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Man-made disasters: why technology and organizations (sometimes) fail

N. Pidgeon ^{a,*}, M. O’Leary ^b

^a*School of Environmental Sciences, University of East Anglia, Norwich NR4 7TJ, UK*

^b*British Airways Safety Services, Heathrow Airport, London, UK*

Abstract

The paper presents a systems view of the organizational preconditions to technological accidents and disasters, and in particular the seminal “Man-made Disasters model” proposed by the late Professor Barry Turner. Events such as Chernobyl, the Challenger and Bhopal have highlighted the fact that in seeking the causes of many modern large-scale accidents we must now consider as key the interaction between technology and organizational failings. Such so-called ‘organizational accidents’ stem from an incubation of latent errors and events which are at odds with the culturally taken for granted, accompanied by a collective failure of organizational intelligence. Theoretical models have also moved on now, from purely post hoc descriptions of accidents and their causes, in the attempt to specify ‘safe’ cultures and ‘high-reliability’ organizations. Recent research, however, has shown us that while effective learning about hazards is a common assumption of such attempts, organizations can be very resistant to learning the full lessons from past incidents and mistakes. Two common barriers to learning from disasters are: (1) information difficulties; and (2) blame and organizational politics. Ways of addressing these barriers are discussed, and the example of aviation learning systems, as an illustration of institutional self-design, is outlined. © 2000 Elsevier Science Ltd. All rights reserved.

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1. Failures in complex systems: man-made disasters theory

The first contemporary theoretical account of organizational vulnerability to disaster was Barry Turner’s path-breaking “Man-made Disasters” model (Turner, 1978; Turner and Pidgeon, 1997). This model holds both a central historical and contemporary relevance for disaster and accident researchers. At its first publication

* Corresponding author.

the man-made disasters account was some 5–10 years in advance of, and provided much of the conceptual foundation for, other 1980s work that has contributed to our present theoretical understanding of industrial catastrophe and crisis as managerial and administrative in origin, from both European (Lagadec, 1980; Rosenthal, 1986; Reason, 1990; Horlick-Jones et al., 1993; Toft and Reynolds, 1997) and US perspectives (Perrow, 1984; Shrivastava, 1987; Vaughan, 1990, 1996; Paté-Cornell, 1993). The simple message of man-made disasters theory is that, despite the best intentions of all involved, the objective of safely operating technological systems could be subverted by some very familiar and 'normal' processes of organizational life.

Based upon a systematic qualitative analysis of 84 British accident inquiry reports spanning a 10-year period, the theory starts from the observation that disasters in large-scale technological systems are neither chance events, nor 'Acts of God'. Nor can they be described purely in technological terms. Rather, Turner argued that disasters arise from an interaction between the human and organizational arrangements of the socio-technical systems set up to manage complex and ill-structured risk problems. Indeed, a disaster is defined in the man-made disasters model not by its physical impacts at all, but in sociological terms, as a significant *disruption or collapse of the existing cultural beliefs and norms* about hazards, and for dealing with them and their impacts. All organizations operate with such cultural beliefs and norms, which might be formally laid down in rules and procedures, or more tacitly taken for granted and embedded within working practices. In Turner's account disaster is then differentiated from an accident by the recognition (often accompanied by considerable surprise) that there has been some critical divergence between those assumptions and the 'true' state of affairs.

Developmental processes are central to the idea of cultural disruption in the theory. The empirical case studies had revealed that there are always very many preconditions to any major systems failure, some originating years prior to the actual event. This phenomenon of increasing underlying system vulnerability, in which a chain of concealed errors and other partially understood events builds-up in a way that is at odds with the existing beliefs and norms about hazards, is labelled by Turner as the *disaster incubation period*. He notes that:

...a disaster or cultural collapse occurs because of some inaccuracy or inadequacy in the accepted norms or beliefs but, if the disruption is to be of any consequence, the discrepancy between the way the world is thought to operate and the way it really is rarely develops instantaneously. Instead, there is an accumulation over a period of time of a number of events which are at odds with the picture of the world and its hazards represented by existing norms and beliefs. Within this 'incubation period' a chain of discrepant event, or several chains of discrepant events, develop and accumulate unnoticed. (Turner and Pidgeon, 1997, p. 72)

Man-made disasters 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 (see

also the discussion in Perrow, 1984). A further key part of the organizational aetiology of disaster incubation is the way in which the 'negentropic' (or order-producing) tendencies of social systems contribute to the generation of extreme hazard from relatively safe situations, through the structured amplification of the consequences of earlier errors. That is, unintended consequences of errors are not propagated in purely random fashion, but may emerge as *anti-tasks* which make non-random use of large-scale organized systems of production. For example, consider the recent serious outbreaks of *E-coli*. food poisoning in Scotland: here the consequences of the original contamination of cooked meat in one location were greatly amplified as the products were then distributed, unknowingly contaminated, to many people via the normal food distribution system.

The man-made disasters model proposes that the build-up of latent errors and events, at odds with the culturally taken for granted, is accompanied by a collective failure of organizational cognition and 'intelligence', as the developing system vulnerability to failure remains concealed by social processes which attenuate evaluations of risk (Freudenberg, 1988; Pidgeon, 1994; Vaughan, 1996). This can be viewed as a form of defective reality testing similar to that observed at a small group level in foreign policy groups (Janis, 1982; 't Hart et al., 1997) and in military intelligence failures. For example, Stech (1979) makes extensive use of the man-made disasters framework in his account of the Israeli failure to predict the onset of the 1973 Yom Kippur War.

2. Safe systems, safety cultures and organizational learning

As the model discussed above illustrates, our understanding of disasters and crises has grown over the past 20 years, along with our knowledge of the range of social and organizational preconditions which render institutions and large-scale socio-technical systems vulnerable to catastrophic failures of foresight and control. The contemporary theoretical debate has, however, moved on somewhat from its origins in socio-technical accident analysis, in that the idea of vulnerability to disaster and crisis is increasingly being juxtapositioned with that of *institutional resilience* (Pidgeon, 1997). That is, researchers and practitioners are now concerned to specify the organizational 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 a connected problematic, and the goal (often undeclared) of all disaster and crisis researchers is to move from one to the other — from risk to safety, from organizational vulnerability to resilience.

However, to understand how vulnerability to failures and accidents arises does not automatically confer predictive knowledge to prevent future catastrophes. For in making this complex move one must forsake the familiar ground of accident analysis and disaster development to enter far more contested waters. It is no simple matter to specify how a theory of institutional vulnerability might then be transposed into one

of practical resilience. Indeed, we can ask whether our analyses and theories of past accidents and disasters tell us anything useful at all for designing institutions with better future performance, or whether we are merely left with the observation that complex organizations, faced with turbulent environments, will repeatedly fail us in unpredictable ways (and that the only practical advice to risk managers is to stay fully alert to this possibility)?

As noted above, the man-made disasters model defines disaster incubation in terms of a discrepancy between some deteriorating but ill-structured state of affairs and the culturally 'taken for granted': or more specifically the cultural norms, assumptions and beliefs adopted by an organization or industry for dealing with hazard and danger. One implication of this analysis is that both culture and institutional design are positioned at the heart of the safety question. Current interest in the more specific term 'safety culture' can be traced to the accident at Chernobyl 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 interpreted by some, in hindsight, to be evidence of a poor safety culture at this plant and within the former Soviet nuclear industry more generally (OECD Nuclear Agency, 1987). Since then interest in the topic has burgeoned, as engineers, risk managers and safety practitioners have attempted to both define and operationalize the concept, to judge its significance, and in a number of empirical projects to search for 'it'. However, the immediate post-Chernobyl discussions of safety culture can be critiqued for their reduction to a combination of administrative procedures and individual attitudes to safety, at the expense of the wider organizational issues. What is crucially missing is the *shared* characteristic of all social organization and culture.

Our own approach to the issue, and that implicit in the man-made disasters model, views culture primarily in terms of the exploration of meaning, and the symbols and systems of meaning through which a given group understand the world (Turner, 1991, 1995). 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 which 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 institutional design we need to go beyond individual attitudes to safety, therefore, to the level of shared cognitions and the administrative structures and resources which support, rather than constrict, the development of organizational understandings regarding risk and danger. We have also argued that a 'good' safety culture might both reflect and be promoted by at least four facets (Pidgeon and O'Leary, 1994):

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

Since Chernobyl the study of safety cultures has been progressed within a variety of diverse methodological approaches, some of which may well ultimately prove complementary (Cox and Flin, 1998). At the level of theory, ambiguity and fragmentation has also characterised much of the field (Pidgeon, 1998). What is common to many accounts, however, is the emphasis upon *organizational learning* as a key component of appropriate safety cultures and institutional designs. Organizational learning as an objective of institutional design also unifies a number of other recent attempts to specify resilient institutional systems, including 'generative' organizations (Westrum, 1995) and high reliability organizations (Roberts, 1993), as well as safety cultures (ACSNI, 1993). However, in the safety domain learning is no easy matter, and in the next section we go on to discuss two common barriers to organizational learning.

3. Barriers to organizational learning

3.1. Information difficulties

The man-made disasters model proposes that the build-up of latent errors and discrepant events characteristic of the incubation period is accompanied by a collective failure of organizational cognition and 'intelligence', as developing system vulnerability remains concealed by social processes which attenuate evaluations of risk (Turner, 1978; Turner and Pidgeon, 1997). Information difficulties are also explicit in Vaughan's (1996) account of the "*Challenger* disaster" (she observes how, in the face of ambiguous signals about shuttle safety, competing views on risk acceptability were resolved, or not, through processes of social negotiation at NASA and its contractors), and in Perrow's (1984) normal accidents model several of the dimensions to 'system' complexity concern lack of full *understanding* by operators and managers of possible interdependencies between system components.

Information difficulties often stem from the attempts of both individuals and organizations to deal with problems that are, in foresight at least, highly uncertain and ill-structured. In the man-made disasters model four types are identified, and all are likely to undermine attempts to learn.

1. Critical errors and events may initially remain latent, or are misunderstood, because of wrong assumptions about their significance. This leads to a selective problem representation at the level of the organization as a whole, a situation which in turn structures the interpretations and decisions of the organization's individual members. Such a representation may arise through organizational 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 (Turner and Pidgeon, 1997, p. 47). A related syndrome described in man-made disasters theory is the decoy phenomenon. Here personnel who are dealing

- directly with risk and hazard management, or others who suspect there is something amiss, may be distracted or misled into thinking the situation has been resolved by attention to related (that is decoy) events. The sum result of both rigidity of beliefs and attention to decoy phenomena, is that when significant warnings of an incubating failure do arise they are more likely to be interpreted inappropriately, or when warnings originate from outside the formal organization they may be brushed aside and ignored completely.
2. 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 organizations can only ever hold partial, and often very different and changing, interpretations of the situation (which Turner labelled a 'variable disjunction of information'). What is more the costs, whether material or political, of gathering the information to generate a definitive account may be prohibitive. Variable disjunction of information is reinforced by the poor communications endemic to both the internal workings of large organizations and those which also arise across organizational boundaries. It is also compounded by ambiguous orders, vaguely drawn responsibilities, and shifting goals during the incubation period.
 3. Uncertainty may also arise about how to deal with formal violations of safety regulations. Violations might occur because regulations are ambiguous, in conflict with other goals such as the needs of production, or thought to be outdated because of technological advance. Alternatively safety waivers may be in operation, allowing relaxation of regulations under certain circumstances (as also occurred in the 'Challenger' case; see Vaughan, 1996).
 4. Finally, when clearcut information or signals warning of impending danger do arise, the outcomes are often worse than they might have been because those involved will initially tend to minimise the danger as it emerges, or to deny that danger threatens them personally, leading to delays in taking preventative action.

3.2. *Blame, organizational politics and cover-up*

The second barrier to organizational learning about failures was first raised by Gephart (1984) in his critique of man-made disasters theory. He argues that the disaster incubation model under-emphasizes the *political* processes and power relationships inherent to the daily life of risk-managing organizations, to the regulator–regulated relationship (Vaughan, 1990), or to a society more widely (Shrivastava, 1987). Such processes will contribute to the construction of differing versions of reality during an emerging event to serve particular group interests. Gephart argues that a political sense-making model of reality better captures why some versions of an event become accepted as legitimate, even in the full glare of hindsight. That is, politics may make the symbolic 'discovery' of the emergent incubation period (i.e. system vulnerability) problematic both before and *even after a serious visible near-miss or accident has*

become manifest, as interest groups argue over what the turn of events signifies: as Shrivastava puts it, was Bhopal a 'technical incident' as claimed by Union Carbide, or a catastrophe as claimed by the victims? Processes of organizational and cultural learning may often become disrupted or blocked as just collateral damage to political infighting and organized cover-up, a point reinforced by Sagan's (1993) analysis of the failure of the US nuclear weapons command and control systems to learn from incidents and failures during the cold war. On the issue of organizational learning Sagan's account is a convincing catalogue of the many political barriers to achieving this, as conflicts over parochial interests lead to faulty reporting of incidents, secrecy, normalization of errors in the face of external accountability, and the reinterpretation of failure as success (Rijpma, 1997).

In one sense, the above considerations *extend* our understanding of the preconditions to the intelligence failures characteristic of major failures of foresight. Pushed to their extreme, however, they raise fundamental doubts about whether we can ever know, in advance, if a complex socio-technical system is more, or by implication *less*, vulnerable to a disaster. That is, for some categories of 'failure' there can be no theory of institutional vulnerability *or* resilience outside of the contested texts that different stakeholders construct about an inherently ambiguous and conflictual world — under such circumstances learning becomes cognitively difficult, politically implausible and may even prove epistemologically impossible.

4. Addressing the barriers

As researchers and practitioners seeking to develop effective safety cultures we need to know whether organizational learning is indeed a realistic design goal. It is argued here that before this goal can be met we need to explicitly address some of the common *institutional* barriers to learning. Before moving on to consider how this might be achieved, however, we first need to resolve the epistemological status of 'warnings'. Few would probably disagree that foresight is limited, and as such the identification of warning signals in advance of a major failure is problematic. But just how limited is our knowledge of future events? If the identification of system vulnerability in foresight sets an epistemologically impossible task, then proactive safety management might never be achieved under any conceivable circumstances. It would seem, however, to be unwise — while at the same time remaining alert to the processes of sense-making in politicised environments that construct different versions of events — to tread the full path of relativism implied by this. Extreme relativism is in any event difficult to sustain due to its inherent contradiction, as the one true account of the world!

On a more pragmatic level, we need to know whether differences in safety performance observed across contexts and in foresight are more than mere error variance. Most of the time, as Sagan's (1993) account only too readily illustrates, it is a matter of judgement as to whether the current safety glass is half-empty or half-full. Certainly, careful observation and measurement of theoretically relevant events (unsafe acts, known barriers to communication, diffusion and fragmentation of responsibilities, financial constraints etc.) is one route to follow and with some success

(Wagenaar et al., 1994), although it remains to be seen precisely which empirical questions at this level of analysis will truly differentiate vulnerable from resilient systems.

However, even if we view risk and safety as merely a construction of events, the interpretations surrounding them will be real enough in their consequences. Recognising that sensemaking brings possibilities for safety too (Gherardi et al., 1996) suggests avenues to counter the first barrier to learning — that of *information difficulties* noted under Section 3.1 above. For example, through argument and logical analysis of competing accounts, arbitration of the power struggles which drive sense-making processes, and cognitive strategies to counter overly rigid problem solving through the exercise of what might be termed *safety imagination* (Pidgeon and O'Leary, 1994).

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. We have argued elsewhere that an important part of any organizational safety culture will be the ways in which these patterns are culturally defined at the institutional level (Pidgeon, 1991; Turner, 1991). However, as Weick (1998) notes, an organization 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 organizational safety culture (Pidgeon, 1998). The man-made disasters model emphasizes 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 organization’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 organization’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 characterizations of safety imagination we have yet to come across. The list is derived from a set of teaching programmes, developed over the past 15 years, for training US fire-fighters in the federal forestry service (Thomas, 1994). The majority of fire service training and acculturation tends to revolve around a hierarchical organizational structure and proceduralized responses, since many of the hazards involved in fire-fighting are well-known (e.g., losing track of personnel) and relevant precautions

Table 1
Guidelines for fostering 'safety imagination'^a

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

^a Source: Adapted from Thomas (1994).

or procedures can accordingly be specified and trained for in advance (strictly monitored entry and exit to a fire-ground). However, there are some hazards that are far less well understood by fire-fighters 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 (Mutch, 1982) the points in Table 1 provide a useful cognitive checklist for any practitioner faced with a potentially ill-structured risk situation. The intention is to counter several of the information difficulties and rigidities of thinking known to be common to many hazard incubation periods: (1) by extending the scope of potential scenarios that are considered relevant to the risk issue at hand (elicit varied viewpoints, play the 'what if' game, visualize near-misses becoming accidents); (2) by countering complacency and the view that "it won't happen to us" (fear the worst, consider the worst case scenarios); (3) by 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; (4) perhaps most critically by attempting to step temporarily beyond, or even suspend, institutionally or culturally 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 (or *active*: Toft and Reynolds, 1997) learning takes place. To achieve this the second institutional barrier — that of *organizational power and politics* raised in Section 3.2 above needs also to be 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 as one means of defending favoured institutional arrangements. For this reason she argues they underpin many contemporary discussions of risk and safety too. Ironically, the late-modern 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, cultural myths of control over affairs ensures that a culprit must be found after a disaster or crisis has unfolded ('t Hart, 1993; Horlick-Jones, 1996).

Blame does of course itself bring positive, as well as negative, possibilities for safety. In so doing it presents a dilemma of institutional design. 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 organizations 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 political sense-making will emphasize 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 pre-condition to vulnerability.

The obstacles which organizational politics place in the way of learning cannot be expected to yield to simple solutions. What is clear is that solutions are required which reinforce and go beyond efforts to improve collective cognition or problem solving (Bovens and 't Hart, 1995). The most important challenge is to devise ways by which politics and blaming can be counteracted. More pointedly, we can ask what political, cultural, symbolic and institutional arrangements *support* the generation of organizational 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, and legal guarantees given to 'whistleblowers' who fear the consequences of speaking openly outside an organization about safety concerns. In concert, convenors of judicial inquiries after major failures and crises might be encouraged to ask the delicate political questions which, by the very nature of inquiries, are typically assiduously avoided ('t Hart, 1993). To illustrate the ways in which politics and blaming issues can be resolved by institutional design at the micro-level, we next consider the case of civilian aviation incident reporting and monitoring.

5. Aviation incident monitoring as institutional self-design?

Aviation incident and event monitoring (of, for example, air near-misses) is held by many to make a positive contribution to collective learning in the industry, and through this to safety (O'Leary and Chappell, 1996). Researchers are now beginning to evaluate such efforts, although discussion typically focuses upon procedural issues of data collection and analysis (e.g. van der Schaaf et al., 1991; Chappell, 1994). The question of how a reporting or monitoring system can be successfully embedded within the local social and political contexts (sometimes both organizational and national) where it will be expected to operate is invariably not posed. One can also speculate that inattention to such issues is a major factor when such systems do not work as intended, or do not work at all.

Accordingly, what is often not discussed in the open literature is that before a reporting system will work at all, a network of delicate formal or more often than

not tacit understandings — as one part of the professional relationship of *trust* (Johnston et al., 1994; O'Leary and Pidgeon, 1995) — have to be in place. In the case of civil aviation such trust relationships span the pilots and their unions, the safety analysts (some of whom are, by design, pilots and union representatives in turn) and the higher level managers and directors of an airline or regulatory agency (Johnston, 1996). Agreements will cover issues such as who has access to the information? Will reports be anonymous or confidential? Under what circumstances will guarantees of confidentiality be preserved and when not? What categories of human or management 'error' are sought by the safety analysts through the process of voluntary candid reporting (perhaps conferring immunity from subsequent sanction or prosecution), and which are to be considered a disciplinary or even a criminal offence come what may? And finally, what actions will be taken to correct deficiencies (particularly human or organizational deficiencies) once identified?

What is more there may be several negotiated solutions running in parallel within one organization, which may have taken many years to evolve in response both to advances in the technologies of data collection and analysis, as well as the perceived need to collect varied forms of information.

For example, the flight crew of one of the largest international airlines, British Airways (BA), participate in at least three such systems (O'Leary and Pidgeon, 1995). First there is the mandatory Air Safety Reporting (ASR) programme. This expands the British Civil Aviation Authority's Mandatory Occurrence Reporting Scheme which requires reports on specified unsafe events (such as a serious technical failure). However, since these reports are fully attributable to particular individuals and crews the airline provides very explicit written *guarantees* that disciplinary action will not normally follow voluntary filing of any such report, although this in turn begs the question of how 'normal' is interpreted by management and crew — and in particular the ambiguous boundary between this and the most extreme of circumstances.¹ An example of why such guarantees are important for learning is provided by Tamuz (1994), who documents that when the US Federal Aviation Authority gave immunity from prosecution in 1968 to pilots who voluntarily filed air-miss reports the yearly filing rate almost trebled. However, when the immunity guarantee was subsequently revoked in 1971 filing dropped back to less than pre-1968 levels.

In addition to the ASR programme, BA also operates an operational monitoring programme using Flight Data Recording techniques. On every aircraft a large number of flight parameters are continuously recorded. A programme called Special Event Search and Master Analysis (SESMA) subsequently searches for incidents where any of these parameters have exceeded defined limits, e.g. too high/low a

¹ In practice this boundary will be defined by at least two criteria: first the more obvious one of criminal negligence, and second in terms of what Johnston (1996) has termed the *substitution test*. He argues that in order to interpret the meaning of a human 'error', particularly where individual actions are embedded in and possibly driven by wider organizational and cultural systems, we should mentally substitute another actor for the person involved and ask the question "in the light of how events unfolded in real time, is it probable that this new individual would have behaved any differently?" (Johnston, 1996, p. 75) If the answer to this question is no, then the act of apportioning blame has no role to play. Rather we should seek to identify the wider causes of the action.

speed for the stage of flight, or too firm a landing. Whilst in other countries, such as the USA, there has been, and remains, severe resistance to the introduction of such monitoring programmes from both pilots and their companies (mostly because of the nature of the US legal system), in BA the system has been in successful operation for over 25 years. The data from the programme is *anonymous* in the sense that crews can only be identified by two individuals, a trusted management administrator and a pilots' representative. Identification only takes place when some serious flight parameter exceedence has been identified by SESMA. In such cases, the pilots' representative has the duty to contact the crew involved to establish the facts of the incident and report these, still anonymously, back to management solely for the purposes of organizational learning.

Finally, the Safety Services department of BA has instigated a more recent voluntary human factors incident reporting programme. This was set up in response to the continuing trend in aviation world-wide for 'crew error' to predominate in the accident statistics, coupled with contemporary insights into organizational human factors, and the belief that the ASR system was not yielding full information on the human performance aspects of unsafe events and incidents. Apparently this new system does generate qualitatively different information from that contained in the mandatory and attributable Air Safety Reports (see O'Leary and Pidgeon, 1995). Unlike the latter, the human factors reporting programme is both *voluntary* and the information remains completely *confidential* to the human factors group within the Safety Services department.

A similarly structured national system is the US Air Safety Reporting System (ASRS), which is confidential, voluntary and in addition gives pilots some immunity from prosecution for infringement of Federal Aviation Regulations. Interestingly, when monitoring of air-misses using air traffic control computer surveillance was first introduced into the USA, this held unintended consequences for ASRS, as voluntary reports both of air-misses and other events increased dramatically (Tamuz, 1987), presumably as pilots sought the protection such disclosure gave them. Clearly then, the complex balance of incentives and disincentives associated with different systems operating in parallel cannot always be assumed to be independent.

The key point to note here is that each of the monitoring systems outlined above has evolved a slightly different set of social arrangements (agreed either explicitly, or tacitly understood by all of those who participate), as a solution to the problem of blame. Of course the precise solution arrived at will vary with different learning goals, together with the local historical, social and organizational contexts. Under some circumstances establishing and maintaining a level of confidence and trust between reporters and evaluators will be critical (O'Leary and Pidgeon, 1995), as will the separation of the primary goal of organizational learning from the use of collected information for instigating sanctions against individuals (Tamuz, 1994). What is more, Pidgeon (1997) points out that the effect of such social arrangements is not strictly a *no-blame culture* (as some advocates of safety culture, ourselves included, have previously recommended; INSAG, 1991; Pidgeon, 1991; ACSNI, 1993; Pidgeon and O'Leary, 1994) but one which establishes the boundary between culpable and tolerable mistakes, in a way that the latter category is as inclusive as

possible, and while at the same time still retaining some degree of responsibility and accountability (Johnston, 1996). All of the solutions outlined above may in fact be examples of the possibility, noted by Toft (1992), that permanent culture change may itself be best approached through processes of long-term organizational learning, or 'institutional self-design' (Rochlin, 1989), rather than solely through management edict (decree) or imposition of external regulation (prescription).

6. Concluding comments

The insights that have been derived from 20 years of accumulated research on complex systems failures have highlighted organizational factors as presenting the most critical background mechanisms in the generation of accidents and disasters across a wide variety of settings. Theoretical analyses that address these issues are increasingly important in bridging European and North American approaches to risk management, to high reliability organisations, to the investigation of past accidents, and to the prevention of future large-scale failures through improved safety cultures and other forms of institutional intervention and design. The increasing globalization 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 and health care). We have yet to resolve all of the difficult questions which surround the attempt to translate the findings from organizational accidents research into properly theorized frameworks which will better inform safety management for the future (Pidgeon, 1998). What is clear, however, is that the inter-linked questions of organizational learning and institutional design will remain central to the safety management agenda at the beginning of the new millennium, and indeed well beyond.

Many new issues are likely to arise as safety specialists explore this new territory - and many of them will be explicitly interdisciplinary in nature. To take just one example, consider the impact of the wider legal framework on incident reporting and learning. It may be impossible to insulate an otherwise well run and negotiated intra-organization learning system from the powerful and symbolic external legal and social blaming processes which inevitably follow any disaster ('t Hart, 1993; Horlick-Jones, 1996). The influence of such societal variables on the promotion of safety cultures are likely to be powerful, and in some circumstances may even dominate, and yet we know almost nothing about them at present.

We have also argued in the paper that organizational learning is a critical facet of an effective safety culture, and one which is common to a number of the emerging models and approaches in the safety management field. However, there remain a number of social and institutional barriers to effective organizational learning and the paper has highlighted two of these — informational difficulties and organizational politics. We need to recognize that in attempting to foster positive safety cultures, as one part of a proactive safety management system, both need to be explicitly

addressed (rather than ignored) as key parameters of the institutional design problem. It is only by explicitly recognising the obstacles to learning that arise in practice that we will then be able to move towards the ideal of 'safe' organizational designs, and through this to counter the incubation of major failures and some of the organizational contexts that we now recognize can foster them.

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