Drawing the Line
Non-Punitive Safety Reporting in Civil Aviation

Prof Patrick Hudson
Department of Psychology
Leiden University

Summary

Incident reporting is essential to maintain and improve safety in aviation. Because of the size and nature of such a complex loosely-coupled socio-technical system, testing against reality forms a major route to identifying where current and future problems lie. People may be unlikely to report because they feel that they will look unprofessional. because they bear messages people in authority do not wish to hear, or because they feel they may be prosecuted for negligent acts they have themselves voluntarily admitted to. With an increasing trend to criminalisation of errors in the aviation, this forms a serious problem if it means vital information is missed.

An analysis of the effects of hindsight bias and the Fundamental Attribution Error shows how acts may appear to others to be careless or negligent, when an analysis of the situation before the event suggests that there is a more complex picture, with the individuals in question being the inheritors of latent conditions, modelled by Reason's Swiss Cheese model of accident causation. One particular set of errors are classified as violations, apparently deliberate deviations from known rules and procedures. But here recent scientific work shows that there are only a few types of violation that can really be designated as unacceptable; many violations occur for reasons of ignorance, because it is impossible to comply in a specific situation, because people try to do what they feel is best for their organisation or even the public, or because they find themselves in totally unusual circumstances. This analysis means that only a restricted number of violations are truly unacceptable, and fortunately such acts can be identified in advance, by those performing them, as well as others. There is no requirement to predict specific dangerous outcomes for such behaviours to be agreed to be unacceptable and, possibly, in need of public approbation.

Many countries already have a reporting system with some form of limited immunity. Lessons learned include recognising the need to have competent analysts and for organisations such as airlines to be allowed to retain their own information with the fear that this will prove compromising.

The proposal is made to take the same approach as Denmark, with a wide-ranging immunity and mandatory reporting, In the light of the competence issues, especially in the area of human factors, a separate body to collect and analyse reports, similar to the American ASRS should be created rather than in the IVW. This could be a specialist department within the Onderzoeksraad voor de Veiligheid. In order to resolve the problems around defining what behaviours can be regarded as unacceptable, a joint body representing equally the aviation sector and the OM should be set up to decide on specific unacceptable behaviours and to review this list regularly in the light of reports.

1.0 Introduction

This paper is intended to examine the issue of the reporting of safety related information in civil aviation in the light of the requirement set out in EU directive 2003/42/EC. First I introduce the basis for setting up safety reporting systems and discuss the importance for such systems to uphold and improve safety. Then I discuss why people might *not* wish to report. One of the main reasons why people might not report, especially their own actions, is the fear of prosecution. This fear is fuelled by the apparent tendency to criminalize safety failures. It is increasingly, but erroneously, assumed that accidents always occur because someone made a reprehensible error and should be prosecuted accordingly. I will show that this assumption is associated with interpreting events after their occurrence.

The following sections provide a brief introduction to human error and rule violation, based upon the latest insights into these topics, including both the organisational and individual contributions to incidents and accidents. I introduce the concept of the Just Culture, intended to bring clarity in this issue, and describe recent thinking that is more directly related to the differentiation in types of human error that have been identified. Putting these together helps us understand why people might wish to concentrate upon those most directly associated with events and the possible legal problems that this might create.

The next section introduces how these problems are handled in a number of other jurisdictions, both within and outside Europe. Finally I make a small number of proposals for how to create a situation acceptable to all parties and consistent with the European directive.

2.0 Why Report? The value of safety reporting in aviation

Aviation is inherently dangerous, so it is necessary to take a variety of steps if we wish to take to the skies and survive. Safe aviation relies upon a combination of aircraft that are well designed, constructed and maintained, flight crews that are competent and function well together, in cooperation with aerodromes and air traffic control centres that ensure that flights take place where and when they should do. Together they form a complex system of interlocking independent elements that has evolved over 100 years, carrying a large number of assumptions that are continuously tested against reality. Because both the system and its constituent elements are complex, it is not possible to identify, in advance, everything that might go wrong and, therefore, prevent it. Reporting of incidents provides us with information about where problems may occur within this system. One of the reasons why reporting of incidents, near-misses, is so important is that in every accident it can be seen that the causes are never a complete surprise, it is the unforeseeable combination of circumstances, failures and errors that is surprising and can be lethal. Not reporting incidents cuts off an essential source of information about what may go wrong in a complex system, leaving us nothing but to wait for those events that cannot be ignored, mainly major accidents.

There are three possible ways to report information about situations, conditions or actions that are potentially dangerous: public, anonymous and confidential. With public reporting, the problems and the reporters are both identified. This is usually not

a problem, although such information may be embarrassing for owners, management or authorities. Reporting by identified individuals may not be appreciated by those in command, so that potential reporters may be discouraged by the thought of personal consequences for whistleblowers. Publicly reporting is also problematic because one's own actions may make one look, at best, foolish and at worst may be regarded as grounds for reprimand, dismissal or prosecution. Reporting the actions of others may create conflict with colleagues. The second way of reporting is anonymous and, while probably solving the problem for whistleblowers and those who feel open to reprimand, anonymous reporting is open to mischievous action and it is not usually possible to find out more about what is being reported and why. Confidential reporting systems, if well managed, allow for reporting without personal consequences for the reporter, while still allowing access to the event so that the causes can be investigated in depth.

In general the main reason we wish to have as comprehensive a reporting system as possible is that we are in search of rare events that may be predictive of future disasters and that it provides information about more frequent failures to monitor trends. In general, incident reporting allows us to calibrate our beliefs about how safe a system is and where attention needs to be paid. It is an unfortunate fact of life that in well-tested systems, such as aviation in 2005, not having an accident still may be due as much to good luck as to design. Concentrating on the normal situation does not tell us a lot. Incidents, on the other hand, give us direct information about how close we are to the edge of our safety envelope. We can learn there both what went wrong and what still worked to avert tragedy. In short, we can probably learn about 10% from what goes well, and 90% from what goes badly. A diet of only good news can be dangerous, while bad news, although unpalatable, provides much more useful information and, as a result, should be encouraged as much as possible.

As aviation systems become increasingly embedded within other systems, we can no longer afford the luxury of seeing each component as a distinct and encapsulated technical system; all parts of the system interact with each other. Passengers are transported by the totality, a system designed and operated by people. In such complex socio-technical systems it is no longer possible to assume that all hazards and failure modes can be identified in advance; we have to test such systems continuously and learn as quickly as possible from what goes wrong, before it turns into a disaster. Fortunately, aviation is 'loosely coupled' (Perrow, 1984), but this does not make prediction any easier.

Reporting systems, if well run, can allow us to identify new hazards and latent failures that have appeared. For instance, the design of the fifth runway at Schiphol created a choke-point at the de-icing area that was not foreseen, but led to wing-tip damage on a Boeing 737 shortly after the runway was taken into operation. At the same time the Delta and Transavia incidents highlighted how societal demands on noise limitation and capacity requirements created problems for operators.

Reporting has long been recognised as a vital source of information to ensure and improve aviation safety. As aviation has become an increasingly complex socio-technical system, reporting of incidents and conditions has probably become even more important because of the impossibility of ensuring, in advance, that all potential problems have been identified and solved. Andlauer et al, (1999) discuss these

problems, originally in the ATM context, and identified three levels of safety certification, with 'classic' ICAO-type certification (Type I) being complemented by Safety Management Systems (Type II) and Good Practice (Type III) approaches, in an attempt to cover all the unexpected but potential lethal traps that lie hidden in complex socio-technical systems. Types I and II are imagination limited – if we cannot imagine it, we cannot prevent it – while Type III looks to see if the system is robust and resilient. Both Type I and Type II necessarily require some form of reporting to assess how well a system is operating, and which elements have to be regarded as dangerous and need to be dealt with in some way. What we may have to accept is that, in order to acquire this vital sort of information, for the wider good, we may need to trade in some degree of control, such as by offering a degree of immunity to reporters.

2.1 The problem. Why *not* report?

While the main problem under consideration is fear of prosecution, it is important to realise that there are other reasons why people might not report. Reporting one's own errors is difficult; it can be embarrassing or it can be threatening from a number of sources. It is hard to admit one has made a mistake or failed to devote sufficient professional attention, even when there is no negative outcome; a degree of humility is required to show one is not perfect, especially in the case of senior professionals such as pilots, air traffic controllers or, in another sensitive area, surgeons and nurses. Reporting the failures of others may be problematical when they are in a position of power over the reporter or close colleagues. Another reason why people might not report useful information is that they may regard reporting as worthless because it will have no effect. For instance, Trommelen (1990) found in a petro-chemical company that a set of reported near-misses had a different structure of underlying causes than actual accidents, with more attention paid to hardware and design problems, and less to 'soft' issues such as organisation and incompatible goals. The interpretation drawn was that people used reporting to highlight issues they felt could be resolved, such as hardware deficiencies, and accepted the softer issues as part of the Human Condition, intractable and impossible to improve and, therefore, not worth reporting.

3.0 Criminalisation and biases

If failures of individuals can be attributed to gross negligence or recklessness then it seems only reasonable that this should be subject to the due process of the law. People in professional jobs should be called to account for failures to exercise due care. In the case of an accident, however, there seems to be growing societal feeling that always someone must be called to account, that always someone should have exercised control and should have prevented the accident. ICAO Annex 13 sec 5.11 explicitly requires investigators to notify the authorities if it becomes known, or suspected, that an act of unlawful interference was involved. This automatically opens the door to prosecution. Moreover, the role of the public prosecutor is not just to prosecute those suspected of criminal acts for the sake of it, but is also to represent the interests of those who have suffered and to ensure that what happened, and why, is exposed in the full view of the public.

Criminal proceedings imply punishment and it is worth considering why one would wish to punish in such circumstances. Traditionally punishment serves one of three goals; deterrence, retribution or reform. There is no evidence that the threat of criminal proceedings makes aviation professionals more careful – the contrary may even be the case when people pay too much attention to those things they think will be likely to attract attention. Professionals are deterred by the fear of failing to meet their own standards and often set the bar far higher than is strictly required. The long-standing attitude in aviation of The Right Stuff can even make pilots and controllers blame themselves when no one else would, simply because they feel that they are always totally in control (see below for a discussion of control). If deterrence is not sensible, then reform is unlikely as well. The only cases where deterrence or reform might work are those where the behaviours are identifiable with or without bad consequences. I will return to these later when I attempt to find where the line should be drawn.

This leaves retribution. There is a tendency that society wants punishment if an accident occurred, regardless of the reasons why someone acted the way they did. As I will argue later on in discussing causes of human error, however, many accidents do not happen because of reprehensible negligence but because of unforeseeable combinations of circumstances. An interesting question is whether this tendency is created by politicians and the media reacting to public perceptions, or whether they are creating it themselves. The evidence from the public response to medical errors suggests that it is how the medical profession acts after incidents that engenders more ire than the incident itself, leading to legal action. Likewise the public may well accept that aviation is inherently risky and that not every accident can be blamed on reprehensible negligence or wilful violations on the part of the responsible people involved.

In the case of an incident, a near miss, the proximity to disaster also translates into the evaluation of an individual's actions as reprehensible because they *could* have caused an accident and are therefore seen as negligent or reckless in so far as they failed to behave in ways that would have prevented the incident. A near-miss is close to disaster and those who fail are regarded as being too close to causing a disaster not to see it coming (See, however, the discussion on biases below). At a certain point such non-consequential failings may also be regarded as sufficient to merit legal attention. In many cases this is likely to be civil action, brought by individuals or as a class action. In the case of wide jurisdiction, as permitted by the Dutch Aviation Law Article 5.3, this can and has also led to criminal proceedings.

3.1 Criminalisation in aviation

Criminalisation in aviation is quite recent. In the USA a note on the House Sub-committee on Aviation in 2000 stated "Since 1982, there have been some 306 U.S. air carrier accidents resulting in more than 2000 fatalities. Until recently, not one of these accidents had resulted in an actual criminal prosecution. After the ValuJet Everglades crash in 1996 this situation changed, with charges of murder and manslaughter against SabreTech Inc as a company and federal charges of conspiracy and making false statements were brought against the company and some employees. After that an increasing number of charges were brought in different cases, resulting, for instance, in imprisonment for the president of a freight forwarding company and fines totalling

5 million dollars against an airline. The USA is a litigious society, where the courts are seen as the natural arena to expose failings and wrongdoing, but this trend also started in the Netherlands with the Delta case after the incident in 1998.

The problem, as seen from the point of view of the psychologist, is that what seems to others to be dangerous may be explained quite differently when seen from the point of view of the individual concerned. There are three major issues that need to be considered. One is the effect of the Fundamental Attribution Error, where people attribute failures by others to deficiencies in those people. The second is the existence of hindsight bias, where knowledge of the outcome biases understanding of how participants should have judged the situation before a critical event. The third is the change in thinking about accident causation that has shifted attention from those directly involved to those who have created the situation within which the events of the accident have been played out. These three issues will be discussed in the following sections.

3.2 Fundamental Attribution Error.

There is a belief, deeply engrained, that bad things happen to bad people. Combined with the Fundamental Attribution Error, this leads to a situation in which there is a belief that accidents are caused by failures in individuals. The Fundamental Attribution Error involves attributing other people's errors and failings to their personal characteristics rather than to the situation in which they find themselves. Furnham (2004) outs it succinctly "Accident investigators have to watch out for attribution errors: that is falsely attributing blame to a person, a piece of equipment or a procedural operation. Often it is a fatal combination of all three." An individual, asked about why an incident occurred, such as damaging a car, will describe the causes with reference to external factors, such as the traffic density, low visibility, other drivers etc. An outside observer, in contrast, will tend to feel that the person is just a bad driver. This phenomenon reverses when the outcomes are good. We attribute our good luck to personal characteristics, while outside observers see someone who has profited from situational forces rather than any inherent 'goodness'. Western, individualist cultures are more likely to make such unbalanced attributions than are the more collectivist Asian cultures. Part of this is caused by a belief in the ability of individuals to exercise control over their environment, so that if something bad does happen to someone, it represents an example of how they must have failed to exercise the control they are perfectly capable of. Such lack of control is a weakness that deserves to be treated accordingly, for instance by punishment.

3.3 Hindsight bias.

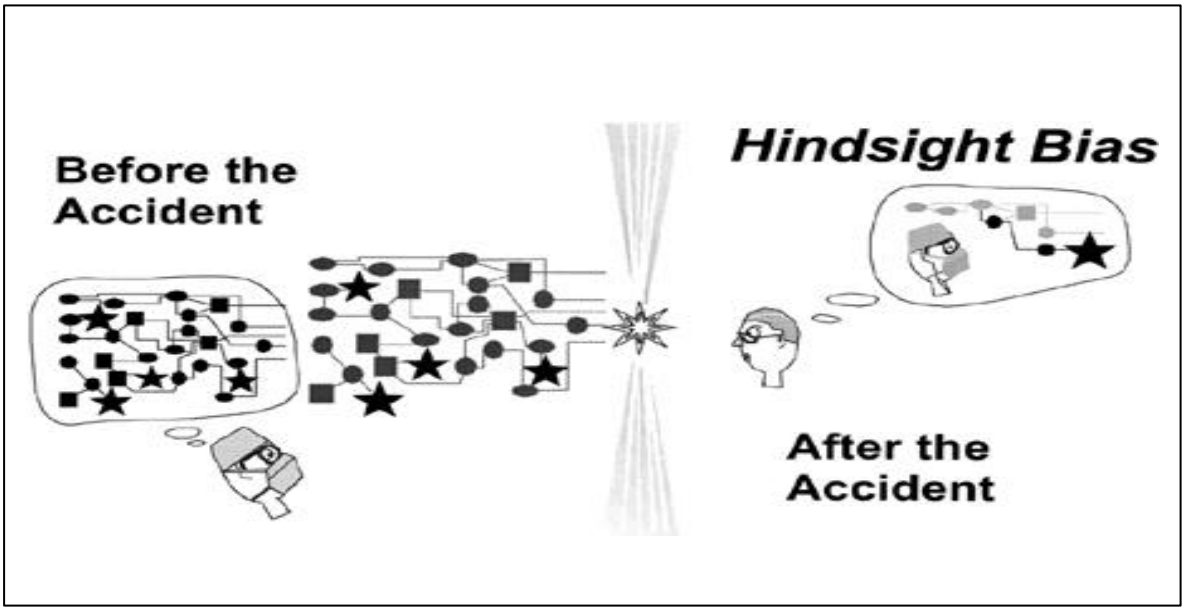

Figure 1. Hindsight bias results in oversimplification of the situation before a critical event.

Fischoff (1975) first discussed the problem of hindsight bias, the "I knew it all along' effect. Hindsight is a luxury for those who already know the outcome, but it is unreasonable to expect the same insight in those who are in the middle of a complex event and who do not know exactly how the events is going to unfold. A critical test is to confront a similar individual, a substitute who does *not* know what happened, with all the information up to a point before the crucial event. A number of factors play a role here. People appear to be less capable of generating possible alternative scenarios if they already know the outcome (see the cartoon for a medical example) and they assign relatively greater *a priori* probabilities to those scenarios that lead to the outcome, in this case the accident, than to other non-accident scenarios. In the most extreme case people armed with outcome knowledge can only see one possible result and, naturally, assume that the individual in that position should have made the same prediction. This assumption is simply false, but unfortunately, it is accepted by all those who judge after the fact, such as prosecutors, relatives and also colleagues. The problem of hindsight bias and its reduction are discussed in more detail in Hudson (2001 a).

3.2 The Reason Model – Swiss Cheese and the Organisational Accident

Reason (1990, 1997) developed the notion of how accidents happen into a model that is generally accepted by a large number of organisations. Developed first within Shell International as the Tripod model (Reason et al, 1987; Wagenaar, Hudson & Reason, 1990; Hudson et al, 1992), it has been taken by ICAO as the standard model of how accidents happen[1]. The model distinguishes between underlying, systemic problems,

[1] The model is actively supported by, amongst others, the US National Transport Safety Board (NTSB), the Australian Transport Safety Board (ATSB), the Raad voor TransportVeiligheid (RvTV now Ongevallen Raad), Transport Canada, The International Air Transport Association (IATA), the

called latent conditions, such as failures in design, procedures, organisational structures, and the active errors of the individuals at the 'sharp end'. The model has been portrayed as a series of slices of defence, or barriers with holes, hence the title the Swiss Cheese model (see Figure 2 for a graphic display). Holes may appear, becoming larger or smaller, depending on local conditions. What the model explains is not just how accidents occur, but also why we have so few accidents even when so much may be wrong and why causal combinations of factors leading to an accident often are so incredible. It is necessary to have all the holes to line up for the hazards to turn into an actual accident.

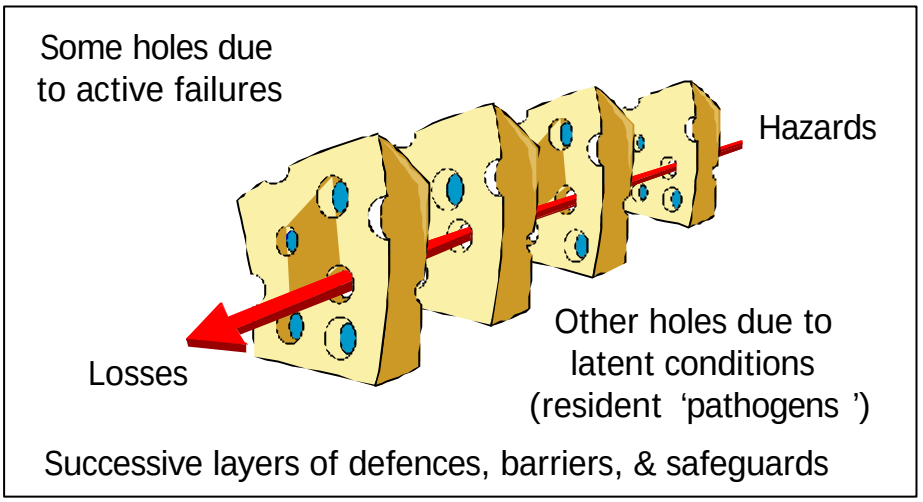

Figure 2. *The Swiss Cheese Model (Courtesy Prof J. Reason.*

In the annexes A.1 and A.4 I present two worked examples that illustrate the Swiss Cheese model by showing how active failures causing accidents or incidents may in fact be the consequence of latent failures that created the conditions for the active failure to produce the accident.

The insight the Swiss Cheese model brings to the occurrence of incidents, and the reason why ICAO has embraced the model, is that it directs attention to where the *real* problems are, such as the initial design, rather than continuing to accept that those forced to use bad designs may occasionally make minor slips and pay major consequences. In this model the human errors described in the annex form the active failures, the acts or omissions of individuals at the end of a chain of underlying conditions that make slips, lapses and mistakes more likely.

4.0 Human Error

This section contains a brief introduction to human error, in order to allow a better understanding of exactly *how* people err, *why* they make errors, and *what* makes errors more or less likely. In the Annex there is a more extensive introduction and two worked examples, an inconsequential flight deck error and the highly lethal problem of the spookrijder. Human errors can be distinguished into two major types: a) *slips and lapses*, where the plan of action for the circumstances is good, but its execution goes wrong, and b) *mistakes* where the plan is inappropriate for the circumstances, but

International Federation of Air Traffic Controllers (IFACTA), as well as such airlines as British Airways, Singapore Airlines, Air Canada and Quantas.

yet is carried out (Reason, 1990). Finally a different behaviour, usually not defined as an error, but falling under the heading of human error, is *violation*, the deliberate failure to follow known rules or procedures.

4.1 Errors – Slips and lapses: Actions not as planned

Paradoxically, people make errors because they are good at what they do. Skilled behaviour is characterised by the ability to perform tasks automatically, often more than one task at a time. We never speak of human error if someone fails to perform a novel or unusual task, one they were not practiced in; that is just a demonstration that they have yet to acquire the skill level we require. The advantage of having skilled performance is that we no longer need devote our full attention to the task, but can also attend to other problems – we can both drive and listen to the radio and often discover that, while we can recount what we heard, we have no memory of how we drove[2] except to realise that it must have gone well enough not to have collected any bumps or scratches. The downside of this is that we do not attend fully to a single task, and some degree of sharing of attention is necessary even for highly skilled tasks. So, for instance, we may switch the dishwasher on before we have loaded the tablet (a slip) or we may forget to start the dishwasher when we go to bed because we are distracted by something more urgent (a lapse). Slips and lapses are typically benign, because we have learned to construct systems robust enough to survive such errors (the exception may be the heart surgeon who has nothing between the scalpel and the aorta except attention to the case in hand – distraction at this point can be unfortunate for the patient).

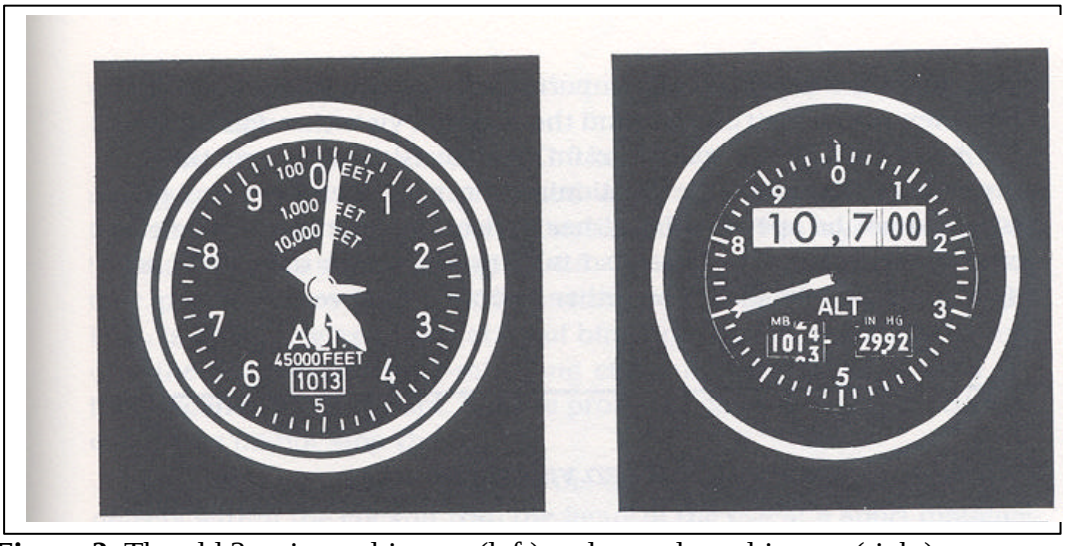

Figure 3. The old 3-pointer altimeter (left) and a modern altimeter (right).

The three-pointer altimeter (see Fig 3 left) was an example of what should not be done and led to a large number of fatal aviation accidents before it was replaced by the current type of altimeter (Fig 3 right). Such a design is just too easy to misread (the 10,000 foot pointer is the smallest and most easily obscured), so telling pilots that it is their professional duty always to read this type of altimeter accurately is *not* the solution. This is a typical example of holes in 'early' slices of cheese – the design and

[2] A study at TNO Technische Menskunde found no decrement in driving performance when the driver's sight was shielded up to 90% of the time.

the expectation that people could read it even in the face of evidence that errors were common – leads to a relyiance upon the last slice, the pilot, to resolve the problems.

4.2 Errors – Mistakes: Actions not as wished

While slips and lapses may be described as occasional but almost inevitable failures to execute good and skilled plans of action, mistakes involve having the wrong plan. People routinely solve problems and sometimes they get the wrong answer. This becomes a mistake when they subsequently carry out a plan of action based on their (incorrect) belief that they know and understand the situation.

Mistakes come in two sorts (Reason, 1990): Rule based mistakes involve selecting an inappropriate behavioural rule to apply, where such rules may be either explicit or well developed rules of thumb; knowledge based mistakes involve failures to solve problems from first principles. Mistakes may be diagnosis errors, failures to understand a situation, or action errors, choosing the wrong solutions after a correct diagnosis has been made. Mistakes are typically a result of a lack of information. Unlike slips and lapses, mistakes once made are hard to recover from. This is probably because people have to make their minds up at some point. This creates a commitment to the plan they have selected and altering it means that it has to be actively suppressed and replaced by an alternative. In contrast, a slip or a lapse is unintentional and so there is no commitment to the action.

4.3 Violations – Intentional behaviour

Whereas errors are never intended, and therefore intentionality is not the issue, violations are very different. Typically a failure to follow rules or procedures or adhere to standard good practice is seen as deliberate and therefore worthy of blame. The simple solution is to say that anyone who makes an error did not intend to do so, so reporting should only carry consequences for those who fail to learn from them, but that anyone who violates should be held responsible because they *knew what they were doing* and still *deliberately continued.*

Analyses of the nature and causes of violation suggest that the situation is much more complex than this simplistic picture. This understanding is vital if we are to discover exactly where to draw the line and it was necessary to clear the undergrowth of error and recrimination to reach this point.

There appear to be four basic types of violation[3]:

1. *Unintentional* – people are not aware that there is a rule or their understanding differs significantly from what is expected by others,
2. *Situational* – some situations arise where the standard procedure is hard or impossible to follow and nothing has been done to improve the rules or procedures to take account of this,
3. *Optimising* – people know and use better ways to get the job done. These may be for personal benefit or for the perceived benefit of the organisation and even the community,

[3] These are the basic categories used in the Shell brochure Managing Rule Breaking.

4. *Exceptional* – Situations arise where people overlook or ignore basic rules, probably because they see the situation as calling for other action.

All of these are very different in their causes, their operation and their solution, so to treat them as a single undifferentiated category is to deny advances in knowledge. There are however examples of how current legal thinking ignores such distinctions:

1. An individual doing 70 Kmh in a 50kmh limit, who thinks they are actually driving under the - mistaken - belief that the limit is 80 kmh, is still regarded as in contravention of the law. The fact that the only 50kmh sign may have been totally unreadable is normally not regarded as an adequate defence. If more people do this, the result is more prosecutions, not fixing the traffic sign.

2. An individual who performs an effective sequence of actions that deviate from the official procedure that is known to be 'wrong', is still in the wrong if anything happens. Typically such cases are known and condoned, but no one has ever got round to solving the problem by rewriting the procedure. What is worrying here is that the US Nuclear Regulatory Commission, in the INPO studies, finds that the majority of procedural errors in nuclear power plant operation are due to people slavishly *following* procedures *known* to be incorrect, because they do not wish to be non-compliant, rather than the smaller number who deviate from safe procedures.

3. People often find better ways of working. We hire people to be inventive and are then surprised when they succeed in finding new ways to operate. People may cut such corners in their own personal interest, a personal optimizing violation, but experience in high risk industries shows that they most frequently cut corners because they see it as being in the interests of the organisation. Technicians who cut corners on safety procedures in railway operations have to be understood in the context of a railway culture, the direct and well-established (since before 1840) ethos of keeping the trains running for the benefit of passengers, even at some cost to themselves (it is usually the track workers who are the victims). The latter may be called organisational optimizing violations and may be seen as an abdication of managerial authority (Hudson 2001b).

4. Some procedures, even if known, are hard to follow in certain circumstances, no matter how sensible they may seem in the comfort of an office. A Grizzly Bear Procedure requires victims to lie very still and not cry out if they are slashed as this annoys the bear (a true Schlumberger exploration procedure!). People often cast sensible procedures away in their attempts to save people in distress (leading to rescuers who drown or are asphyxiated while the original victim survives).

Over and above these basic types there is the question of whether a violation is routine and then if it is only a single person who routinely violates or a large number of different individuals. This question is one of the bases of the substitution test

> *Would a significant proportion of individuals with the same training and experience have acted in the same way under the same circumstances? E.g.*

determine whether the action was quite unique to that individual or something that many people would have been likely to have done.

What this test highlights is not only the question of whether an individual would violate on one occasion, but also whether such a violation would be unique to that person or be found to be done by many others. In the case of the disastrous SQ 006 take-off on the wrong runway at Taipei Chiang Kai Chek airport, the error, at first sight a one-off failure to establish the right runway, became to be seen in a totally different light when it emerged that the same error had occurred the previous evening and more frequently before that (the problem here was that none of this was reported to the airport, so Singapore Airlines knew nothing about the fact that selecting 05R rather than 05L was not an unknown event.

4.4 Errors, violations and culpability – Drawing the line

4.4.1 Violations

What does all this mean for what we could regard as culpable and, in many cases, who should we regard as culpable? The way to start drawing the line is to examine which errors and violations are incontrovertibly on the wrong side. Sabotage, drunkenness, substance abuse and other evident unfitness to operate are clearly unacceptable. Personal optimising violations, such as leaving work early without finishing the job, signing off equipment without some form of professionally acceptable check, using the wrong tools and equipment when the correct ones are available, are all examples of what might be generally considered reprehensible. What might also be considered are reckless behaviours such as horseplay or clowning about (Reason & Hobbs, 2003). Such individuals have invariably shown a track record of failure and misdemeanour and an organisation, which has not acted earlier, will have demonstrated that it too is part of the problem.

All of the above are violations and can be recognised as such, at the time, without any requirement to predict what consequences might happen in the future. Violations as a result of awareness failures are really a form of mistake, a lack of appropriate information. Unintentional violations are solved elsewhere in an organisation, with training, distribution and checking whether what is understood is what was originally intended. Situational violations are typically the result of a managerial failure to detect and amend problems, combined typically with perpetrators who are trying to get the job done. In many cases the actual actions described as a situational violation may well be the best way to do the job, but not the official way. Optimizing violations, when made in the interests of the organisation rather than being personal, also require a response from the organisation rather than simply telling individuals not to do them. Exceptional violations can be extremely complex – Chernobyl was a classic example of a whole team who thought they were doing the right thing, against all the official guidelines – but the most effective solutions are found in the area of training people to deal with the unexpected. In aviation we expect people, in the last resort, to fly out of danger regardless of regulations such as SIDs and noise abatement procedures and they are trained as such[4]. In all of these there *is* one requirement for

[4] Of all the laws in aviation, there are two laws that take priority over all others, and they are the laws of aerodynamics and gravity.

the person breaking the rules, and that is to report, otherwise no one might ever know until it is too late, so what might be considered blameful is *not reporting* rather than the violation itself.

In summary the only violations that are obvious candidates for some form of action against the person violating appear to be of the personal optimizing sort. All of these actually appear to be agreed amongst aviation professionals (e.g. IFATCA 2003).

4.4.2 Slips, lapses and mistakes

In contrast to violations, slips and lapses are unintentional, only recognisable after the event (Oops! What did I just do?). It can be difficult, if not impossible, to foresee the consequences of a slip during the action (before is, by definition, meaningless) and lapses are equally invisible. If a slip can have immediately disastrous consequences this should be identified, which may be difficult to do exhaustively, but we expect that people will operate within systems that are sufficiently robust to survive a mere slip (with the exception perhaps of our heart surgeon). Solutions for both slips and lapses lie in the construction of the working environment, including the pressures that overload attention and fill up memory. What is clear is that the idea of the accident-prone individual is erroneous; at the most people go through phases, usually identifiable, when they are more vulnerable to distraction, as when they are under particular long-term stress. Once the problems go away, the underlying non-accident-prone individual reappears.

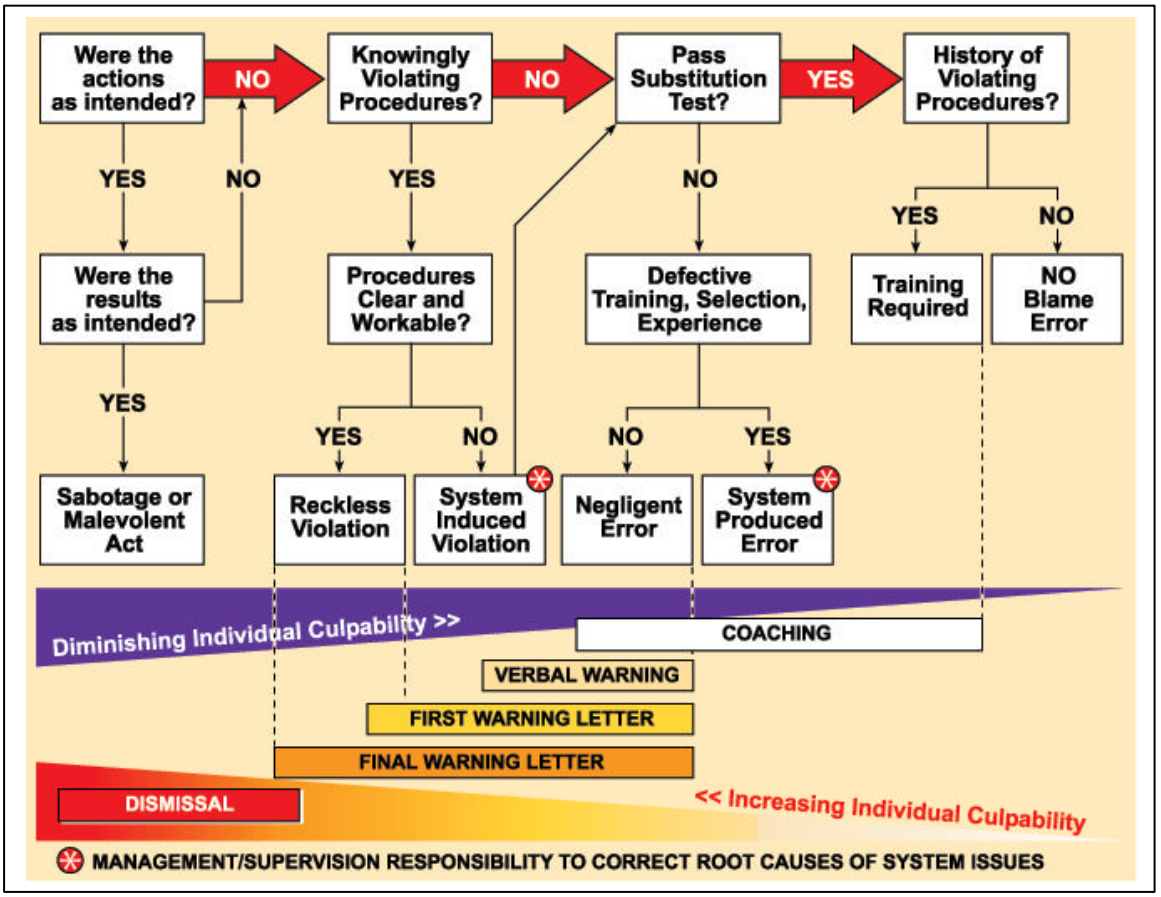

Figure 4 The Original Just Culture decision tree.

Lapses form a serious problem in aviation, especially in maintenance (Reason & Hobbs, 2003). The problem is typically the result of overloading human memory in some way, or of allowing distractions to be permitted. A typically dangerous example is allowing a technician overhauling the main rotor head of a helicopter to be called away during the task without taking precautions; under such conditions the likelihood that the technician will forget something rises alarmingly and the rotor head is the most sensitive part of the whole aircraft. If anything is to be considered for prosecution in this situation it would be managerial failure to realise the psychological limitations of humans in the performance of safety critical tasks. The problem was raised in 1992 (OECD – Hudson, 1992) but little has been done since then.

Mistakes can be disastrous. Pilots believe they are somewhere else, the 180^{o} error can result in flying *into* rather than away from a mountain. Mistakes are honest but can be difficult for others to understand. This is one of the problems of hindsight bias; once we know the answer it is almost impossible to imagine that anyone else would not have known it too. Because of the 'make your mind up' principle, that at some point we have to decide and act – those early human beings who continued to weigh up the situation got eaten by the lions – actions mistakenly predicated on a bad plan tend to require a lot more counter-evidence to be rejected. Again a source of difficulty for those of us who, wiser after the event, know better.

4.4.3 the Just Culture

Figure 5. A new model for the Just Culture Part 1

The notion of the Just Culture arose to try and bring clarity into the issues discussed here. The example shown in Fig 4 shows a decision flow chart. This is intended to make it clear that a number of actions are unacceptable, such as sabotage, reckless violations and negligent errors. Unfortunately it is usually seen by the workforce as "ten ways to get sacked" and has, in practice, not produced the advantages that have been expected. More recent research, using knowledge about the different categories, has made more explicit the roles and accountabilities of all parties. What are referred to in Fig 4 as System Induced Violations include all of Unintentional, Situational and Organisational Optimizing violations. As the solutions and the role of the individual differ in each one of these three, this is not a fully adequate solution and has not, in practice, been as effective as one would have wished. It is similar, therefore, to the situation under consideration here.

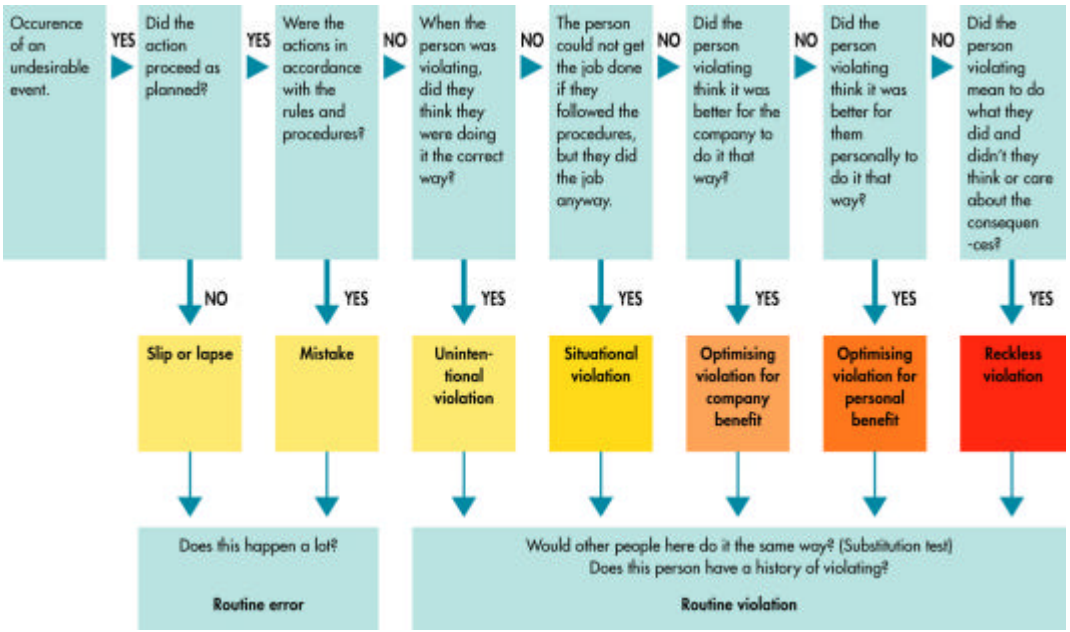

Figure 6. The decision flowchart for the new Just Culture model. Oart 2.

The more modern approach includes rewards for reporting, especially one's own errors, as well as consequences for individuals who fail to report. The latest model, shown in Figures 5 and 6, has more serious consequences for managers and supervisors of those individuals for creating a culture in which reporting is difficult. For the purposes of the discussion here the crucial elements of a modern culture (sometimes referred to as blame-fair) appear to be the existence of clear examples of what is regarded as unacceptable, primarily drawn up by the people in the sector itself, the existence of sanctions for those who allow such situations to arise and continue (e.g. management), and the existence of rewards or recognition for those who are willing to expose themselves. This reflects the current reality within major Oil and Gas producers and has resulted in few sanctions but an increasingly open reporting culture.

5.0 What is happening elsewhere?

This section is a brief compilation of information about reporting in a number of countries and supranational organisations.

5.1 ICAO

ICAO has made it clear that information gathered after an accident for investigation purposes under Annex 13 should not be used for purposes of prosecution.

> 5.4.1 *Recommendation. – Any judicial or administrative proceedings to apportion blame or liability should be separate from any investigation conducted under the provisions of this annex.*

Nevertheless there is a role for judicial authorities even within Annex 13, but the costs of what is regarded as inappropriate use is seen as high, as is shown by the following section.

> *Non-disclosure of records*
>
> 5.12 The State conducting the investigation of an accident or incident shall not make the following records available for purposes other than accident or incident investigation, unless the appropriate authority for the administration of justice in the State determines that their disclosure outweighs the adverse domestic and international impact such action may have on that or any future investigations:
>
> a) all statements taken from persons by the investigation authorities in the course of their investigations;
> b) all communications between persons having been involved in the operation of the aircraft;
> c) medical or private information regarding persons involved in the accident or incident;
> d) cockpit voice recordings and transcripts from such recordings; and
> e) opinions expressed in the analysis of information, including flight recorder information.
>
> *Note. – Information contained in the records listed above, which includes information given voluntarily by persons interviewed during the investigation of an accident or incident, could be utilized inappropriately for subsequent disciplinary, civil, administrative and criminal proceedings. If such information is distributed, it may, in the future, no longer be openly disclosed to investigators. Lack of access to such information would impede the investigation process and seriously affect flight safety.*

5.2 European Union

The EU directive 2003/42/EC states in Article 8

> 3. Without prejudice to the applicable rules of penal law, Member States shall refrain from instituting proceedings in respect of unpremeditated or inadvertent infringements of the law which come to their attention only because they have been reported under the national mandatory occurrence-reporting scheme, except in cases of gross negligence.

These supra-national bodies (ICAO, EU) basically require a situation in which States should at least exercise considerable restraint if legal action should prejudice the reporting process because of the overall potential effects on flight safety. The EU directive nevertheless refers to gross negligence (a difficult concept in Dutch law apparently) but this has to mean in the context of a report of an incident and not an accident (otherwise it would not be likely to be unknown without a reporting scheme).

5.3 Australia and New Zealand

Australia has an act, the Transport Safety Investigation Act (2001), that expressly prohibits disclosing information from a Cockpit Voice recorder to any person *or to a court*, with a penalty of 2 years imprisonment. The exceptions to the prohibition arise once an investigation of an offence is already in progress, for someone not a crew member, or for criminal proceedings against a crew member for an offence punishable by a maximum penalty of imprisonment for life or more than two years. New Zealand earlier implemented a very similar act.

5.4 USA and Canada

The ASRS system is administered by NASA. It offers limited immunity if reports are submitted within 10 days, there is no criminal activity and it is not an accident. The FAA is an enforcement agency so is not able to offer much immunity and, typically, does not. Canada has the Securitas system, similar to ASRS. These systems are supported by specialist personnel whose task is to analyse and follow up.

5.5 UK

In the UK the CHIRP system provides an opportunity for confidential reporting operating in ways similar to ASRS. British Airways has long operated its own Air Safety Reporting programme, but in 1993 they added a confidential Human Factors reporting program run by a pilot who also has a PhD in cognitive psychology (O' Leary, 1996). This program is separate from Flight Operations and operates with full confidentiality, partly because the types of report received are not those that are mandatory reports to the CAA. This shows that most of what happens and is reported never need extend beyond a reporting authority, but also that technical knowledge is essential to gain full value from the system. The airline is fully aware of the benefits of the system. The CAA does not attempt to prosecute cases in the confidential system.

5.6 Nigeria

Nigeria is a country with a reputation for being a blame culture, nevertheless the director Airworthiness Standards, F.C. Onyeyiri (2003) stated:

> "In a voluntary reporting system, pilots, air traffic controllers and others involved in aviation are invited, rather than required, to report hazards, discrepancies or deficiencies in which they were involved or observed. I believe that a trusted 'third party' could be more effective in managing this system. In reality, people are reluctant to report their mistakes to their employers or to the government agency, which licences them. I personally support or see no reason why pilots or other personnel can not report to a specially appointed body who will then carry the information to those who can effect rectification *without reprisal on anybody*." (my italics)

5.7 Korea

The Korean Aviation Act Article 50-2 (Aviation Incident reporting) provides a level of immunity similar to the US ASRS. This section is taken from the aviation authority website (not all acronyms are explained).

"Accident or Criminal events may not be reported to KAIRS. These kinds of reports can not be processed by KOTSA and should be filed directly to KMOCT or Police. The Korean Aviation Act. article 50-2 (Aviation Incident Reporting) defines that

> "where a person who caused the incident to occur, files a report to pursuant to para and fall under the provision of article 33 3 and 4 , the disposition under the provision of article 33 3 and 4 may not be taken. "

this means that in the case that a person could be revoked for their Qualification or Certification of Aircrew's Physical Examination due to the incident which they report to the KAIRS, they can submit the returned PIS and get the immunity when the following conditions are met.

- The reported incident or events is not the accident or events which are under the provision of Act. 50;
1. Crash, collision or fire on the aircraft
2. Death and injury of persons or damage and destruction of things due to the aircraft
3. Death or missing of a person on board the aircraft ,
4. Other accident on the aircraft as prescribed by the Ordinance of the KMOCT.

- The report is filed to the KAIRS within 10 days after occurring."

5.8 Denmark

Denmark appears to have the most far-reaching legislation which applies specifically to safety reporting in aviation. Passed in 2001 the law provides strict immunity against penalties and disclosure if reported with 72 hours. Peter Majgård Nørbjerg, the head of incident investigation at Naviair wrote:

The benefit of flight safety reporting systems to flight safety has been recognised for many years and many systems are in operation today in the North America, Europe, Australasia and elsewhere. Most of these systems share as a common feature that reports are anonymous and aviation personnel who submit reports do so on a voluntary basis. A few systems – such as the ASRS and the CHIRPS makes it possible to report incidents without risking legal action under certain circumstances.

As opposed to these systems, the recently introduced system in Denmark is a mandatory, nonpunitive, and yet strictly confidential system. The reporting system is mandatory in the sense that air traffic personnel is obliged to submit reports of events, and it is strictly non-punitive in the sense that they ensured indemnity against prosecution or disciplinary actions for any event they have reported. Furthermore the reporting system is strictly confidential in the sense that the reporter's identity may not be revealed outside the agency dealing with occurrence reports. Reporters of incidents are ensured immunity against any penal and disciplinary measure related to an incident if they submit a report of within 72 hours of its occurrence and if it does not involve an accident or does not involve deliberate sabotage or negligence due substance abuse (e.g., alcohol). Moreover, punitive measures are stipulated against any breach of the guaranteed confidentiality.

He noted that before the act *only* separation losses between aircraft were reported, about 15 a year. Two years after implementation this had risen to 40-50 per year. Furthermore one year after the system was started a total of 980 reports were received (of which 20 in the first 24 hours!).

6.0 Analysis

6.1 Reporting is essential and must not be hindered in aviation

Reporting is an essential way to gain information that can enhance the safety of operations. In the case of aviation, possibly above any other high-hazard activity, such as nuclear power, this is a complex socio-technical system made of a large number of loosely coupled entities. Aircraft fly between locations in an essentially independent manner, relying on the operation of a vast number of separate technical and human elements to operate. Such systems are too complex to describe fully and to predict everything that can go wrong; we have to rely on reality to tell us how well we are doing. This means that reporting in aviation must have an extremely high priority. In fact we might, as a society, be willing to trade in demonstration of disapproval of individuals, no matter how bad their behaviour, if we can increase the frequency and quality of reporting. In short, failures to report may be more harmful to society than allowing some people to go free even if we feel that they may have behaved in ways that might be considered sufficiently poor for legal action. This is a judgement for society to make, but the consequences of such a decision need to be clear *before* anything actually goes wrong, rather than making decisions on the basis of emotion, as happens just after a major incident or accident.

6.2 There *are* some unacceptable behaviours

Nevertheless, there appears to be considerable agreement within the aviation sector that some behaviours are unacceptable un any circumstances (e.g. this is the IFATCA position). These behaviours are typically of the reckless or personal optimising variety. For instance the following might be considered within the aviation sector

- Sabotage
- Premeditated dangerous behaviours
- Drug abuse
- Alcohol
- Horseplay
- Reckless behaviours
- Actions that are explicitly forbidden
- Use of inappropriate tools and equipment when the proper materials are easily available

I would argue that all other behaviours, even though they may seem to have been 'bad', should be treated with the care an understanding of hindsight bias and of the fundamental attribution error requires. Errors, slips, lapses or mistakes, can appear to be careless or negligent after the event, but one of the differences is that they are typically behaviours that, at the time *before* an incident, would not appear to be reprehensible and could also pass the substitution test. The list above, however, describes behaviours that can be recognised as unacceptable as such, even in the event that there are no bad consequences.

6.3 There is no explicit guidance

One major problem with reporting is that there is no explicit guidance from the OM on what they will regard as significant enough to start proceedings with their own investigation. Until this is at least made explicit the fear of prosecution will remain. The best way to have people accept that the system is fair is to have the people who will be stepping over the line be those who will draw the line. This must be done transparently, hence the need for both the sector and the OM to participate to ensure that the line is not perceived by the public as drawn too leniently. Nevertheless, people who step over their *own* line will be found to accept the consequences far better than those who are compelled to operate with a line drawn by others (even if they are almost identical).

The definitive list of unacceptable behaviours should therefore be drawn up by the sector *together* with the prosecuting authorities, probably in a properly constituted forum, and made public. This can solve a number of problems for both parties because:

1. The line so drawn will be experienced as fair because it represents the industry view of what is unacceptable;
2. The OM can help define what is prosecutable and how it can be defined so that both sector and OM know what they mean.

Provisions should be made to amend the list as a result of experience with the reporting system, which is another reason for having a constituted body. The changes,

where introduced as a result of experience with what is reported should not, however, be used retrospectively.

Once such a list is available, agreed and made public, reporting everything that is discovered on the 'right' side of the line should be made mandatory. The price of essentially a high degree of immunity is the obligation to report, even when one looks foolish or stupid.

6.4 There is a problem with the legal approach

I have discussed the effects of hindsight bias, the fundamental attribution error and the modern understanding how those closest to the incident are themselves the inheritors of a chain of events and decisions going back in space and time. What I have proposed is that there is a small set of actions, essential those violations defined as personal optimizing or reckless, that can be identified in advance. These acts are clearly identifiable to those performing them (and outsiders) *without the requirement for consideration of the consequences*. If we require the need to have predicted the outcome, to be aware of what control was necessary in advance, then our understanding of the events will be heavily influenced by the biases discussed while, in all cases, there will not have been any real evidence of premeditation. I propose that all such cases fall under immunity and that, because of the information about the system as a whole that they can deliver, that they should *always* be reported.

One problem is that while many acts are exempted from immunity in many countries, in The Netherlands Article 5.3 of the aviation means that almost anything, as it currently stands, *could* be seen as bringing into danger and therefore worth considering for prosecution. There are many countries where there is some form of immunity provided to those who report in a timely manner. Exceptions are typically when the act is recognised as criminal – but who defines that an act is criminal without investigation? Hindsight bias in an outsider may make an act look potentially criminal while the person who did it sees it as merely unfortunate. Finally, when there is an actual accident, apparently all bets are off.

Another problem with the legal approach lies in where most attention is paid. This is usually the 'sharp end', engineers, pilots and controllers whose actions are closest to the event. The evidence is strongest here, easiest to link unequivocally to specific individuals, while higher up in the organisation it becomes increasingly difficult to prosecute successfully (c.f. all the recent cases in the UK after the Hatfield rail disaster). Do we go for a successful prosecution of those who are often victims of a poorly managed system, or attempt to identify those higher up who allow poor conditions to be maintained?

6.6 Criminalisation may be arbitrary

There is a major problem with the investigation of accidents and major incidents, which is that the very existence of the possibility for criminal proceedings means that the police and prosecutors may feel that they have a duty to intervene and investigate. A major problem arises when there is an accident or a major incident, which is that there is (perceived) public pressure to react. Politicians must be seen to represent the

interests of the community and may easily fall into the Politician's Syllogism (from *Yes Minister* - BBC)

- We must do something
- This is something
- Therefore, we must do this

The media, at the same time, not only respond to, but also create, public interest that can only increase the pressure that can lead to the prosecutor feeling that they have a duty to become involved. If, after all, the investigation is hidden away in an investigation agency with immunity, there may appear to be a significant lack of transparency. So, we are left with an almost inevitable push toward some form of legal action. But it is a good idea to ask what purpose this may serve if prosecution were to be successful and what distinguishes an actual accident from an unknown incident.

The classic view of punishment by law is that it can serve one or more of three purposes

- Deterrence
- Reform
- Retribution

Of these professionals are unlikely to be made to be more careful, either in advance (deterrence) of after the event (reform), by the threat of prosecution. In fact I argue this threat may even be counter-productive. The only cases where deterrence might be effective are just those that we can already identify as falling on the wrong side of the line. This leaves retribution as the goal and it is good to stand still and ask if this is what society wants in the case of an accident, let alone a non-consequential incident, when the knowledge we now possess about accident causation suggests that many parties have to play their role for an accident to happen.

The problem with demands for retribution may lie more with the politicians and the media than in the real victims. Experience in the medical world shows that an early admission of fault and humility usually satisfy people. People do seem to accept that medicine, and aviation, are inherently hazardous and can go wrong from time to time, they sue when people who should know better start to deny and cover up. If this is the reality in the civil world, why can it not be transferred to the criminal as well? As de Roos (2001)has pointed out, the criminal law should be the court of last resort, not a first choice for the management of risks.

6.7 Investigations may be amateur

One driving force for a prosecutor can be the desire to have matters of public interest exposed in the public arena, rather than being decided behind a smokescreen. But there is a problem with the technical competence of prosecutors and police. The public interest is therefore best served if *relevant* information is freely available but, as per 2003/42/EC Art 8.2, this should not contain names and addresses. In fact information should be scrupulously de-identified[5]. The IVW, currently nominated as

[5] We should not forget the Skyguide controller murdered by a victim's relative after the Uberlingen accident.

the body to manage the reporting system, is also not competent unless they have access to a clearly defined set of guidelines about what is to be submitted to the OM. The OVV appears to have an ideal role to play in being able to understand both the technical and the human factors issues that will arise as well as being able to act as a source of public education.

The fact is that in such technical accidents or major incidents as happen in aviation or medicine, there will be a professionally competent organisation (The OVV in this case) that has a statutory role but is in competition with the Public Prosecutor who may find that there is a suspicion of a criminal act (leaving terrorism aside – even here the question is, how would the police know if it was without having sufficient technical competence?). It seems essential that the most competent investigators should have first access. The problem is that this would lead to decisions about whether to report possible criminal acts to the investigating authority, which would only be interested if there was an independent reason for them to proceed. This is not a problem when there is no obvious publicly known incident, which is what will happen with most reports. What might be preferable is for the OM, upon learning of an incident, to submit a formal request to the investigating body. The response to such a request could be considered under the provision that, like an accident report, such evidence cannot itself be used as evidence for prosecution. The question becomes, what should the OVV do when they identify behaviours as falling with the unacceptable and therefore open to potential prosecution. The current law on the OVV appears to explicitly forbid any reporting at all.

Another issue that arises is that information that is reported to the Minister (i.e. the IVW) may also be retained by the organisation for their own safety purposes and there is a fear, highlighted by the VACS, that this information would fall outside any immunity. Perhaps here we will need to 'ring-fence' such information. The Danish approach appears to offer immunity once the information has been registered

6.8 Why not accidents as well? Joined up law-making

One possibility is that we allow prosecution only in the case of actual accidents. In such cases the information has, as it were, become obviously available by a route other than the reporting system. But there are other conditions and actions that all agree should not be exempted, such as substance abuse, even if they do not lead to an accident. Given that the difference between an accident and an incident is all too often chance, why do we make exceptions for accidents? While this issue is outside the scope of the original remit, it should be considered in order to have what can be referred to as 'joined up' legislation.

6.9 Summary

Aviation incidents need to be reported, because the value of the information acquired is considerable. The problem is that what is reported will probably only be reported because some danger to the aviation system has arisen, prima facie grounds for the application of Article 5.3. The critical behaviours that should be reported, because of the information they represent, are characterised as certain forms of human error, including many violations. It is also the case that there are a small number of behaviours that can be agreed by the aviation sector to be unacceptable. Many other

behaviours may appear unacceptable, but there is a significant effect of hindsight bias and attribution error and that can increase the belief that activities are deserving of attention. In this context there is an increasing tendency to criminalize aviation incidents as well as accidents and, in order to ensure that reporting actually takes place, some degree of immunity will be necessary. Because of the highly technical nature of modern aviation there may be doubts about the level of technical competence of some investigation agencies and this will also impact on the body analysing the report data.

7.0 Proposals

1. Adopt the Danish approach to reporting and immunity and lobby for European harmonisation. This means that a degree of immunity should be offered with only a small number of clear-cut exceptions to be defined as below.

2. Create a separate body, either staffed with technically competent individuals, including human factors specialists, similar to the ASRS. This could be a specialist department within the OVV.

3. Create a panel consisting of both legal and aviation experts from the sector to draw up a set of explicit guidelines for unacceptable behaviours in the aviation industry, to be adapted where appropriate as experience develops.

4. Develop clear guidelines for the division of technical capability between OM, IVW and the OVV in the case of suspected criminal activity (including terrorism). As there are no explicit constraints on this in ICAO Annex 13 or EU 2003/42/EC this should not be a problem.

5. Extend the role of the Onderzoeksraad voor Veiligheid in public information about incidents and accidents.

Annex Human error

A 1 Slips and Lapses

Slips are actions that are not as intended, such as taking the wrong turning early off a highway, while lapses are failures to act, forgetting to do something intended, such as missing a highway exit. Making photocopies provides many examples of such errors. People make slips when they put the paper in the wrong way up and get perfectly white copies of the back of the paper. People make lapses when they forget to take out the last original sheet, with non-automatic photocopiers, and depart satisfied that the last copy has been made, but having left the last page of the manuscript behind.

Slips and lapses happen when people exercise highly practiced skills in an environment that invites such errors while their attention is directed elsewhere. Most slips are benign, if embarrassing. For instance, pilots starting the starboard engine of a Boeing 757 or 767 are sometimes found to be turning the forward cabin No Smoking sign on and off instead of starting the engine. The reason is that one pilot is looking *down* at two engine instruments (engine exhaust gas temperature EGT and engine RPM) to see if the engine is starting, while the other is simultaneously turning the start switch located *up* on the overhead panel (See picture). The motion is exactly like starting a car, the switch is turned and held in until there is an indication that the start has succeeded and the engine will continue to run. If there is no indication of success (in a car or the aircraft), then the person inevitably returns the switch and turns it again. The overhead panel of the Boeing 757/767 has pairs of identical switches in the

sequence – Port and Starboard Engine Start (labelled 12) –No Smoking and Seat Belt switches (labelled 16). If the pilot has made a slip, and grasped the No Smoking switch, the passengers can see the sign flicking on and off, while the pilot grapples with the problem that the engine will not fire up. The solution, often implemented by pilots or company engineers, is to create a tactile distinction by filing out a notch or adding dots of hard paint to one of the switches. Pilots then expect to feel such a marker, as part of their skilled automatic sequence of actions, and react immediately, by moving to the correct switch.

Crucial to slips and lapses are the existence of sequences of habitual practiced actions, design that encourages or invites specific types of action, and the lack of attention. The lack of sufficient attention does not necessarily mean that attention has wandered, but rather that due attention is being paid elsewhere. In the case of the Boeing start procedure, attention is directed to the engine RPM and EGT instruments, while the manual sequence of grasping the switch and turning it is very automatic[6]. It is in the nature of attention that it is restricted to the point of focus; it is in the nature of highly skilled activity that attention no longer need be paid to performance of skilled actions. Learning to change gears in a car initially demands considerable attention, but as the skill is acquired attention can be directed back to the road where it belongs. One reason for failure to devote attention is therefore *over*-attention to other issues, while relying on skilled behaviour to proceed automatically and not hold up proceedings. Another common example of a slip is when people pull on doors to open them even when they say 'Push', because the shape of the door handle invites pulling. A plate, without a handle, on the door invites the only possible behaviour, pushing; no instructions are necessary in this case.

Lapses are harder to control because nothing has happened, but exactly the same principles apply; the importance of habitual behaviour, design that invites specific actions and attentional problems. Items are left out of sequences, most often when actions have to be repeated in the middle of the sequence or when a final action is distinct from the rest (the photocopy problem described above).

Slips and lapses are characterized, amongst other features, by sensitivity to information indicating that one has erred. The solution to the Boeing start problem, a small notch or blob of paint on the switch, is perfectly sufficient to provide information that a slip is in progress when the person involved feels (or fails to feel) the expected tactile feedback. The problem, interestingly, is at least in part due to the manufacturer's desire to have common design standards, leading to identical switches. In itself a reasonable wish, there are nevertheless unintended consequences of such decisions that may take an accident before they are recognised. The human factors amateur, looking at a row of identical switches on a control panel, might experience a feeling of aesthetic pleasure at a neat design. The human factors professional, in contrast, sees the potential for confusion, the requirement for careful labelling and the possibility of numerous errors caused by the designers and carried out by the operators. These are typical examples of how problematical situations, called latent conditions, introduced by designers and manufacturers, propagate through to the

[6] It is physically impossible for human beings to look down at the instruments and up at the switch at the same time. The pilot moving the switch usually also looks at the instruments.

front-line operators. It is the front line operators (pilots, air traffic controllers, train drivers etc) upon whom people rely to make up for the errors of those who came before, by not making active errors. Yet the way latent conditions have their effect is all too often to make active errors more likely. Superficial investigation places the blame for failure on the front-line operator, a more considered analysis shifts the onus to those who, having created situations that make slips and lapses more likely, then also fail to review and see if there were problems caused by their designs and procedures.

The Aircraft Start Switch Problem

- Company standardizes on a minimal set of components (e.g. Flight Deck Switches)
- The design means that the start switches and the engine instruments can not be seen at the same time
- There is no established procedure for checking human factors problems in usage
- Pilots are always busy during engine start-up
- A pilot during start-up may have to respond to a request from ATC, drawing attention away from the current task

The process whereby slips and lapses occur can be seen by understanding skilled behaviour in terms of 'mental programs'. These are sequences of specific actions that are triggered and run automatically to their conclusion. Part of such a sequence would usually include specific information that should be checked to ensure that the program is running properly. Such checks require attention, briefly, to be diverted from other activities and, because they are usually passed successfully, can be missed. Building in an expectancy for a specific 'feel' on the engine start switch makes use of such a process. While a sequence is running[7] there is a natural internal 'inertia' that ensures that the sequence is taken to its conclusion so that the intention is satisfied without excessive demand on restricted attentional resources.

Nevertheless, people making slips are sensitive to counter-evidence and ready to stop what they are doing or recover from lapses. The intention is clear and the actions not as planned, so people are fully capable of realising that they have made an error once they have received information that all is not as expected. In most cases slips and lapses are benign when there are sufficient defences built around the system. One exception, with slips, is in surgery, when a slip with a scalpel may be disastrous and the only defence is the skill of the surgeon; there are no 'hard' barriers between a scalpel and a coronary artery. Where slips and lapses have disastrous consequences, one is forced to ask how the design or accepted procedures were allowed to be so sensitive to minor aberrations by individuals. In surgeons this is recognised, and training is long and thorough, but even there as many safeguards are put in place by the profession to ensure that a single slip does not mean a life.

[7] There can be more sequences running at the same time. This is why humans are so good at being able to do many things at the same time, such as driving a car and taking part in a conversation, or controlling two flows of aircraft, one landing, one taking off.

A.2 Mistakes

Mistakes, in contrast to slips and lapses, represent a failure to understand the world correctly and are characterized by not recognizing information indicating that a mistake is being made. Because a problem is understood in a specific, and incorrect, way, an inappropriate plan of action is selected. Mistakes come in two general types: a) Rule-based mistakes, when people follow a procedure that is usually correct but inappropriate in the circumstances, and b) Knowledge-based mistakes when they attempt, unsuccessfully, to solve a problem for the first time.

Rule-based mistakes involve selecting the wrong procedure, or plan of action, under the circumstances. The plans are generally standard solutions for well recognised problems. The pairing of a problem and an associated solution is called a rule, from the computer science models that underlie this understanding of mistaken behaviour. Rule-based behaviour applies when problems are known and solutions are trained for (the mistake involves incorrect selection). A knowledge-based mistake occurs when someone has to solve a problem from first principles, without previous experience.

While people are exceptionally good at solving problems when given enough time, as with the luxury of hindsight, they are also very likely to make a mistake when time is insufficient, as the diagnosis process is constrained by the need to find a solution. Mistakes also happen when people have insufficient information, either from outside or from their own experience, or apply inadequate reasoning processes. They do not possess all the facts, and may not know that they are in ignorance One solution to mistakes lies in training people, so that they possess sufficient information to solve their problems and so that they do not use restricted thinking processes that mean they arrive at incorrect solutions. The other solution requires ensuring that people have enough time and can practice finding solutions out of the line of fire.

Once someone has found the solution to their problem they generate a plan of action and proceed to execute that plan. The mistake therefore is either:

a) Making an incorrect diagnosis, followed by a plan that is appropriate for the diagnosis but not for the real state of affairs, or
b) Selecting an incorrect plan for a problem that has been diagnosed correctly

In all cases people move through the phases and, having decided what the problem is, stop worrying about the diagnosis and get on with the problem of implementing a solution[8]. This makes what happens when a mistake is being made quite different from what happens when a slip or even a lapse is occurring. People are remarkably resistant to counter-information about the diagnosis once the plan is being executed and will carry on even in the face of considerable evidence that a mistake has been made. Military history is replete with examples of mistaken commanders who sacrificed their men for their mistaken understanding of the situation. One particular example, relevant here, is what happens when people drive the wrong way on

[8] The requirement to make up one's mind and act on it is common to many professions. To remain open to doubts and to fail to make one's mind up and take action forms sufficient grounds to reject someone as a candidate for becoming an air traffic controller or a judge.

motorways (spookrijden). This is based on an analysis carried out by one of my students (de Niet, 2001) and is described in more detail below.

A.3 Violations

The one type of human error that can be described as involving deliberate behaviour is the violation or non-compliance error. This is often seen as reckless, but our studies of rule-breaking in industrial environments (Hudson et al, 1997) suggest that people bend the rules in order to get the job done rather than for kicks or out of malicious intent. More often than not the rules and procedures are in need of improvement and this creates an environment in which rule bending is acceptable. While road traffic is an area where people clearly break the rules for their own convenience, putting others at risk, the industrial setting, including the Air Traffic Control tower, is one where the over-arching goals of the organisation determine more how people will act. If the rules and procedures get in the way of achieving those higher goals, people will often bend or break the rules to get the job done.

Experience with the management of rule-breaking (Shell, 2001) in the international industrial environment shows that many failures to follow the rules are due to factors outside the immediate control of those in non-compliance. They require management action to detect and remedy problems such as irrelevant or inaccurate procedures, failures to inform or train on procedures and guidelines and the existence of rules and procedures that are too difficult to understand and, even, written only in languages those who are expected to use them can not be expected to understand adequately. Even rule-breaking is seen as best managed in a way that equates such non-compliances with mistakes rather than with deliberate and wilful failures to comply. In the latter situations, and only then, disciplinary measures are deemed necessary, with the willing support of the majority of the workforce. Even in such situations, however, the question must always be considered: Why was this individual tolerated for so long?

A.4 Driving the wrong way - Spookrijden

People who drive the wrong way on highways are usually regarded as being in violation of the traffic rules. This is certainly true of those who are found driving carefully on the hard shoulder in the wrong direction, probably because they have missed their intended exit (a lapse) and are recovering illegally in order to avoid a long trip back. But what of those drivers, usually middle-aged, who are found to have been driving on the innermost lane, the fast lane, in the opposite direction? The police investigation concentrates upon the location of the almost inevitable collision with another vehicle, but all we see is that two vehicles collided with a considerable combined speed. Analysis was based upon the notion that, rather than being in deliberate violation, such drivers were driving in the mistaken belief that they were driving on the correct side of the road, and in the slow lane as well. The evidence for this was found by looking at the junctions where numbers of such incidents occurred. The paint work on the road was more worn and the majority (statistically significant) of drivers came from the direction that meant they had to turn left, over the carriageway of the main road, to enter the second motorway entrance road. It appeared that, in doing so, a small proportion made a slip and selected the *first* rather

than the second part of the road – in this case the motorway exit lane. With worn road markings, after sunset and with no other traffic on the road, all that remains is the No Entry board, with the addition of the *ga terug* sign added. Furthermore the exit ramp, especially when coming from the left, is visually much more compelling than the entrance road, sometimes the latter is even invisible because of barriers and uncut vegetation. The regulations stipulate that one sign should be placed on the outside part of the road, but all too often two boards have been placed, one on the side and one in the middle. A driver looking straight ahead, possibly wondering if they are on the correct road, will see the central No Entry board and should stop at that point.

Picture 1. The bridge over the A4 at Schiphol, travelling East. Photograph taken April 2001. People must ignore *both* No Entry signs but obey the 70 kmh limit..

The problem now is that these drivers at risk, like all Dutch drivers who venture onto motorways, will be used to seeing a No Entry board in the middle of a motorway entrance; in fact it forms a confirmation that the problem has been solved and now action can be implemented, so the accelerator is pushed in and disaster becomes inevitable. Picture 1 shows the situation at Schiphol taken from a car travelling in the correct direction. Dutch drivers all know to drive through this piece of misinformation, although foreigners who have just flown in and hired a car have been known to be thrown into considerable doubt and may even stop!

This example allows us to understand how people, once caught up in a mistake, can reject information that is intended to save their lives because it is not sufficiently inconsistent with what they understand. Whereas with slips and lapses quite small amounts of inconsistent information are sufficient to induce someone to stop and repair their actions, with mistakes people are more likely to blame the outside world "See, this entrance is really badly built. Look, they have even put the Go Back sign in the wrong place!"

The Spookrijder problem

- Highway entrances and exits are designed like ordinary roads
- Regulations require single No Entry boards, but forbid extra markings on the road
- Officials believe two No Entry boards will be safer
- The road markings on the road joining the highway entrance are worn
- It is dark and there are no other cars to follow
- The driver is not familiar with the specific entrance

While the natural attitude of an outsider is to see the driver as deliberately and recklessly ignoring traffic signs, this analysis suggests that poor road markings and the over-enthusiastic use of signs turn an initially innocuous slip into a lethal mistake. The drivers, far from wanting to drive on the wrong side of the road, are misled by the environment into doing just what they wanted to avoid.

References

Andlauer, E., Chenevier, E., G. Gaudiere, G., F. Girard, F. & Hudson, P.T.W. (1999) Analysis of the Air Traffic Management Certification Problem. Work Package Report 3 ARIBA Program, EU DGVII. pp 51

De Niet, M. (2000) Van de verkeerde kant. Masters Thesis, Department of Psychology, Leiden University.

De Roos, (2001) Strafrecht als risicomangement. In E.R. Muller & C.J.J.M. Stolker (Eds.) *Ramp en Recht: Beswchouwingen over rampen, verantwoordelijkheid en aansprakelijkheid.* Boom Juridische Uitgevers: Den Haag. Pp 221-234

Fischhoff, B. (1975) Hindsight = foresight: The effect of outcome knowledge on judgement under uncertainty. *Journal of Experimental Psychology: Human Perception and Performance*, **1**, 288-299.

Furnham, A. (2004) Management and Myths: Challenging business fads, fallacies and fashions. Palgrave MacMillan: New York NY

Hudson, P.T.W. (1991) *Prevention of Accidents involving Hazardous Substances: The Role of the Human Factor in Plant Operation.* OECD Environment Monograph nr 41, OECD Paris

Hudson, P.T.W., Reason, J.T., Wagenaar, W.A., Bentley. P.D., Primrose, M & Visser, J.P. (1994) Tripod Delta: Proactive Approach to Enhanced Safety. *Journal of Petroleum Technology*, **46**,58-62.

Hudson, P.T.W. (2000) Bending the rules in the air. In R. Jensen, B. Cox, J. Callister, and R. Lavis(Eds.) Proceedings of the Tenth International Symposium on Aviation Psychology. International Journal of Aviation Psychology. [CD-ROM] 6 pp.

Hudson, P.T.W. (2001) They didn't see it coming: Hindsight and foresight on the road to disaster. In E.R. Muller & C.J.J.M. Stolker (Eds*.) Ramp en Recht: Beswchouwingen over rampen, verantwoordelijkheid en aansprakelijkheid.* Boom Juridische Uitgevers: Den Haag. Pp 91-102

Hudson, P.T.W. (2001) Corporate manslaughter: Bringing corporations to account. In E.R. Muller & C.J.J.M. Stolker (Eds.) *Ramp en Recht: Beswchouwingen over rampen, verantwoordelijkheid en aansprakelijkheid.* Boom Juridische Uitgevers: Den Haag. Pp 235-246.

IFATCA Churchill, D. (2003) Just culture in aviation safety management. *The Controllers Magazine* September 2003.

O'Leary, M. (1996) New developments in the British Airways confidential human factors reporting system. In B.J.Hayward and A.R.Lowe (Eds.) *Applied Aviation Psychology - Achievement, Change and Challenge.* Avebury: Aldershot, UK.

Perrow, C. (1984) Normal Accidents: Living with high risk technologies. Basic Books: New York NY

Reason, J.T. (1990) *Human error*. Cambridge University Press: Cambridge UK.

Reason, J.T. (1997) *Managing the risks of organisational accidents.* Ashgate: Aldershot UK.

Reason, J.T. & Hobbs, A. (2003) *Managing maintenance error: A practical guide.* Ashgate: Aldershot UK.

Trommelen, M. (1990) Incident and Accident Analyses at a chemical plant. Masters Thesis, Department of Psychology, Leiden University.

Wagenaar, W.A., Hudson, P.T.W. & Reason, J.T. (1990) Cognitive Failures and Accidents. *Applied Cognitive Psychology*, **4,** 273-294

Wagenaar, W.A., Groeneweg, J., Hudson, P.T.W. & Reason, J.T. (1994) Promoting Safety in the Oil Industry. *Ergonomics*, **37**, 1999-2013