

**The "brainy bunch": (left to right) Professor James Reason, originator of the "Swiss cheese" model of accident causation; Captain Dan Maurino, head of human factors at the International Civil Aviation Organization; and Dr Bob Helmreich, Director of the University of Texas human factors research project, which has conducted thousands of observations of how crew recover from threat and error in normal operations.**

• **Reason, Helmreich and Maurino were key speakers at the fifth Australian aviation psychology symposium, which was held in Manly, Sydney, in November 2000, and was organised by the Australian Aviation Psychology Association (AAvPA).**

**Membership of AAvPA is open to all individuals or organisations interested in aviation psychology and human factors; the cost is \$30 per year, plus a joining fee of \$15. Membership application forms are available from [www.vicnet.net.au/~aavpa/](http://www.vicnet.net.au/~aavpa/).**

**For more information about the Association, contact the AAvPA President, Dr Graham Edkins: [gedkins@qantas.com.au](mailto:gedkins@qantas.com.au).**

# James Reason



## The benign face of the human factor

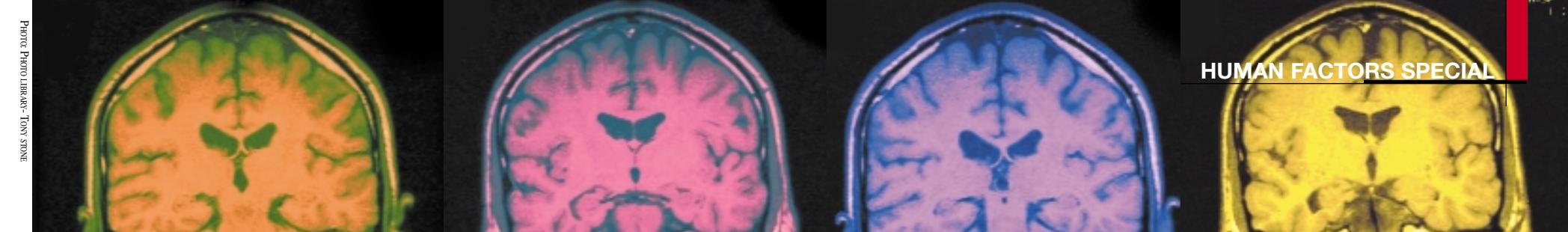
**T**HREE ARE TWO approaches to studying human performance in high-technology hazardous systems: one involves the "fly-on-the-wall" observation of normal activities; the other is triggered by the occurrence of an adverse event. An "event" is something untoward that disrupts the flow of normal or intended activities and which may, and often does, have harmful consequences.

In human factors research at least, there can be little doubt that the dominant tradition is the event-dependent one. Such analyses focus upon the errors and violations that either constitute or contribute to an event. The worse the event, the more intensive is the investigation of the preceding decisions and actions. As a result, we have learned a good deal about the varieties of unsafe acts and, to a lesser degree, we know something of the circumstances that can provoke and shape them.

Unfortunately, this has established a very biased view of the human factor—as something that is causally implicated in the large majority of bad events. To compound the problem further, stating that people make errors is probably one of the least interesting observations about the human condition – on a par with declaring that we breathe oxygen and will some day die. Such information is undoubtedly important, but hardly newsworthy. Nonetheless, errors are sufficiently uppermost in the minds of the managers of hazardous technologies that they often regard the main goal of safety management as the elimination of human fallibility rather than the avoidance of its damaging consequences.

So if human fallibility is a mere truism, what is there that is really interesting about human performance? The answer I believe, lies on the reverse side of the coin. As operators of complex systems, people have an unmatched capacity to adapt and adjust to the surprises thrown up by a dynamic and uncertain world. This includes the often remarkable ability to compensate for their own errors.

Making errors is a fact of life, but recovering them – particularly when these recoveries involve heroic improvisations – is quite another matter.



## Heroic compensations:

### The benign face of the human factor

**Gimli glider:** On 23 July 1983, a Boeing 767 aircraft enroute to Edmonton from Ottawa ran out of fuel over Red Lake, Ontario, about halfway to its destination. The reasons for this were a combination of inoperative fuel gauges, fuel loading errors and mistaken assumptions on the part of the flight crew. These errors and system failures were dealt with at length in the 104-page report of the Board of Inquiry.

Only three paragraphs were devoted to the most extraordinary feature of this event: the forced landing at Gimli, a disused military airstrip, from which all 61 passengers and eight flight crew walked away unharmed from an aircraft that was fit for service after relatively minor repairs.

When the second engine stopped, the aircraft was at 35,000ft and 65nm from Winnipeg. All the electronic gauges in the cockpit had ceased to function, leaving only stand-by instruments operative. The first officer, an ex-military pilot, recalled that he had flown training aircraft in and out of Gimli, some 45 miles away. When it became evident that they would not make it to Winnipeg, the captain, in consultation with air traffic control, redirected the aircraft to Gimli, now 12 miles away on the shores of Lake Winnipeg. The report continues as follows:

"Fortunately for all concerned, one of Captain Pearson's skills is gliding. He proved his skill as a glider pilot by using gliding techniques to fly the large aircraft to a safe landing. Without power, the aircraft had no flaps or slats to control the rate and speed of descent. There was only one

chance of landing. By the time the aircraft reached the beginning of the runway, it had to be flying low enough and slowly enough to land within the length of the 7,200ft [2,200m] runway.

"As they approached Gimli, Captain Pearson and First Officer Quintal discussed the possibility of executing a side-slip to lose height and speed close to the beginning of the runway. This the captain did on the final approach and touched down within 800ft [244m] of the threshold."

The last laconic sentence is a masterpiece of

**"It is unlikely that either Boeing or Captain Pearson's employers had ever imagined the side-slip manoeuvre being applied to a ... jet airliner."**

understatement: "It is unlikely that either Boeing or Captain Pearson's employers had ever imagined the side-slip manoeuvre being applied to a wide-bodied jet airliner."

As it turned out however, it was almost certainly the only way that the aircraft could have made a safe landing under those circumstances.

This was heroic improvisation at its most inspired.

**Theoretical framework:** The literature provides relatively little in the way of theoretical guidance when it comes to understanding and facilitating these remarkable adaptations. Most safety-related studies have focused upon identifying those factors that create moments of vulnerability rather than elucidating the nature of resilience. The two notable exceptions are, firstly, the observation-based analyses of high-reliability organisations; and, secondly, the more person-oriented work on mental readiness in the achievement of sporting and surgical excellence. Although these two research areas derive from different disciplinary backgrounds, they reveal similar processes operating at both the organisational and individual levels.

There would appear to be at least two vital components underpinning both high-reliability organisations and individual excellence:

- a mindset that expects unpleasant surprises.
- the flexibility to deploy different modes of adaptation in different circumstances.

In short, there is a mental element and an action element. Of these, the former is at least as important as the latter. Effective contingency planning at both the organisational and the personal levels depends on the ability to anticipate a wide variety of crises. Both components are resource-limited. Any person or organisation can only foresee and prepare for a finite number of possible circumstances and crisis scenarios.

Crises consume available coping resources



## The "Swiss cheese" model of accident causation

**The new Reason "Swiss Cheese" model:** All systems have multiple layers of defence against hazards and errors. It is only when the failures in these defences line up that an accident or incident results.

The last line of defence, represented in the model by a slice of cheddar cheese, is the operator's ability to compensate for errors

very rapidly. Only those people or organisations that have invested a considerable amount of preparatory effort in the pre-crisis period will be able to deploy compensatory responses in a sufficiently timely and appropriate manner so as to maintain the necessary resilience.

These three concepts – cognitive readiness, pre-prepared responses and the restricted nature of coping resources – proved to be extremely valuable in interpreting the data obtained from the surgical study described below.

**Good compensators:** Over the past few years, we have been investigating the compensations carried out by UK paediatric cardio-thoracic surgical teams during the course of the neonatal arterial switch procedure. We were fortunate in having a skilled human factors observer present at 165 of these procedures. In other words, it was an event-independent study. Twenty-one consultant surgeons in 16 institutions throughout the country performed these neonatal switch operations.

The arterial switch operation (ASO) involves correcting cardiovascular congenital defects in very young babies by transposing the great arteries – the pulmonary artery and the aorta –

and adverse events. This ability is eroded as the number of minor events increases. All operators make errors, but the best of them have the ability to compensate for any adverse effects. This ability depends on their skill and experience, as well as the extent to which they have mentally rehearsed the detection and recovery of their errors.

so as to permit the full circulation of oxygenated blood. Without such an intervention, the child would die.

The children upon whom the ASO is performed are born with the great vessels of the heart connected to the wrong ventricles: the aorta is connected to the right ventricle and the pulmonary artery to the left ventricle. The operation may last for five to six hours and is highly demanding both technically and in human terms.

The most challenging part of the procedure involves relocating the coronary arteries, each comprising very thin friable tissue. The arterial switch procedure takes the surgical team – and particularly the consultant surgeon – close to the edges of the human performance envelope on a variety of parameters: psychomotor skills, naturalistic decision making, and in its claims upon knowledge, experience, leadership, management and communication skills.

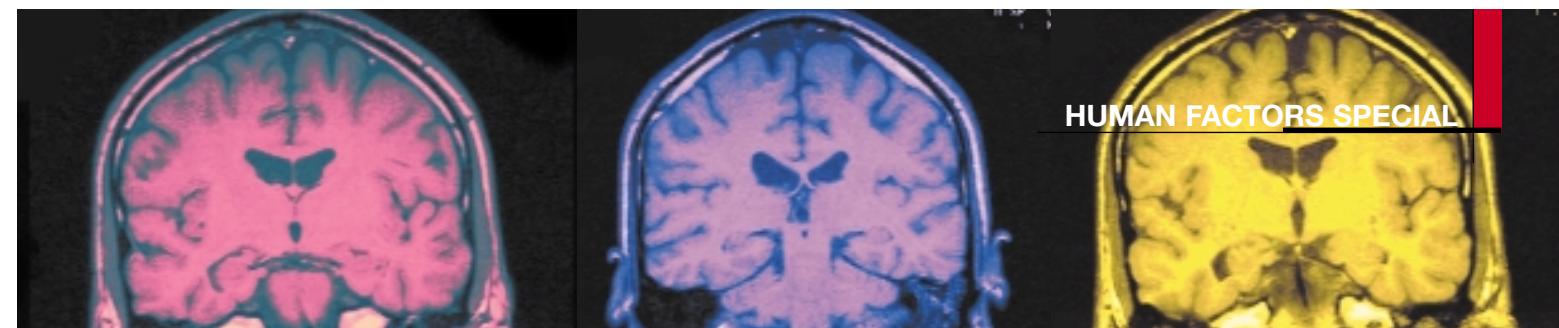
Errors of one kind or another are almost inevitable under such conditions. What matters are not the errors per se but whether or not they are detected and recovered. In the surgical context, as we shall see, bad outcomes

happen when major adverse events, usually the result of errors, go uncompensated. Happy outcomes – by far the majority – are due in large part to effective compensation by the surgical team.

On average, there were seven adverse events per procedure. One of these was life-threatening (a major event); the remaining six were relatively minor events that disrupted the surgical flow but did not immediately jeopardise the safety of the patient. Nearly all of these events arose as the result of errors on the part of the surgical team.

Over half the major events were successfully compensated. When this happened, there was no increase in the risk of death in that particular procedure. However, only 20 per cent of the minor events were compensated. Surgical teams varied in their compensatory success. Good compensators had good outcomes.

Compensation for minor events was far less important than their total number within a given operation. The larger the numbers of minor events, the less likely were the team to cope effectively with a major event. Minor events appeared to exert an additive effect by



HUMAN FACTORS SPECIAL

cumulatively eroding the limited compensatory resources of the surgical team.

The message from this study was clear. All surgeons make errors, but the best of them have the ability to compensate for any adverse effects. This ability depends on the skill and experience of the surgeon, as well as the extent to which they have mentally rehearsed the detection and recovery of their errors. The variability paradox: The reduction – or even elimination – of human error has now become one of the primary objectives of system managers. Errors and violations are viewed, reasonably enough, as deviations from some desired or appropriate behaviour. Having mainly an engineering background, such managers attribute human unreliability to unwanted variability. So, as with technical unreliability, they see the solution as one of ensuring greater consistency of human action.

They do this through procedures and by buying more automation. What they often fail to appreciate however, is that human variability in the form of moment-to-moment adaptations and adjustments to changing events is also what preserves system safety in an uncertain and dynamic world. And therein lies the paradox. By striving to constrain human variability, they are also undermining one of the system's most important safeguards.

The problem has been encapsulated by Weick's insightful observation that "reliability is a dynamic non-event". It is dynamic because processes remain under control due to compensations by human components. It is a non-event because safe outcomes claim little or no attention.

The paradox is rooted in the fact that accidents are salient, while non-events by definition are not. Recently, Weick and his co-workers have challenged the perceived wisdom that an organisation's reliability depends upon the consistency, repeatability and invariance of its routines and activities. Unvarying performance, they argue, cannot cope with the unexpected. To account for the success of high-reliability organisations in dealing with unanticipated events, they distinguish two aspects of organisational functioning: cognition and activity.

**II All [operators] make errors, but the best ... have the ability to compensate for [them]. This ability depends on the ... extent to which they have mentally rehearsed the detection and recovery of their errors. //**

pated events, they distinguish two aspects of organisational functioning: cognition and activity.

The cognitive element relates to being alert to the possibility of unpleasant surprises and having the collective mindset necessary to detect, understand and recover them before they bring about bad consequences.

Traditional "efficient" organisations strive for stable activity patterns, yet possess variable cognitions – these differing cognitions are most obvious before and after a bad event. In high-reliability organisations, on the other hand, flexibility is encouraged in their activity, but there is consistency in the organisational mindset

relating to the operational hazards. This cognitive stability depends critically upon an informed culture – or what Weick and his colleagues have called "collective mindfulness".

Collective mindfulness allows an organisation to cope with the unanticipated in an optimal manner. "Optimal" does not necessarily mean "on every occasion", but the evidence suggests that the presence of such enduring cognitive processes is a critical component of organisational resilience.

Since catastrophic failures are rare events, collectively mindful organisations work hard to extract the most value from what little data they have. They actively set out to create a reporting culture by commanding, even rewarding, people for reporting their errors and near misses.

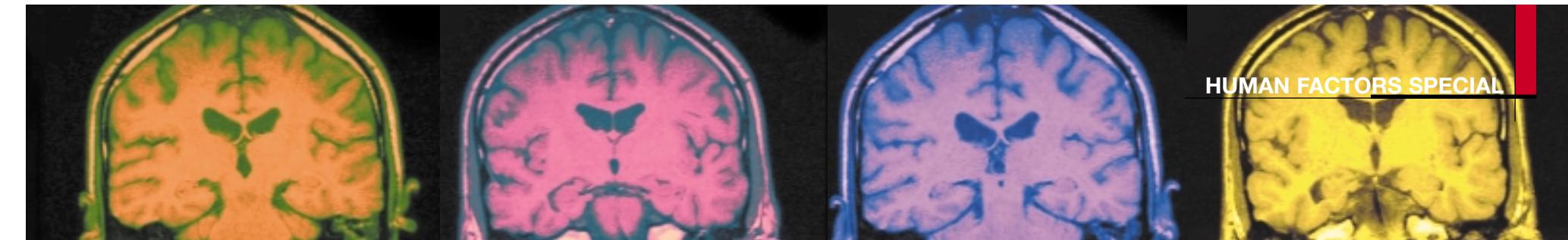
They work on the assumption that what might seem to be an isolated failure is likely to come from the confluence of many "upstream" causal chains. Instead of localising failures, they generalise them. Instead of applying local repairs, they strive for system reforms. They do not take the past as a guide to the future.

Aware that system failures can take a wide variety of yet-to-be-encountered forms, they are continually on the lookout for "sneak paths" or novel ways in which active failures and latent conditions can combine to defeat or by-pass the system defences.

Professor James Reason, Department of Psychology, University of Manchester, Manchester, UK.

## Be prepared

- Human variability is both a source of error and a vital system defence. How can we limit one while still promoting the other?
- The key to resilience at both the individual and organisational levels lies in being mentally prepared for nasty surprises, and having the counter-measures in place to deal with them.
- The ability to make effective compensations appears to be resource-limited, and is liable to be eroded by the cumulative effects of minor stressors.
- Mental preparedness and flexibility of response help to limit the stress-related attrition of these crucial coping abilities.



# A closer inspection: What really happens in the cockpit

ACHIEVING SAFETY requires accurate data about the way an organisation functions in normal operations and how it responds to threat and error.

However, airlines have historically relied on data from performance in training and on formal proficiency checks conducted in simulators.

These data provide accurate information on a pilot's technical competence and ability to respond to particular challenges. In the case of line oriented evaluation (LOE) the data show ability to respond to normal and abnormal situations. Data are also obtained from line checks in which an evaluator grades performance during normal flight operations.

The limitation of this kind of data is that they do not tell you how crews behave when they are not under formal surveillance. Are the behaviours during formal evaluation routinely followed by crews not under scrutiny?

Another source of safety data comes from monitoring digital flight data recorders (flight operations quality assurance or FOQA). FOQA data provide a precise record of flight parameters and crew actions and have been hailed as a major contribution to safety.

However, the limitation of FOQA data is that no information is recorded about why particular actions were taken.

Finally, formal analyses of data on accidents and incidents provide insights, but are limited because they are rare events that may not be representative.

To get a full picture of crew behaviour and system performance and to check on the impact of safety initiatives such as crew resource management (CRM), our research group at the University of Texas at Austin placed specially trained, expert observers in the cockpit of normal line flights. We call this a line operation safety audit, or LOSA.

The critical difference between a LOSA flight and a line check is LOSA's guarantee of anonymity for the crew. Data are entered

into a de-identified database and no crew actions are reported to management or the regulatory agency.

From the information we have collected, we are confident that trust has been achieved, and that we are indeed observing normal operations.

One of the important aspects of LOSA is the fact that it captures exemplary as well as deficient performance: it is important for organisations to know areas in which they excel as well as those in need of improvement.

Observers generate a narrative of the flight classified by phase. Coding begins with crew behaviour in the pre-flight phase and includes ratings of the behavioural markers of CRM practices developed by the University of Texas group (see Helmreich and Foushee, 1993 for history).

Up to 1997 we observed more than 3,000 flight segments in five airlines using ratings based on CRM behaviours. Since 1997 the research group has focussed explicitly on threat and error, and has observed more than 1,000 flight segments. This involves coding external threats to safety and errors committed by external agents such as air traffic control. The behavioural markers employed to manage threat are also coded.

Error is classified in LOSA as deviation from organisational or crew expectations or intentions. Errors committed by the flight crew are described and coded along with actions (if any) taken to deal with the consequences of

the error.

**Varieties of error:** Drawing from the observations of error, we have been able to classify all of the errors seen into five broad categories: procedural errors, communications errors, decision errors, proficiency errors and violations.

**Procedural errors.** These are what most people think of as errors: crews intending to follow a

**“ The data show that 72 per cent of flights observed encountered one or more threats, with an average of two per flight ... ”**

**Decision errors.** When crews choose to follow a course of action that unnecessarily increases risk to the flight in a situation not governed by formal procedures, this action is classified as a decision error. For example, crews may choose not to deviate around weather on their flight path, resulting in an encounter with turbulence.

**Proficiency errors.** This classification is applied to situations where a crew member lacks the knowledge or stick-and-rudder skill necessary to perform a task. A number of observed proficiency errors involve lack of knowledge of flight deck automation.

**Intentional non-compliance.** When crews obviously and intentionally violate company or regulatory requirements, these are classified as intentional non-compliance errors. Failing to abort an unstable approach as required by company procedures would fit into this classification.

The outcomes of threats and errors can be inconsequential or consequential. In our methodology, consequential errors are those that result in an undesired aircraft state or lead to additional crew error. Undesired aircraft states include deviations from desired navigational path or altitude, unstable approaches, long or hard landings, being on the wrong runway or taxiway and arriving at the wrong airport or wrong country. Most undesired states put flights at increased risk.

When an error (or threat) becomes consequential, the crew is no longer managing threat

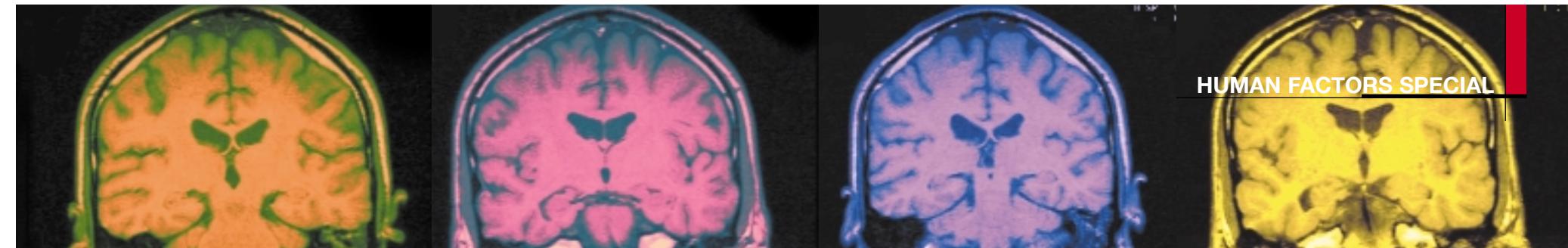
Bob Helmreich







Dan Maurino



# Tired of sweeping up at the end of the parade

**A**nalysis of the behaviour of operational personnel in accidents and incidents has traditionally been the method used to assess the impact of human performance on safety.

The behaviour preceding a negative outcome is analysed, searching for human error, with usually only limited consideration of the processes that could have led to the "bad" outcome. An investigator will already know that the behaviours displayed by operational personnel were "bad" because the negative outcomes are a matter of record, a benefit the operational personnel obviously did not have at the time. In this sense, investigators examining human performance in safety occurrences enjoy the benefit of hindsight.

Conventional wisdom holds that, in aviation, safety is first. Consequently, human behaviours and decision-making are considered to be totally safety oriented. However, all production systems – and aviation is no exception – generate a migration of behaviours: under the imperative of economics and efficiency, people tend to operate at the edges of the system's safety space.

A more realistic approach is to consider operational behaviours and decision-making as a compromise between production and safety. The optimum behaviours to achieve the production demands may not be fully compatible with what is needed to achieve the theoretical safety demands. In fact, it might be argued that the trademark of experts is not years of experience, but how effectively they manage the compromise between production and safety.

Operational errors do not reside in the person, as conventional safety knowledge would have us believe. They reside within task and situational factors, emerging as the consequence of mismanaging compromises between safety and production. These compromises are a complex and delicate balance, and

humans are generally very effective in applying the right mechanisms to achieve success, hence the extraordinary safety record of aviation.

Humans do sometimes fail to balance the compromise, so contributing to safety breakdowns. However, since successful compromises far outnumber failures, in order to understand human performance in context the industry needs to systematically analyse the mechanisms underlying successful compromises, rather than those that failed.

**Incident and accident investigation:** The most widely used tool to document operational human performance and define remedial strategies is the investigation of accidents. However, there are limits to the lessons available through this process.

For example, it might be possible to identify the type and frequency of errors, or discover specific training deficiencies related to identified errors, but this is only the tip of the iceberg.

Nevertheless, accident investigation has a clear role within the safety process. It remains the appropriate tool to uncover unanticipated failures in technology or rare, bizarre events. If only normal operations were monitored, defining assumptions about safe/unsafe behaviours would prove to be a task without a frame of reference.

Therefore, a properly focussed and contemporary accident investigation can reveal how specific behaviours, including errors and error management, can generate an unstable or cata-

**... operational personnel develop informal and spontaneous group practices that circumvent poor equipment design, clumsy procedures, or policies incompatible with operational realities, all of which complicate operational tasks. //**

of aviation and therefore capture only the external manifestations of errors. Second, incidents are self-reported, so the processes and mechanisms underlying an error may not reflect reality. Third – and most importantly – incident reporting systems are vulnerable to what has been described as "normalisation of deviance". **Normalised deviance:** Over time, operational personnel develop informal and spontaneous group practices that circumvent poor equipment design, clumsy procedures, or policies incompatible with operational realities, all of which complicate operational tasks. Precisely because they are normal, neither these practices nor their down sides will be noted by incident reporting systems.

This problem is compounded by the fact that the most willing reporters may not fully appreciate what events should be reported. If you are continuously exposed to substandard managerial practices, poor working conditions, or flawed equipment, you might have difficulty working out what problems are reportable.

While these factors would arguably be reported if they generated incidents, there remains the difficult task of evaluating how they create less than safe situations.

Incident reporting systems are better than accident investigations for understanding system and operational human performance. Their value lies in pinpointing areas of concern; however, incident information does not necessarily capture the concerns themselves.

strophic state of affairs. Should accident investigation restrict itself to mere retroactive analyses, its only contribution in terms of human error would be increased industry databases, the usefulness of which remains dubious.

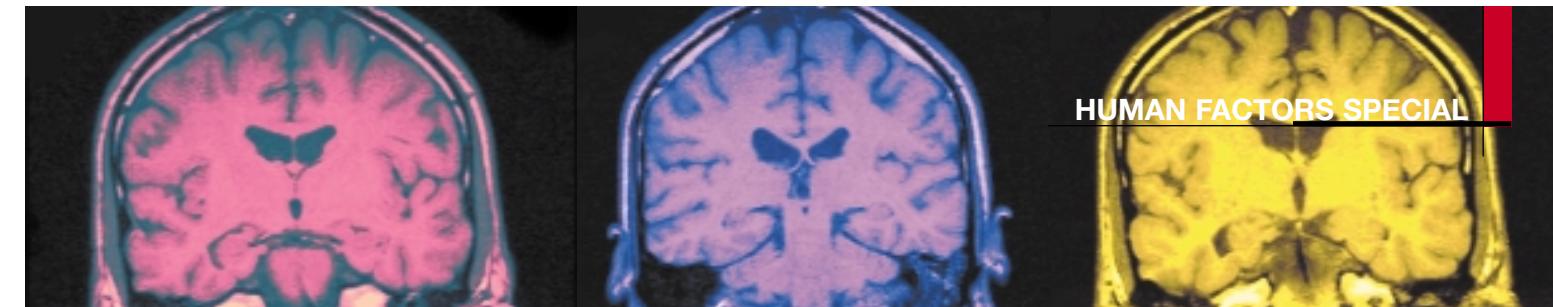
Incidents are more telling markers than accidents – at least of system safety – because they signal weaknesses within the overall system before it breaks down. There are, nevertheless, limits to the value of this information.

First, incidents are reported in the language



# Score your safety culture

CHECKLIST FOR ASSESSING INSTITUTIONAL RESILIENCE				
<b>Scoring:</b> YES = This is definitely the case in my organisation (scores 1); ? = "Don't know", "maybe" or "could be partially true" (scores 0.5); NO = This is definitely not the case in my organisation (scores zero).				
	YES	?	NO	
	<b>Mindful of danger:</b> Top managers are ever mindful of the human and organisational factors that can endanger their operations.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<b>Accept setbacks:</b> Top management accepts occasional setbacks and nasty surprises as inevitable. They anticipate that staff will make errors and train them to detect and recover from them.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<b>Committed:</b> Top managers are genuinely committed to aviation safety and provide adequate resources to serve this end.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<b>Regular meetings:</b> Safety-related issues are considered at high-level meetings on a regular basis, not just after some bad event.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<b>Events reviewed:</b> Past events are thoroughly reviewed at top-level meetings and the lessons learned are implemented as global reforms rather than local repairs.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<b>Improved defence:</b> After some mishap, the primary aim of top management is to identify the failed system defences and improve them, rather than to seek to divert responsibility to particular individuals.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<b>Health checks:</b> Top management adopts a proactive stance towards safety. That is, it does some or all of the following: takes steps to identify recurrent error traps and remove them; strives to eliminate the workplace and organisational factors likely to provoke errors; "brainstorms" new scenarios of failure; and conducts regular "health checks" on the organisational processes known to contribute to mishaps.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<b>Institutional factors recognised:</b> Top management recognises that error-provoking institutional factors (like under-manning, inadequate equipment, inexperience, patchy training, bad human-machine interfaces, etc.) are easier to manage and correct than fleeting psychological states such as distraction, inattention and forgetfulness.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<b>Data:</b> It is understood that the effective management of safety, just like any other management process, depends critically on the collection, analysis and dissemination of relevant information.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<b>Vital signs:</b> Management recognises the necessity of combining reactive outcome data (ie, the near miss and incident reporting system) with active process information. The latter entails far more than occasional audits. It involves the regular sampling of a variety of institutional parameters (scheduling, budgeting, fostering, procedures, defences, training, and the like), identifying which of these "vital signs" are most in need of attention, and then carrying out remedial actions.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<b>Staff attend safety meetings:</b> Meetings relating to safety are attended by staff from a wide variety of departments and levels.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<b>Career boost:</b> Assignment to a safety-related function (quality or risk management) is seen as a fast-track appointment, not a dead end. Such functions are accorded appropriate status and salary.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>



	YES	?	NO	
	<b>Money vs Safety:</b> It is appreciated that commercial goals and safety issues can come into conflict. Measures are in place to recognise and resolve such conflicts in an effective and transparent manner.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<b>Reporting encouraged:</b> Policies are in place to encourage everyone to raise safety-related issues (One of the defining characteristics of a pathological culture is that messengers are "shot" and whistleblowers dismissed or discredited).	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<b>Trust:</b> The organization recognises the critical dependence of a safety management system on the trust of the workforce – particularly in regard to reporting systems. A safe culture – that is, an informed culture – is the product of a reporting culture that, in turn, can only arise from a just culture.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<b>Qualified indemnity:</b> Policies relating to near miss and incident reporting systems make clear the organisation's stance regarding qualified indemnity against sanctions, confidentiality, and the organisational separation of the data-collecting department from those involved in disciplinary proceedings.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<b>Blame:</b> Disciplinary policies are based on an agreed (ie, negotiated) distinction between acceptable and unacceptable behaviour. It is recognised by all staff that a small proportion of unsafe acts are indeed reckless and warrant sanctions, but that the large majority of such acts should not attract punishment. The key determinant of blameworthiness is not so much the act itself – error or violation – as the nature of the behaviour in which it was embedded. Did this behaviour involve deliberate unwarranted risk-taking, or a course of action likely to produce avoidable errors? If so, then the act would be culpable regardless of whether it was an error or a violation.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<b>Non-technical skills:</b> Line management encourages their staff to acquire the mental (or non-technical) as well as the technical skills necessary to achieve safe and effective performance. Mental skills include anticipating possible errors and rehearsing the appropriate recoveries. Such mental preparation at both the individual and organisational level is one of the hallmarks of high-reliability systems, and goes beyond routine simulator checks.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<b>Feedback:</b> The organisation has in place rapid, useful and intelligible feedback channels to communicate the lessons learned from both the reactive and proactive safety information systems. Throughout, the emphasis is upon generalising these lessons to the system at large.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<b>Acknowledge error:</b> The organisation has the will and the resources to acknowledge its errors, to apologise for them, and to reassure the victims (or their relatives) that the lessons learned from such accidents will help to prevent their recurrence.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

## INTERPRETING YOUR SCORE

- 16-20 So healthy as to be barely credible.
- 11-15 You're in good shape, but don't forget to be uneasy.
- 6-10 Not at all bad but there's still a long way to go.
- 1-5 You are very vulnerable.
- 0 Jurassic Park

## HEALTH WARNING

High scores on this checklist provide no guarantee of immunity from accidents or incidents. Even the "healthiest" institutions can still have bad events. But a moderate to good score (8-15) suggests that you are striving hard to achieve a high degree of robustness while still meeting your other organisational objectives. The price of safety is chronic unease: complacency is the worst enemy. There are no final victories in the struggle for safety.