obstacles to learning that arise in high-risk contexts that we will then be able to move towards the ideal of 'safe' organisational designs, and through this to counter the incubation of major failures in the future.

Acknowledgements

I wish to thank the late Barry Turner as well as David Blockley, Brian Toft and Mike O'Leary as sources of inspiration for much of this work. Any errors, however, are mine alone.

References

Beck, U., 1992. *Risk society: towards a new modernity*. London: Sage.
Blockley, D., 1980. *The nature of structural design and safety*. Chichester, UK: Ellis-Horwood.
Blockley, D., ed., 1992. *Engineering safety*. Maidenhead, UK: McGraw-Hill.
Cox, S. and Flin, R., 1998. Safety culture: philosopher's stone or man or straw? *Work and Stress*, 12 (3), 189–201.
Douglas, M., 1992. *Risk and blame*. London: Routledge.
Guldenmund, F.W., 2000. The nature of safety culture: a review of theory and research. *Safety Science*, 34 (1–3), 215–257.
Guldenmund, F.W., 2010. *Understanding and exploring safety culture*. Thesis (PhD), Delft University, The Netherlands.
INSAG, 1991. *Safety culture: a report by the International Nuclear Safety Advisory Group*, Safety Series No. 75-INSAG-4. Vienna: International Atomic Energy Agency.
Jeffcott, M., *et al*., 2006. Risk, trust and safety culture in UK train operating companies. *Risk Analysis*, 26 (5), 1105–1121.
OECD Nuclear Agency, 1987. *Chernobyl and the safety of nuclear reactors in OECD countries*. Paris: Organization for Economic Co-operation and Development.
Perrow, C., 1984. *Normal accidents*. New York: Basic Books.
Pidgeon, N.F., 1991. Safety culture and risk management in organizations. *Journal of Cross-Cultural Psychology*, 22 (1), 129–140.
Pidgeon, N.F., 1997. The limits to safety? Culture, politics, learning and man-made disasters. *Journal of Contingencies and Crisis Management*, 5 (1), 1–14.
Pidgeon, N.F., 1998. Safety culture: key theoretical issues. *Work and Stress*, 12 (3), 202–216.
Pidgeon, N.F. and O'Leary, M., 2000. Man-made disasters: why technology and organizations (sometimes) fail. *Safety Science*, 34 (1–3), 15–30.
Pidgeon, N.F., Blockley, D.I., and Turner, B.A., 1986. Design practice and snow loading: lessons from a roof collapse. *The Structural Engineer*, 64 (A), 67–71.
Pidgeon, N.F., Blockley, D.I., and Turner, B.A., 1988. Site investigations: lessons from a late discovery of hazardous waste. *The Structural Engineer*, 66 (19), 311–315.
Reason, J.T., 1990. *Human error*. Cambridge, UK: Cambridge University Press.
Thomas, D., 1994. *Prescribed fire safety: preventing accidents and disasters part II. Unit 2-G in course 'prescribed fire behavior analyst'*. Marana, AZ: National Advanced Resource Technology Center.
Toft, B. and Reynolds, S., 1997. *Learning from disasters: a management approach*. 2nd ed. Leicester, UK: Perpetuity Press.
Turner, B.A., 1978. *Man-made disasters*. London: Wykeham Science Press.
Turner, B.A., 1991. The development of a safety culture. *Chemistry and Industry*, 1, 241–243.
Turner, B.A., 1995. Safety culture and its context. *In*: A. Carnino and G. Weimann, eds. *Proceedings of the international topical meeting on safety culture in nuclear installations*. Vienna: American Nuclear Society (Austria), 321–329.
Turner, B.A. and Pidgeon, N.F., 1997. *Man-made disasters*, 2nd ed. London: Butterworth-Heinemann.
Vaughan, D., 1996. *The challenger launch decision: risky technology, culture, and deviance at NASA*. Chicago, IL: Chicago University Press.
Weick, K.E., 1998. Foresights of failure: an appreciation of Barry Turner. *Journal of Contingencies and Crisis Management*, 6 (2), 72–75.
Weick, K.E. and Sutcliffe, K.M., 2001. *Managing the unexpected: assuring high performance in an age of complexity*. San Francisco, CA: Jossey-Bass.

Copyright of Civil Engineering & Environmental Systems is the property of Taylor & Francis Ltd and its content may not be copied or emailed to multiple sites or posted to a listserv without the copyright holder's express written permission. However, users may print, download, or email articles for individual use.