The Australian and New Zealand Societies of Air Safety Investigators
1999 Australasian Regional Air Safety Seminar

Shaken but not stirring? - The 'need to know' basis of aviation safety.

Dr. Graham Braithwaite
Senior Research Associate
Department of Aviation, University of New South Wales, Sydney NSW 2052

Abstract

Aviation has amassed a wealth of knowledge in the field of safety and accident prevention. Much of this has been the result of painful experience and detailed investigation. However, these efforts are wasted if this knowledge is not communicated accurately and to the right people.

Whilst the frontiers of aviation safety may appear to be constantly moving forwards, there is a critical need to ensure that lessons already learned are not forgotten or lost. Indeed, at present, aviation folklore suggests there are no new accidents, only variations upon recurring themes.

This paper examines lessons learned in aviation and other industries and how that information is, or is not being communicated to those who need to know. The importance of knowledge as well as skills, especially in the areas of safety, human factors and CRM is discussed in the context of training within a large Australian carrier. Consideration is also given to the role of tertiary education and research in communicating safety critical information in Australia.

Get the Facts Straight

The aim of aircraft accident and investigation is to prevent future recurrence of either similar events or those that exhibit any similar characteristics.

Whilst determining the facts, drawing conclusions and producing recommendations are the main responsibilities of the investigator, the need to pass on relevant information to the right people is perhaps one of the key areas for improvement in the future. Aviation folklore suggests that there are no new accidents, only variations on a recurring theme. Similar causes are to be found in many accidents, not least at the organisational and individual levels.

Academic research is expected to conform to the rules of academic rigour. Data must be demonstrated to have been collected in an unbiased way and to be statistically significant. Conclusions should be drawn on data, and not on personal opinion or supposition. The same may be said of accident investigation. Lewis (1989) clearly stated in the title of his presentation to ISASI that "the investigator does not theorise or analyse until the fact finding process is complete." In other words, without a significant data set, it is inadvisable to conduct an analysis or draw conclusions. Such a move may introduce confirmation bias or lead investigators to an early, but incorrect conclusion. Indeed, as this is the investigative technique apparently used by much of the media, it is small wonder that the 'causes' published so soon after a crash are so often wrong.

The ISASI Code of Conduct (1983) states that in maintaining the highest standards of objectivity, each member shall:

3.1 Ensure that all items presented as facts reflect honest perceptions or physical evidence that have been checked in so far as practicable for accuracy.

3.6 Avoid speculation except in the sense of presenting a hypothesis for testing during the fact-finding and analysis process.

The accurate determination of facts at the investigation stage is of critical importance, as inaccuracies will be inherited by the entire accident prevention process. The concept of 'garbage in, garbage out' covers not just the accuracy of data, but also its completeness. An incomplete set of facts may not disprove a hypothesis, but it may allow a false conclusion to be drawn. A historical view of accident investigation may give the impression that organisational failures have only recently developed as contributory factors. What is closer to the truth is that investigation has only relatively recently started to explore this area.

Tell the Right People

Having stated these concerns, however, it should be noted that the quality of investigations is generally high, particularly in more developed countries such as Australia and New Zealand. The greatest scope for improvement seems to be in the transfer of knowledge from investigator to trainer and from trainer to student. (Note: Student in this context represents all those in a learning situation from Chief Pilot to undergraduate.) In its macro sense, the systemic problem is one that Crew Resource Management (CRM) attempts to fix at the micro level: that of the right information needing to be supplied to the right people at the right time. There must surely be nothing more disappointing for investigators than to see the same type of accidents over and again.

The availability of free Bureau of Air Safety Investigation (BASI) reports, both in hard copy and now electronically is an excellent way to disseminate information, as are the articles published in magazines such as *Asia-Pacific Air Safety* and CASA's *Aiming Higher*. However, the written word is rarely enough to get the message across by itself.

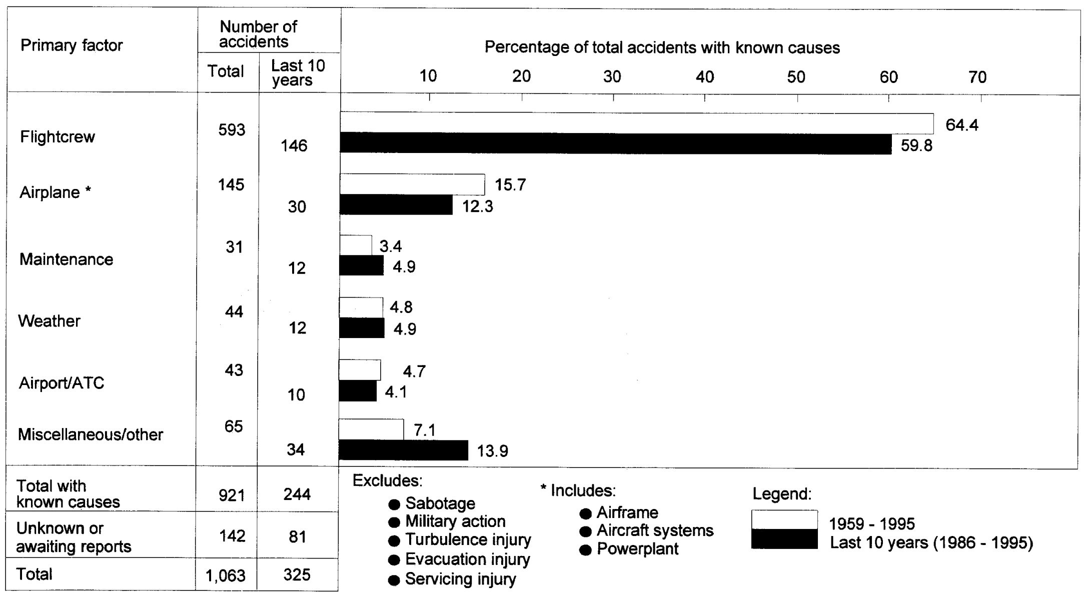
Operators have the opportunity of various forms of training to get the safety message across, ranging from *ab initio* or apprenticeship training to recurrent training in areas such as Emergency Procedures or Crew Resource Management. The industry also has an ever-growing opportunity to educate through the tertiary education system where aviation-specific degrees now exist at both the undergraduate and postgraduate levels. Information must be communicated to the right people at the right level and that is a responsibility that is shared by all of us, whether we consider ourselves educators or not.

Keep the Facts Straight

Irrespective of the level or method of training, there is a critical need to ensure the integrity of information. This is not the message of an academic trying to emphasise the importance of his profession, but rather that of a safety professional, concerned that inaccurate or distorted information can have a negative effect. Remember that “people respond to the hazards they perceive.”(Slovic, Fischhoff and Lichtenstein, 1980). Consequently if these “…perceptions are faulty, efforts at public and environmental protection are likely to be misdirected.” In other words, given the wrong script, even the finest actor will act out the wrong play.

A classic example is the continuing confusion regarding the contribution of 'pilot error' and 'human error' to aircraft accidents. Boeing has produced a set of accident statistics for a number of years entitled "Statistical Summary of Commercial Jet Aircraft Accidents". Amongst the statistics is a diagram of 'Primary Cause Factors' for the Worldwide Commercial Jet Fleet since 1959. It is a diagram that has been repeatedly used, not least in the furtherance of Crew Resource Management (CRM) and human factors training.

Primary Cause Factors – All Accidents
Worldwide Commercial Jet Fleet



Source: Boeing, 1996

However, the Boeing graph appears to have presented the aviation community with a set of statistics that are quoted all too frequently and with subtle changes in detail. The tendency is to talk interchangeably in terms of 'pilot error' or 'human error' ignoring the difference between the two, or the significance of 'primary cause factors'. Examples of the confusion appear in even the finest texts. Beaty (1996), for example, observed that "For the last twenty-five years, about 70 per cent of aircraft accidents have been attributed to pilot or human error". Are Air Traffic Controllers, Meteorologists or Engineers not human too?

A recent posting on the CRM Developers E-mail discussion group asked:

> *The most common statistic used to describe the degree to which human error contributes to or is responsible for airline accidents is 70%. Can anyone tell me from where this statistic originates and possibly what articles, websites, or books it can be found?*
>
> *Additionally, the figure of 75% has been cited by other organizations such as SimuFlight in their Crew Resource Management Course Outline. Who is correct?*
>
> *70 or 75% is not so much the issue, I am mostly interested in finding a credible source in order to quote this statistic in a paper.*

One reply suggested:

> *Just to add to your range of figures: Per GAO Report (GAO/RCED-96-151), "Human Factors: Status of Efforts to Integrate Research on Human Factors Into FAA's Activities," human error contributed to 80% of the fatal aviation crashes, according to FAA officials." I do believe the document would be considered a credible source.*

Another stated:

> *For lovers of statistics, go to the Boeing web site.*
>
> *Here you will find "Statistical Summary of Commercial Jet Airplane Accidents - Worldwide Operations 1959 - 1997".*
>
> *Flight Crew get 70% here.*

The differences may seem minor, or even unimportant to some, but they have the potential to be very misleading. In the first posting, the author refers to *human error* in the context of *contributes to…* or *is responsible for…* Human error is arguably present in 100% of aviation accidents (Braithwaite, Faulkner and Caves, 1997), but may not be the primary cause (where investigative authorities still publish one). Pilot error is not the same as human error, it is merely a subset of it.

The danger is in bastardising statistics to the point of changing their meaning or misleading the reader. If human error in aircraft accidents is perceived to be exclusively the domain of pilots then how easy is it going to be for those involved in, say Air Traffic Control (ATC) or Engineering (E & M) to introduce training in these areas. When the statistics are broken down, it is human error that is the overwhelming primary cause ATC and E & M classified accidents.

It is not just misinformation, but also a lack of information that is a problem in incident / accident prevention.

If the Facts Aren't There, Get Them

Whilst the science of aviation safety has made amazing advances, there is still a great deal that remains unknown. Investigation and research have enormous roles to play both now and in the future, but the processes remain imperfect. Research, training and funding efforts are often based on anecdotal evidence, media coverage and public perceptions. Whilst these factors are important, they can often be inaccurate, or at least based on unscientific data. Without hard facts, decision makers cannot be expected to get things right.

The role of academia in aviation safety research, particularly within Australia is a good example of potential that is yet to be realised. Many Universities now offer academic programs for both undergraduate and postgraduate students, but high-level research is struggling to establish itself as a resource. Part of the problems is in establishing streams of funding to attract high-calibre researchers whilst the aviation industry seems nervous to take chances on relatively new resource.

Large research grants are available from the Australian Research Council (ARC), which provide funding for three years. This would provide funding for skilled postgraduate or postdoctoral researchers, which may be employed from around the world. However, such grants are highly competitive with a success rate for funding of around 18%. Researchers who apply for the grants must be able to demonstrate a strong track record in their field, which includes publishing in 'rated' journals. The irony being that presenting a paper on air safety at a forum such as the A/NZSASI Regional Seminar is worth zero in research track record, but writing for a journal such as the International Journal of Aviation Psychology (IJAP) is worth a great deal. How many people here read IJAP or use its contents in your training?

Applications for Large ARC Grants must be submitted in February and funding is announced in November after a refereeing process. The money becomes available the following January for up to three years. Large ARC grants may only be applied for once a year and a researcher may apply for a maximum of two grants.

In acknowledging the low success rate for applications, the Government are encouraging researchers to apply for Collaborative Grants offered through its SPIRT Scheme. Basically, a research institution teams up with industry for a three-year project where the Government pays half of the cost and the industry partner pays the other half. Some of the industry's contribution may be 'in kind', but this depends on the nature of the contribution and the perceived ability of the collaborator to pay. In some cases, partners may be able to apply for a tax rebate on their contribution of up to 125%. Once again, the application process takes just short of a year, although the success rate is much higher.

However, whilst collaborative grants can effectively pay for world-class researchers, at relatively little cost to the industry, aviation does not appear to have grasped the opportunity. The budgeting implications of committing four years ahead in an industry as dynamic as aviation are a large factor, as are attitudes towards ' pure research' over consulting.

Attitudes within academia are also a problem. In reviewing a large (non-collaborative) grant application, a non-aviation panel will look at possible uses for the work in industry. If a project is seen to benefit the large carriers, (where most of the fare-paying passengers are) there is a distinct likelihood that they will think "This is of use to Ansett and Qantas and they make millions of dollars. They should be paying for this." The application will probably be culled forthwith!

Certain catastrophic accidents or incidents have changed the face of aviation safety research and development, sometimes in ways that may be contrary to risk management principles. This may be the consequence of technological advancements, or the all-important, customer or political perceptions.

Research into cabin evacuations, conducted under Prof. Helen Muir at Cranfield University, UK is an interesting example. This research followed the 1985 B-737 fire at Manchester in which 55 souls perished. The output from this project has been first-class and of value world-wide. However, such work is centred upon a relatively rare occurrence, i.e. a cabin fire where the aircraft fuselage has not been disrupted. A number of high profile accidents have occurred in recent years involving fire, but many also involve severe damage to the fuselage. Examples include:

• UAL	DC-10	Sioux City	1989
• British Midland	B-737	Kegworth	1989
• Air Ontario	F-28	Dryden	1989
• Martinair	DC-10	Faro	1992
• KLM Cityhopper	Saab 340	Schipol	1994
• China Airlines	A-300	Nagoya	1994
• Garuda	DC-10	Fukuoka	1996
• American	MD-80	Little Rock	1999

From a pure risk-management perspective, research should also consider evacuation from disrupted fuselages where it is known that doors are often inoperative, and passengers tend to escape through breaks in the cabin. Indeed, some may suggest that a greater focus on primary safety (i.e. preventing accidents) is more beneficial than focusing on secondary safety measures (i.e. what happens once things have gone wrong). Muir's work is excellent, but ideally should be widened in its focus. The crucial question is whether the funding bodies can recognise this.

In Australia, the best opportunities may lie in applying for funding to look at 'high profile' problems, not necessarily just those with the greatest safety potential.

For example, in-flight violence appears to be on the increase, based on reported incidents and media coverage. However, whilst there are a number of programs in place to train cabin crew in how to deal with such incidents, there is little in the way of research into the factors which contribute to disturbances. A primary safety strategy of prevention is surely preferable to a secondary safety strategy of response, even if the most credible solution is likely to be a mixture of the two. Many of the contributory factors seem obvious (e.g. alcohol or drug use, increased sector length, fear of flying), but without sound data, can we be sure of the nature or frequency of the problem?

The Universities of New South Wales, Calgary and Curtin have collaboratively submitted a large research grant application to conduct work in this important area with the assistance of the Asia Pacific Cabin Safety Working Group of ISASI. Hopefully this will capture the imagination of the research council and be of use to the industry too!

Don't Forget What You Already Know

Most of us would like to believe that advances in aviation safety are evolutionary. As our understanding of accidents and incidents grows, so our ability to mitigate hazards will increase. Unfortunately, the reality is often disappointingly different.

As new lessons are learned, the temptation is to move on from the existing knowledge rather than building upon it. Innovations risk becoming fashions, leaving older, unfashionable basics behind. However, this can leave new entrants to the industry without critical knowledge. For example, it may be important to recognise that CRM has evolved into its 'fifth generation' (Helmreich, Merritt and Wilhelm, in press) where error management is the name of the game. Indeed, there is little point in an operator starting a modern CRM program at generation one, but there is also a need to remember why CRM came about and why it is needed within the industry.

The mere mention of the name 'James Reason' or 'The Reason Model' appears to solicit a collective groan from a number of areas, particularly at safety or human factors gatherings in Australia. Occasionally, threats of bodily harm accompany any attempt to raise the subject of the ‘Swiss-Cheese’ model, but is this a fair situation? Certainly Reason’s work has received a great deal of coverage, but has it reached the end of its natural life? The now famous model owes part of its popularity to its simplicity and ease of application in investigation. It provides an excellent methodology for studying the multiple failures that result in accidents or incidents, and allows all levels to understand their contribution to system safety. But is the model being used to its full potential, or are the right people getting to know about it? It was only last year that a certain large Australasian carrier started to use it on its CRM course, with considerable success. Far from being passe, the model is only just starting to get to some of its most important audiences including the coal face!

Beware - You Can't Know It All

Systems complexity is an increasing challenge for aviation safety, not least as airlines grow in size and consolidate into super-carriers or global alliances. A very real danger exists where operating systems become so complex that one area of the operation does not know what effect it is having upon another. There are numerous examples of where this could compromise safety.

A current Notice of Proposed Rule Making (NPRM 9809RP) proposes the ratio of flight attendants to passengers on RPT aircraft in Australia be changed from 1:36 to 1:50. This would allow aircraft as large as the Canadair Regional Jet, soon to be introduced within Australia, to legally operate with a single flight attendant. This would put Australia in line with Canada, which currently allows this type of operation under special dispensation. The effect this would have on crew workload, or the ability of flight attendants to deal with issues like disruptive passengers has been the source of considerable debate. However, other proposed changes to the system have the potential for a compound effect. The Smith report (1998) advocates major reductions in Airport Rescue and Firefighting (ARFF) cover in Australia. One of the report's main assertions is that ARFF are not effective in altering the outcome of accidents and the survival of passengers depends largely upon the efforts of the Flight Attendants and the passengers themselves. A reduced crew complement in addition to a reduction in ARFF cover would have a compound effect. Add to this the fact that passenger profiles are changing such that evacuations are becoming more difficult and certification standards more dubious. US FAR 25.803 requires "A representative passenger load of persons" which includes "(ii) approximately 5% must be over 60 years of age…" to be used in evacuation demonstrations. However, in research conducted over 519 precautionary evacuations between 1988-1996, Hynes (Air Safety Week, 1998) found that "…nearly 30 percent of passengers involved in precautionary evacuations were over 60 years old." The average age of travellers is increasing in line with population and changing customer demographics and will continue to grow as a problem for evacuations.

Other examples abound where safety margins are reduced at both ends, either because their compound effect is unknown, or because certain people hope they will go unnoticed. As the growth of aviation means that accident rates will have to drop if absolute accident numbers are to remain stable, such moves should be of concern. The proposal to allow TCAS-climbs is another example of where a safety advance or additional filter may be negated by a reduction in separation standards.

Its How You Tell It

One hazard to safety education is the literal interpretation of 'example accidents'. This is where a student is unable to interpret the case study or apply its lessons to other situations or circumstances. This can be the result of inappropriate depiction of the event, poor facilitation, or a lack of base knowledge. High-profile accidents influence not just research emphasis, but also the content of training syllabi. The availability of 'good' video reconstructions risks leaving a distorted view of the prevalence of certain events. Indeed there is a general trend to focus on extreme examples of what went wrong, rather than the, admittedly less exciting, examples of where things went right. (The Ansett BAe 146 video is a noteworthy exception.) Spectacular reconstructions may keep an audience interested, but can also leave a feeling of unreality. Apparently good examples can seem too amazing to be credible, especially for those with limited personal experience. To many, it may seem incredible that an experienced jet crew could turn off the wrong engine in a twin-engined aircraft or that a junior crewmember would apparently rather die than speak up, but the factors behind such accidents are not far-fetched.

Experience with teaching undergraduates demonstrates the danger of using dramatic accidents such as the 1977 Tenerife disaster, which can leave students with a limited ability to apply knowledge. Feelings that 'it could never happen to me' or 'if I was in the same situation, I would have obviously spoken up' are not uncommon and seem to be due to a lack of comparable experience. The use of incidents rather than accidents can be more appropriate as it may be easier for students to see themselves in a similar situation.

A lack of basic knowledge can also mean that the message from case-studies or discussions can be lost. Indeed, this principle applies in daily operations where a lack of technical knowledge can leave individuals with an inability to understand what is wrong, or even realise that anything is wrong at all. The Flight Attendant aboard the Air Ontario F-28 which crashed at Dryden in 1989 who reassured a passenger that snow accumulating on the wings would blow off during the take-off run, is a good example. Unfortunately, she was proven wrong and the aircraft failed to climb due to contaminated wings, with the loss of 23 souls, but there was no real reason why she should have known any different. Flight Attendant training did not go into such technical detail.

Whilst much of training is concerned with influencing behaviour, without basic knowledge, the process is likely to be much more difficult. Imagine explaining the concept of, for example, Ground Proximity Warning Systems (GPWS) to someone who had no idea of the significance of or variables behind Controlled Flight Into Terrain (CFIT).

Those involved in CRM and other types of training have recognised for a number of years, the importance of facilitation over lecturing or instruction. This is not always appropriate, for example in situations where basic technical knowledge is required first. Nevertheless, the secret to applying lessons from accident and incident lies in the facilitation. Students need to be able to understand the lessons in a way that they can apply them to a variety of situations.

It is often not enough to simply present the facts of an accident and expect the reader to understand it or be able to apply it to their own work. The facilitation process must help develop the recognition that *'this could happen to me' or 'what would I really do in similar circumstances?*'

Putting This into Practice

In 1997, Ansett Australia took a bold decision to introduce human factors training into all areas of Operations. (Operations includes flight crew, cabin crew, ramp, E & M and CSO's.) The program, known as Operational Team Skills (OTSP) is aimed at increasing operational efficiency and safety. In attempting to set up the program, a Steering Committee considered the training needs for such a program whilst taking into account the need to evaluate its progress.

"...The Operational Team Skills Program aims to reinforce Ansett Australia's commitment to excellence in Operational Services and Delivery. This will be achieved by ensuring that the best Human Factors practices and research are part of normal operations of Ansett Australia."

In setting up an evaluation system to drive the project, it was considered vital to discover three simple things:

1. What do people know?
2. What do people think?
3. What do people do?

One of the aims of OTSP is to be able to bring different groups from Operations together for joint training. To do this requires compatible knowledge bases. Collecting baseline information regarding knowledge and attitudes was considered essential to this. To measure the effect of OTSP, information regarding knowledge, attitudes and behaviour was considered essential and is to be collected recurrently during the life of the project.

By using in-house skills and the work of agencies such as BASI and Universities, Ansett is making sure that it is using high quality, up-to-date information for its training programs. In recognising the role that all areas of Operations have to play in system safety and by ensuring that training is aimed at all levels from senior management to the line, the information is starting to get to the right people.

Basic Human Factors and safety training for those who have not yet been exposed to them, as a precursor to the joint training, is aimed at ensuring levels of knowledge and skill are compatible. The evaluation component of the program is aimed at keeping track of what people know, think and do. If content needs to be tailored to re-inforce a message, correct misinterpretation or include new research findings, then the recurrent design allows for this.

OTSP does not hold all the answers, but is an exciting attempt to make sure that those who 'need to know' actually do.

Concluding Remarks

Accident investigation must be one of the few professions whose members' ultimate goal is to make themselves redundant. However, until such perfection is reached, the driving aim must be prevention through education. Such a process requires a number of factors to be taken into consideration. Investigators, trainers and educators must take care to ensure the integrity of facts, that they are delivered to the right people and that they are not forgotten by the system.

The Australasian region provides numerous examples of excellence in achieving this, but there is still room for improvement, even if only to guard against complacency. Hopefully everybody will have learned something new at the 1999 seminar. More importantly, we should all hope that we are able to pass on the information to all those who *really* …need to know.

References

Air Safety Week (1998) Evacuation Myth Revealed. Page 3. November 23rd 1998.

Boeing (1996) Statistical Summary of Commercial Jet Aircraft Accidents - Worldwide Commercial Jet Fleet 1959 - 1995. Boeing Commercial Airplane Group, Seattle.

Braithwaite, G. R., Faulkner, J. P. E. and R. E. Caves (1997) Latitude or Attitude? - Airline Safety in Australia. Paper presented at the Risk Engineering Society Conference, Canberra. October 2-3rd.

Helmreich R. L., Merritt, A. C. and J. A. Wilhelm (in press) The Evolution of Crew Resource Management Training in Commercial Aviation. International Journal of Aviation Psychology.

ISASI (1983) Code of Ethics and Conduct. International Society of Air Safety Investigators.

Lewis, K. S. (1989) The Investigator Does Not Theorise or Analyse Until the Fact Finding Process is Complete. ISASI Forum. February 1989. ISASI, Washington.

Slovic, P., Fischhoff, B. and S. Lichtenstein (1980) Facts and Fears: Understanding Perceived Risk. Paper from 'Societal Risk Assessment'. Proceedings of an International Symposium held October 8-9th 1979, GM Research laboratories, Warren, Michigan. Plenum Press, New York.