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The Human Factor in New Zealand Aviation Accidents and Incidents

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A number of recent aircraft accidents and incidents within New Zealand have highlighted deficiencies in our recognition of the potential role of the human factors psychologist in aviation. This paper reviews a number of areas in which such a contribution could be made and argues for a greater awareness of human factors considerations in accident reporting as well as in designing systems for overall aviation safety.

Ever since someone first observed that 'the pilot is always the first to arrive at the scene of an accident' there has been a general interest in the role of pilot behaviour in accident causation and flight safety. Early aircraft were often relatively unstable, difficult to fly and more subject to mechanical and structural problems than today's designs. Technological developments have resulted in advanced engines and airframes of great integrity and reliability and most types of aircraft from Cessna 150's to Boeing 747's are viceless and easy to fly. When accidents have occurred and no obvious mechanical defect could be found there has been a tendency to regard the cause of an accident as 'pilot-error'. Whilst no-one would ever have regarded 'engine-error' or 'wing-error' as acceptable causes for an accident, human beings are widely held to be more unpredictable and unfathomable and the label has found general acceptability. Psychologists, however, have not regarded the label as useful since Fitts and Jones (1947) first reported their analyses of numerous 'pilot-error' accidents in military aircraft. Their studies of operating control errors and instrument reading errors revealed a breath-taking confusion of control placement and display design. The situation they discovered would be analogous to finding a lack of uniformity on the placement of the three automobile control pedals by different manufacturers. What were described as pilot-errors in this case were clearly examples of poor systems design in which no account of the operators' behaviour had been taken. Whilst the aircraft industry has been relatively quick in taking the human factors lesson revealed by Fitts and Jones to heart, accident investigators have been considerably slower in giving the human factor equal weight to the mechanical and engineering aspects of accident analyses. Progress in this field has varied widely from one country to another, with New Zealand still lagging considerably behind most western countries. As far as the training and crew development side of the industry is concerned, "even a cursory examination of the existing flight training curricula shows a process which has changed little from that which was in operation 40 years ago" (Hunt & Crook, 1985, p8).

Progress in human factors in accident investigation overseas

Many countries now pay more than lip-service to the role of human factors in accident prevention and investigation. The US National Transportation Safety Board (NTSB) which probably investigates the greatest annual number of aircraft accidents of any agency in the world, has had a human performance division since 1983 (Strauch 1985). The division employs six behavioural scientists covering the areas of concern to the NTSB which extent to automobile, rail and marine accidents in addition to aviation. In Australia, the Bureau of Air Safety Investigation appointed an Assistant Director and three research officers in 1982 to form an Air Safety Research Group. In addition to maintinaing a detailed aviation accident and incident data base, these psychologists provide assistance in the field to the Bureau's other accident investigators. "In the case of a major accident a Bureau psychologist would be part of the team despatched from Central office at the outset" (Lee, 1985, p.42). Similar involvement can be found with the UK Ministry of Defence, the UK Civil Aviation

Authority as well as investigative bodies in Germany, Switzerland, Finland, the Netherlands, Belgium and Austria. In New Zealand, the office of Air Accident Investigation which is statutorily independent of the Civil Aviation Division contains no human factors expertise. The case for drawing upon such expertise can be made from a consideration of a number of specific instances reported by the office of Air Accident Investigation. These examples are not cited in criticism of the investigators nor their reports, but to support the argument that accident prevention and investigation in New Zealand would benefit from a greater awareness of human factors.

Near-miss, South of Rotorua, October, 1985

This incident occurred just after 3 p.m. on the 4th of October, when a southbound HS748 beloning to Mount Cook passed within 200 feet vertically and 800 metres laterally from an Air New Zealand Friendship. The latter had been cleared to descend to the same altitude as the HS748 on its approach into Rotorua. The error had occurred because the Rotorua controller mistakenly called 'Newmans one one' whilst intending to refer to the Mount Cook flight 11 which was designated as 'NM11' on the flight progress chart. The call was answered by another flight in the area which had just departed to the north from Rotorua, operated by Newmans Airlines. The controller therefore mistakenly believed that he had instructed the Mount Cook flight to remain at 8000 feet and proceeded to clear the Air New Zealand Friendship down to 9000 feet. In fact both aircraft were at the same flight level. It is possible that the incident could have had disastrous consequences had both aircraft been flying in cloud instead of clear air as was the case. Whilst there were other factors to be considered in relation to the controller's performance, there is good reason to believe that the controller's mistake was "set up" in much the same way as the so-called pilot errors investigated by Fitts and Jones (1947) were shown to be system induced. The two-letter aircraft identifiers (e.g. 'NZ' for Air New Zealand) are intended to provide a unique identifier for every flight. The controller at Rotorua was controlling three separate flights by three separate airlines whose identifiers were NZ, NM (Mount Cook) and NY (Newmans). There is no doubt of the potential for confusion between such similar codes, particularly as the NM for Mount Cook contained the two stressed consonants of the Newman's name. One would like to believe that a human factors psychologist would have drawn attention to the potential for disaster which was invited when these codes were introduced. The Office of Air Accidents Investigation has quite properly come to the same, if rather belated, conclusion (Office of Air Accident Investigations, 1985).

Gear-up Landing at Kaitaia, June 1984

This unfortunate arrival of a Piper PA28 on the morning of the 29th June illustrates a wide number of issues relating to workload, stress, operating manuals and warning systems which are familiar to aviation psychologists. Whilst the basic details are outlined in the Accident Brief (Office of Air Accident Investigations, 1984), there is no hint of the complex human factors which might have led a very experienced pilot to produce such an inelegant arrival. The conclusion of the flight was carried out in poor weather with strong, gusty winds and light rain. The approach was executed satisfactorily until the last moment, when the pilot realised that the undercarriage had not been selected down. The undercarriage was prevented from falling automatically by an overide switch which had been selected on a previous flight. The warning light was not noticed by the pilot, and was not referred to in any of the manufacturers' check lists used for take-off and landing. Considerable attention has been given to the concept of workload, although satisfactory definitions and measurement have proved elusive (Casali & Wierwille, 1984). It is generally agreed that when a primary task becomes sufficiently difficult, the amount of attentional resource available to allocate to a secondary task decreases. This principle forms the basis of the most common workload measures — interference with a secondary task such as digit shadowing or mental arithmetic (Wierwille & Connor, 1983). Given the circumstances of this attempted landing into a cross wind, which was gusting to over 30 knots (moderate gale or Force 7 on the Beaufort scale), it can be assumed that the pilot's available attention was mostly concentrated on the landing itself, and the secondary task of executing the landing check-list was not carried out as thoroughly as it might have been. Any well-designed system would recognise this possibility and include some form of warning system to alert the pilot to critical omissions. Modern commercial aircraft have a multitude of warning systems — approximately 886 on the Lockheed Tristar for example. Designers appear to have simply added warning systems for every conceivable eventuality with little thought for the overall impact of such a large number of signals (Thompson, 1981). Neither of the warnings built into the Piper PA28 aircraft seem to such have been much help to the pilot. The selector override warning was given a very low priority and was not even included as an item in the check list. Failure to prioritise necessary warnings has been identified as one of the main problems in current design practice for caution and warning systems (Thompson, 1981). When a high priority warning did sound moments before touch-down, this failed to alert the pilot due to a classic confusion of warning systems of exactly the kind publicised by Fitts and Jones nearly forty years ago. The signals for stall warning and undercarriage-up conditions used by the two main manufacturers of light aircraft in widespread use in New Zealand depend on either a warning horn, a warning light or a combination of the two. Landing such an aircraft in the proper nose-high attitude generally results in the stall warning signal being activated as the main wheels make contact with the runway. In this case, the sound of the horn indicating the 'undercarriage-up' condition failed to warn the pilot of the imminent belly landing, since this is precisely the same signal he would have expected to hear from a Cessna aircraft warning of the normal stall on landing. Since 46% of the aircraft available for hire from New Zealand aero clubs and flying schools are Cessna's and 44% are Pipers it is clear that considerable opportunity exists for such confusion.

Once again, as in the previous case, pilots and controllers appear to have been well set-up to make errors by poorly designed systems.

Friendship crash at Auckland, 17 Feb. 1979:

This F27 operated by Air New Zealand crashed into the Manukau harbour whilst approaching the north-eastern runway at Auckland International. The investigators report (Office of Air Accident Investigation, 1979a) concluded that the probable cause was that "a visual illusion misled them into believing a normal approach was being maintained." The illusory effects were caused by heavy rain showers encountered on final approach. One well known effect of this, which has been referred to in many accident reports world-wide, is that light can be refracted through the rain drops making the runway appear lower than is actually the case. The effect would be exacerbated by the lack of a visible horizon through the showers. Thus the crew continued a dangeroulsy low approach into the harbour itself. Due to their heavy reliance on visual cues, pilots are extremely susceptible to a variety of visual illusions. These can occur in all kinds of conditions, although those occurring at night or in rain seem to be particularly misleading. Whilst the existence of such illusions has been readily accepted by the aviation community, the underlying explanations have not been so readily assimilated. The extent of such phenomena is therefore not properly understood. This is partly due to a mistaken belief that psychological explanations are somehow less real than those couched in medical terms for example. This misapprehension may have had some part to play in the reluctance of the investigators to believe that a visual illusion could have had a significant part to play in the Erebus disaster (Vette, 1983). The DC10 owned and operated by Air New Zealand was on a sightseeing flight over the Antarctic in the vicinity of Scott base. The aircraft impacted on the side of the 12,000 foot volcano of Mount Erebus. The initial report of the Inspector of Air Accidents (Office of Air Accident Investigations, 1979b) was critical of the crew for flying at low level in conditions of poor visibility. Subsequent investigation revealed a more complex story involving changes in critical navigational coordinates by the airline, and the existence of a whiteout effect which deprived the crew of effective perceptual information, leaving them unaware of the crucial loss of visible texture which surrounded them. Had it not been for the dogged persistence of a colleague of the captain of flight 901 in searching out the appropriate psychological literature, the worst crash in New Zealand aviation history would undoubtedly have been written off as yet another case of "pilot error".

Pilot Judgement and decision making:

The accident record for general aviation, i.e. non-airline public transport flying, is considerably worse than the very good record of the commercial and airline operations. The latest available figures from the International Civil Aviation Organisation ("A record year", 1985) shows a worldwide fatal accident rate of 0.14 per 100,000 hours flown on scheduled air services, compared to approximately 2.1 per 100,000 hours of general aviation operations. The New Zealand figures are slightly worse, at approximately 0.4 per 100,000 hours of airline flying and approximately 3 per 100,000 hours of general aviation. The latter figure woud probably be somewhat higher if private flying were taken into account. The accident reports often allude to errors in planning, judgement and decision making. Unfortunately, it is not possible to arrive at any estimate of the prevalence of such errors as the New Zealand accident data are presented solely in relation to the phase of flight in which the accident occurred. This simply confirms the well known observation that a disproportionate number of accidents occur during the most critical flight phases of landing and take-off. The figures published for New Zealand (Office of Air Accidents Investigations, 1984b) show that for 1984, 27% of general aviation accidents occurred at take-off and 47% during landing. To discover any more about the underlying factors we have to turn to the accident data held by other countries, such as Australia, which have incorporated a human factors perspective into their accident investigation branches. The Australian Bureau of Air Safety has estimated that 76% of accidents can be regarded as "human factors" accidents. That is, only one in four accidents involves a clear mechanical or structural failure over which the pilot has little control. As a second estimate, the Bureau has classified between 45% and 59% of these accidents as the result of faulty judgement and decision-making. A number of such cases, involving pilots pressing on into deteriorating weather conditions are reported in New Zealand each year. Whilst the basis of motor skill learning has been reasonably well developed (Schmidt, 1982), the psychological bases of judgement and decision-making are as yet little understood (Hogarth, 1982). A growing number national agencies have targeted pilot decision-making as an important topic for future research. This invitation to psychologists to participate in applied research deserves to be widely noted. A good deal of experimental and social psychology has its roots in the productive interplay between practical problems and theoretical understanding, with each serving as a constant stimulus to the other. Vigilance research grew from the problem of detecting submarines on airborne radar (Mackworth, 1950), whilst a good deal of experimental work on skilled performance developed from the Cambridge Cockpit studies of the effects of fatigue on the performance or aircrew (Davis, 1948). Of course the beginnings of human factors research as a whole can be found in the Fitts and Jones study of pilot error referred to previously. There is the exciting prospect that a strengthened theoretical psychology of decision-making and judgement may emerge from the study of such real-life problems in difficult circumstances.

Conclusions

In contrast to many overseas countries, New Zealand has been slow to develop a human factors perspective on aviation accident reporting and prevention. This paper presents a number of specific instances which demonstrate the value of such a perspective. There is evidence for the need for heightened awareness of human factors knowledge in the investigation and reporting of aviation accident data. Psychologists in New Zealand should be more active in publicly promoting psychology as a discipline which can contribute to applied problems in the future through a successful mixture of practical investigation and theoretical development. The recent formation of a New Zealand Ergonomics Society is a welcome development in an appropriate direction. Civil Aviation has already taken an initiative by drawing up a series of proposals (Hunt & Crook, 1985) relating to the future of professional flight crew development in this country. The report identifies three problem areas which need to be addressed. These revolve around the problem of defining the necessary skills which underly the modern pilot's role as system manager and decision-maker in the highly automated flight deck now being introduced into airline service. The civil aviation licencing authorities need to address such issues as whether the skills involved in judgement, decision-making and teamwork can be defined, taught and assessed in the same way as the traditional handling skills of flying. There is substantial scope for psychologists to be involved in these developments and subsequent proposals. It would be good for the pilot to be not only the first to arrive at the scene of an accident, but also the first to benefit from the growing understanding of psychological factors in aviation.

References

A record year for airline safety. (1985, July). *International Civil Aviation Organisation Bulletin.*

Casali, J.G., & Wierwille, W. (1984). On the measurement of pilot perceptual workload: A comparison of assessment techniques addressing sensitivity and intrusion issues. *Ergonomics, 27,* 1033-1050.

Davis, D.R. (1948). Pilot error. Air Ministry Publication AP3139A, London: HMSO.

Fitts, P., & Jones, R. (1947). Analysis of factors contributing to 460 "pilot-error" experiences in operating aircraft controls. Report TSEAA-694-12, Aero Medical Laboratory, Air Materiel Command, Wright-Patterson Air Force Base, Dayton, Ohio.

Hogarth, R. (1980). *Judgement and Choice.* New York: Wiley.

Hunt, G., & Crook, C. (1985). (1985). *International Trends in Professional Flight Crew development.* Massey University: Instructional Systems Programme.

Lee, R. (1985). Analysis and evaluation of human performance factors in aircraft accident investigation: Current developments in the Australian Bureau of Air Safety Investigation. *Report of the XVI Conference of the Western European Association for Aviation Psychology,* Helsinki, Finland.

Office of Air Accident Investigation. (1979a). Aircraft Accident Report No. 79-034. Wellington: New Zealand.

Office of Air Accident Investigation. (1979b). Aircraft Accident Report No. 79-139. Wellington: New Zealand.

Office of Air Accident Investigation. (1984a). Aircraft Accident Report No. 84-068. Wellington: New Zealand.

Office of Air Accident Investigation. (1984b). *New Zealand Civil Aircraft Accidents 1984.*

Office of Air Accident Investigation. (1985). Aircraft Incident Report No. 85-0-429. Wellington: New Zealand.

Schmidt, R.A. (1982). *Motor control and learning.* Champaign: Human Kinetics Publishers.

Strauch, B. (1985). The use of psychology in the investigation of transportation accidents. *Report of the XVI Conference of the Western European Association for Aviation Psychology.* Helsinki, Finland.

Thompson, D.A. (1981). Commercial air crew detection of system failures: State of the art and future trends. In J. Rasmussen & W.B. Rouse (Eds.) *Human detection and diagnosis of system failures.* New York: Plenum.

Vette, G. (1983). *Impact Erebus.* Auckland: Hodder & Stoughton.

Wierwille, W., & Connor, S. (1983). Evaluation of 20 workload measures using a psychomotor task in a moving-base aircraft simulator. *Human Factors, 25,* 1-16.