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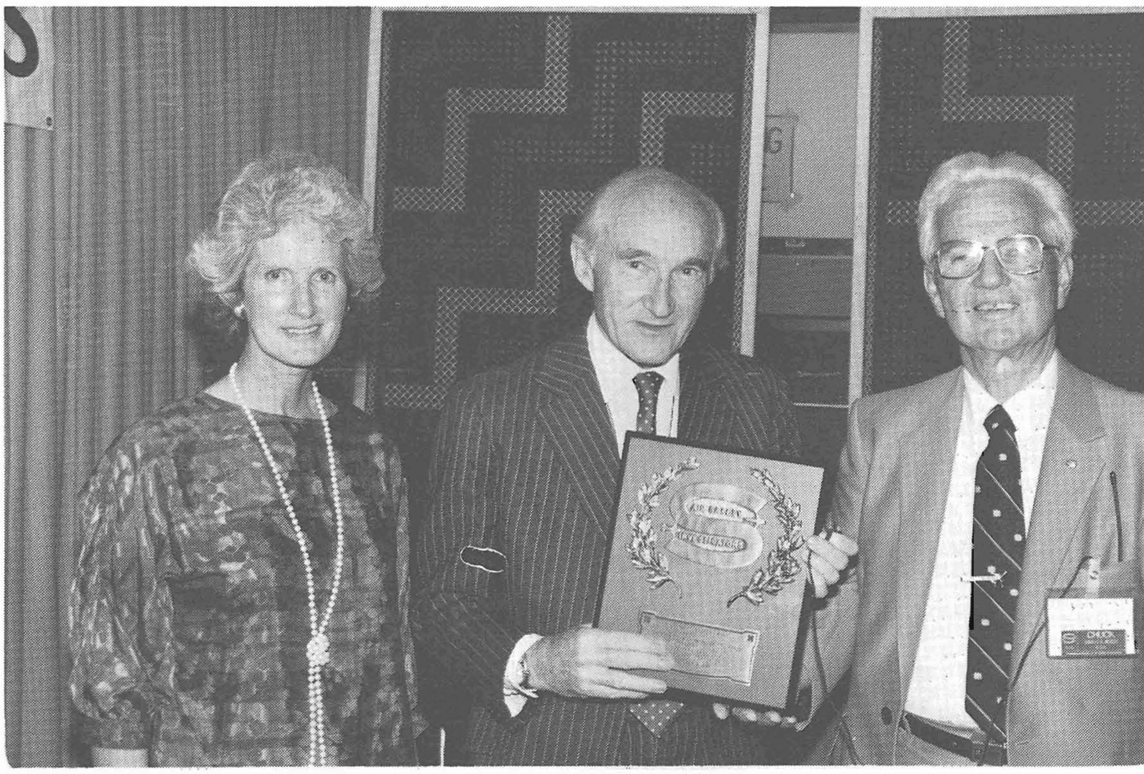
1986 Jerome F. Lederer Award

G. C. Wilkinson Receives THE JEROME F. LEDERER AWARD



Geoffrey C. Wilkinson (C) receives the Jerome F. Lederer Award from President Charles R. Mercer. Virginia Wilkinson is at left.

Geoff's career is marked by a number of milestones, major investigations and public inquiries, all of which enhanced his reputation. He made significant contributions to the international accident investigation procedures through ICAO, and with others, pressed for CVR's leading to their use on UK registered aircraft. His achievements are a tribute to his fearless personality and drive in tackling any task or confronting any person, regardless of rank or status, in the name of air safety.

Geoff was the first Chief Inspector of Accidents at the Accidents Investigation Branch to be a graduate of the Empire Test Pilots' School, bringing a technical appreciation to the task as well as significant flying experience.

He studied aeronautical engineering for a year before joining the RAF for pilot training. His flying career started at the end of World War II when he served in the Fleet Air Arm. He subsequently served with the RAF for eleven years, including jet fighter squadrons in Germany and on attachment to the U.S. Air Force in Korea.

He served as an experimental test pilot at Farnborough. He retired at his own request and ran a small private airline prior to joining the Accidents Investigation Branch in 1965, and became Chief Inspector of Accidents in 1981.

Geoff holds an ATP license endorsed for B-747 and Concorde aircraft. He holds the Air Force Cross and U.S. Air Medal and is a fellow of the Royal Aeronautical Society.

Perhaps one of Geoff's most lasting contributions to air safety investigation has been a clear demonstration that uncompromising dedication to his principles and beliefs was an attribute that contributed to his own success as well as to air safety. It is a lesson too often lost in this era to compromises and accommodation.

Opening Address of ISASI 17th International Air Safety Seminar

By T. Sanger
Deputy Secretary for Transport

Mr. President, Ladies and Gentlemen, welcome to New Zealand.

It is a real pleasure to attend the opening of the 17th Annual International Seminar of the International Society of Air Safety Investigators. Unfortunately, the Minister of Civil Aviation and Meteorological Services, because of commitments overseas, cannot be here today. He has asked, however, that I pass on his best wishes for the discussion and activities that you will be participating in during the next few days.

It is certainly an honour for New Zealand to host a conference for an international organisation as distinguished and vital as yours, particularly when one considers that these international seminars are only held outside the United States in alternate years. That being the case, it is unlikely that any of us present today will be around the next time ISASI holds its annual conference in New Zealand. Indeed, given the nature of your job I hope when you do next visit our country it will not be on business, but to experience and enjoy its hospitality and its varied and often spectacular scenery, or if you are sports enthusiasts to watch New Zealand defend the Americas Cup in 1991 and every four years thereafter.

Anyway, I trust you will make the most of the long journey you have undertaken to reach our rather remote corner of the world. Often that isolation is a drawcard for many visitors to these shores. Nonetheless, it does have less attractive connotations. Our isolation from the world's technological, manufacturing, research and population centres means that immediate access to, for example, up-to-the-minute technology usually eludes New Zealand.

The problems associated with this are further compounded by a limited resource base, physical and human, which has to some extent restricted development of this country's research, manufacturing, technological and financial potential.

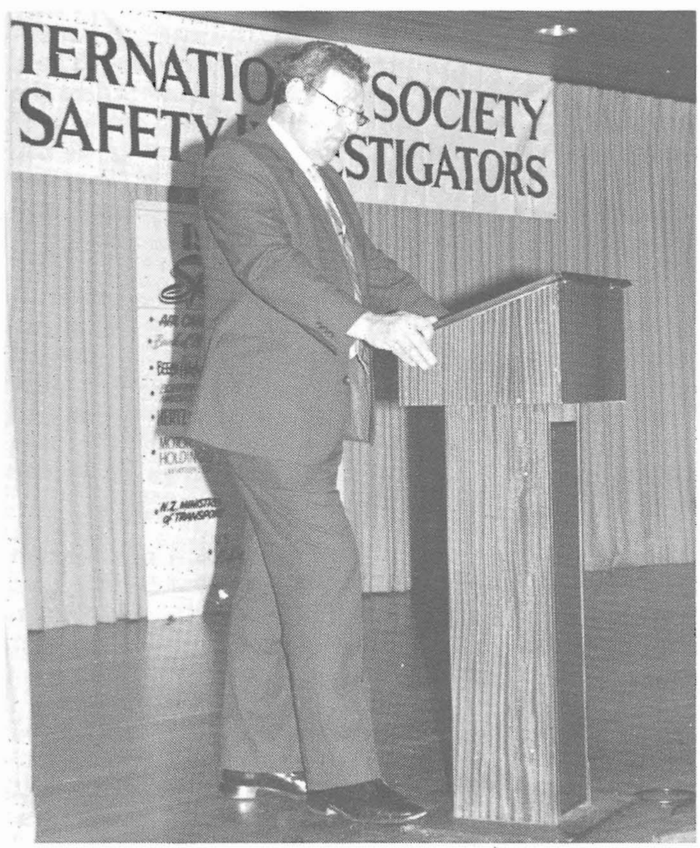
One means by which we have sought to overcome these obstacles is through the exchange of ideas, information and resources with other countries.

The fact is that in an increasingly interdependent world, few countries, businesses, or organisations would now challenge the wisdom of looking beyond national borders to search for expertise, resources and partners.

ISASI is a case in point. For 17 years it has recognised the value of seminars as a medium through which to exchange ideas and information, since as you are well aware there is always considerable scope for the exchange of expertise and resources where air accident investigation is concerned.

Recent events have confirmed this. The accident involving the Air India Boeing 747 off the coast of Ireland, for instance, demonstrated the multifarious problems that can arise when an accident occurs in an area beyond international boundaries.

New Zealand confronted a similar situation when a DC10 was lost in Antarctia in 1979. We were fortunate then to have the assistance of other countries, but there is clearly a need for procedures that can be rapidly invoked for the express purpose of assembling specialized international expertise in the aftermath of a major accident.



Mr. T. Sanger, Deputy Secretary for Transport, New Zealand

In these times, such adaption is inevitable. The airline industry is no more immune to the challenges imposed by the drive for greater efficiency, sophistication and a larger share of the market than any other industry. In New Zealand, for example, the government has recently decided that some of the heavily capitalised areas of government functions which are already generating a financial return should be made into corporations.

Our Airways system falls into that category. The Civil Aviation Division of the Ministry of Transport has two main functions. The first is the regulating of aircraft, pilots and the way they fly and the second the operation of the control of airspace.

The latter function as you will all know is one which swallows capital at an alarming rate. The whole New Zealand system is in need of updating to meet the increasing volume of air traffic and to keep up with the technology. We have had troubles over the years with our Treasury who argue that when we replace a piece of equipment purchased in the '49s or '50s that we should do a direct replacement. Any enhancement of that piece of equipment they have regarded as "new policy" and therefore funded in a different way. They don't seem to have realised that one can no longer purchase dodos!

Recently I read a report by the National Academy of Public Administration in the United States on "The Air Traffic Control System: Management by a Government Corporation". In this study of the Federal Aviation Administration they pointed to the same sort of difficulties with which we are faced in New Zealand. These are firstly funding from a government source where the FAA was competing with all the other instruments of government for its slice of the cake. Secondly, is the somewhat rigid control exercised by the central personnel authority over the distribution, recruitment and rewarding of staff.

By their very nature airways systems are time critical for resource allocation. It is no good being given money in three years time for a radar which needed replacing last year. As traffic volumes grow and equipment becomes older and less effective the only way to cope is by putting in more staff. If one cannot do these things promptly it makes the management of an airways system more difficult.

It is, therefore, in the light of this sort of situation that the government decided to establish an Airways Corporation perhaps as a limited liability company. To keep us on our toes the introduction date for the new enterprise is 1 April 1987.

So far we have an established Board appointed which will guide the establishment of the corporation. My part in this exercise is to be the Interim Chief Executive Officer. The Board has met on three occasions and is still very much on the "learning curve" because only one out of the seven has any profound knowledge in the area. The others have been appointed by the government for their commercial expertise. I must say that I never ceased to be amazed at the speed with which they come to the heart of the problem.

Before the Board at the moment are three major points:

1. Whether there can be an effective "split" between the regulatory function and the operational function of the Civil Aviation Division. As far as this is concerned the operational part has no regulation making powers at the moment. This, therefore, seems to me as a good reason for the split to go ahead. As I see it the Civil Aviation Division of the Ministry of Transport will put in place regulations which the Airways Corporation must adhere to. The Division's responsibility will be to ensure that whatever rules are put in place are followed by the Corporation.

   There is a fear among some staff on the division that the commercial requirements will overrule the safety of the operation. The Chairman of the Board has told some representatives of the union that the Corporation will have a social conscience and will be ensuring safety is predominant. However, there is "safety" and "safety". One's trousers won't fall down if you wear a belt and braces and therefore one can fairly ask the question is a second belt or a second pair of braces really necessary.

2. The second is the area of coverage of the Corporation. There are three options for consideration.

   OPTION 1 - Chock to chock or apron to apron. This will mean that most of the functions now carried out by the operations part of the Division would be assumed by the Corporation. A group of consultants working for the Ministry has put it another way - the Corporation is responsible for the aircraft, the airport is responsible for the people. In other words the Corporation is to be responsible for the "air side".

   While the Board has discussed this it has not yet made a recommendation to the Government.

3. The last is the form of the Corporation. Ideas differ widely. At one end of the spectrum you have the view of the union that a separate government department should be established while at the other end is the limited liability company. Somewhere in between is a corporation sole. The Government would like to see a limited liability company where it is the shareholder and the directors of the board are responsible to the shareholder.

While this discussion is going on about the Airways Corporation other government agencies are being converted into limited liability companies. Our Forest Service is one, the Land Development Work of the Lands and Survey Department is another, both the Coal and Electricity Divisions of the Ministry of Energy are included plus the Division of the Post Office into three companies covering postal, savings and telecommunications.

The major task facing the Corporation when it is up and running is the putting in place of the National Air Traffic Service Systems Modernisation Plan, referred to affectionately as the NATS Plan. You will recall that I mentioned earlier that the New Zealand Airways System was faced with the task of facing up to increased traffic volume and the advancing technology. Because much of our equipment is entering the last phase of its life we have to completely redesign the system to operate in the new technology environment. This means consideration of a single air traffic centre rather than the four centres we have at present in Auckland, Ohakea, Wellington and Christchurch. Modern communication systems make this a possibility. While we had moved beyond the use of flags passing information from hill top to hill top by semaphore we are still not up with what is on today. Computer networks make a mockery of communication systems which we have known.

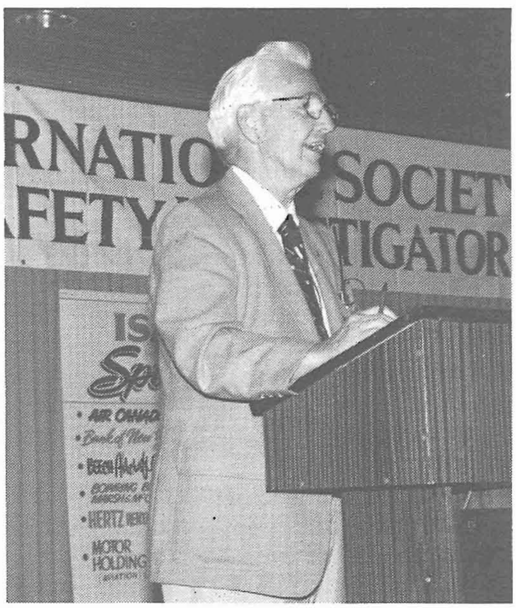
Again aircraft are moving much faster, separation is parament when there is only so much sky. The control systems have got to be updated so that with the aid of secondary surveillance radar we can bring separations down to a safe minimum. In your short stay in New Zealand you may have recognized the hilly terrain in which we have to operate an airways system.

The Corporation is going to have to pay tax and also a dividend to its shareholder. For too long the capital involved in the airways system has not returned a cent to the long suffering taxpayer. The user airlines are going to be able to make proper commercial decisions on routes they wish to fly.

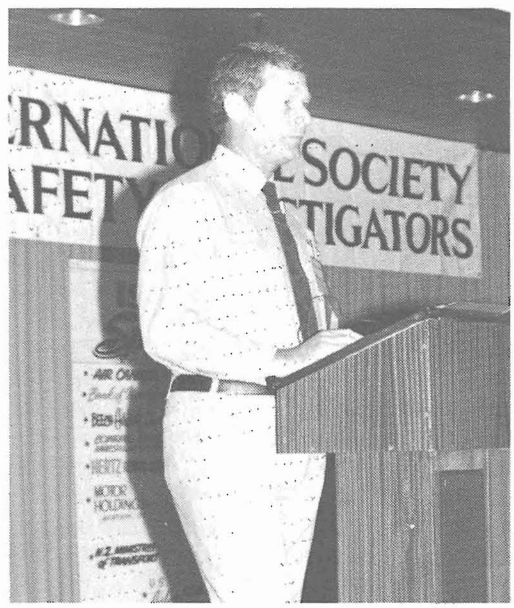
All in all we are living in exciting times.

Ladies and gentlemen, I trust you will make the most of your visit. Certainly, the range of research and expertise that will be pooled and exchanged during the next few days is very impressive. Such cooperation and assistance is vital if you are to improve further your excellent record of aviation accident investigation.

On behalf of the Minister of Civil Aviation and Meteorological Services I have much pleasure in opening the 17th Annual Seminar of the International Society of Air Safety Investigation.



Opening remarks by ISASI President, Charles R. Mercer.



Peter M. Rhodes, Technical Papers Chairman, introduces the first speaker, Mr. T. Sanger, Deputy Secretary for Transport.

Protection of Individual Rights

ADDRESS BY:
By Bernard M.-Deschenes, Q.C., Chairman
Canadian Aviation Safety Board

The newly created Canadian Aviation Safety Board and some of its experience in international cooperation and adaption

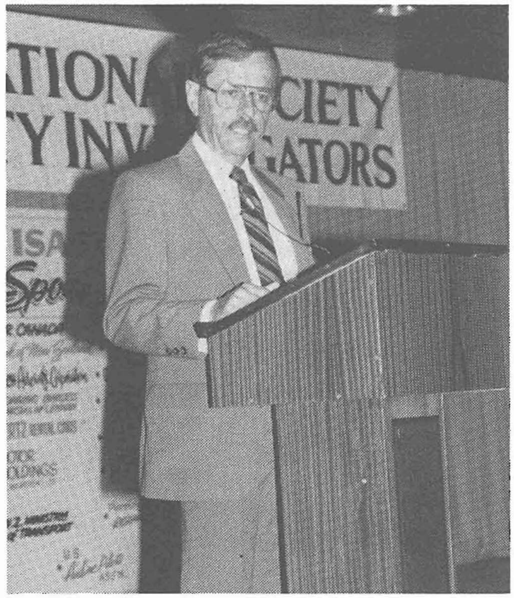
As in many countries, aviation accidents were, prior to 1 October 1984, investigated in Canada by the Department of Transport. However, as had been the case in the United States (U.S.) allegations of conflict of interest had been raised, with increasing frequency since the late sixties. The Canadian Bar Association and the Canadian Air Line Pilots Association were among the most vocal on this issue, and they underlined the perceived as well as the actual conflict between Her Majesty's acting as the independent investigator and Her Majesty's acting also as the regulator, the enforcer, the provider of numerous services, the operator of a large aircraft fleet, and more and more often as an interested litigator.

After 15 years of studies, debates and preliminary parliamentary bills, a royal commission of inquiry on aviation safety, presided by Mr. Justice Dubin, stated in 1981 in its Recommendation No. 1 that a tribunal independent of any department of government, should be created and should be called the Canadian Aviation Safety Board.

In the fall of 1983, the Canadian Parliament unanimously adopted the Canadian Aviation Safety Board Act (CASB Act), whereby the proposed Board was given the mandate to advance aviation safety by conducting independent investigations and public inquiries into aviation occurrences; by identifying safety deficiencies as evidenced by such - aviation occurrences; and by reporting publicly thereon and making safety recommendations. Furthermore, the CASB Act stipulated that "for greater certainty", it is not the object of the Board to determine or apportion any blame or liability in connection with aviation occurrences."

Let me digress here for a moment to mention that, although this requirement is also mentioned in Annex 13 of the ICAO Convention, it is quite difficult to apply in practice since human involvement is found to be a contributory factor in the majority of investigations and since the identification of such involvement in the conclusion of a report may imply, at least indirectly, some element of blame or even of liability.

We are still in the process of indoctrinating our investigators in the use of phraseology that will reflect only factual objectivity. Words such as 'pilot error' are of course not part of our vocabulary even though some will often argue strongly that human performance was the sole cause of an accident. However, this real and every day difficulty is helping us more and more in advancing safety because it obliges us to go further back into the causation chain which has resulted in the so-called 'pilot error'. By doing so, we do not limit ourselves to the most apparent or most immediate cause.



Barnard Deschenes, Q.C.
Chairman, Canadian Aviation Safety Board

The CASB Act, which became operational on 1 October 1984, brought about some major changes in Canada, and I will briefly review some of them with you.

1. The Canadian Aviation Safety Board, when it investigates, has been given the exclusive jurisdiction to determine the contributing factors and causes of aviation occurrences, thus taking away any such jurisdiction from the Department of Transport. We have the power to delegate our jurisdiction, but, so far, it has been the Board's policy to carry out the investigations itself in all cases.
2. It must be noted that the expression 'aviation occurrence' has been defined very broadly in order to give us jurisdiction not only over accidents but also over incidents and over "any situation or condition that the Board has reasonable grounds to believe could, if left unattended, induce an accident or an incident."

3. The Board has been given authority to hold public inquiries. We have set in place regulations modelled somewhat on the U.S. National Transportation Safety Board (NTSB) practice whereby such inquiries are to be fact-finding proceedings, without any pleadings, issues or adverse parties. We have so far held five such inquiries, and we are satisfied that the non-adversarial objective can generally be attained even when lawyers are present and participate. These inquiries, which, in each case, were completed in a few days, were productive and relatively inexpensive. One of these inquiries was held not as a result of a specific occurrence but as a result of a study of several hundred reported conflicting situations between aircraft/aircraft and aircraft/vehicle on or near the ground at airports, or, as it is called in the U.S., 'runway incursions'.
4. In order that the Board might be in a truly impartial position when issuing a report, a clear separation was created between the Board Members and the investigators. A Director of Investigation was appointed with the exclusive authority to direct the conduct of investigations by the Board. Unlike our American colleagues, our Board Members do not go to an accident site for the purpose of participating in the investigative process. However, the Board can request that the Director of Investigation explore further certain aspects of an occurrence and report back to the Board.
5. In order to further ensure the objectivity, completeness and impartiality of the process, all reports issued by the Board must first be submitted as drafts, on a confidential basis, to all interested parties, the Minister of Transport always being designated as a party. The interested parties then have the right to comment and make representations to the Board, generally in writing; however, the opportunity to do so orally is also provided. Before issuing a final report, the Board has the obligation to consider these representations formally. In our view, the arm's length relationship established between th Board and its investigators and the opportunity given to involved parties to present their views to the Board for consideration constitute two very strong safeguards of individuals' rights which may be affected even indirectly by an investigation report.
6. All reports of the Board must be made available to the public. I should add that the Board's policy is one of total openness and responsiveness, subject to certain restraints established by the CASB Act.
7. The Board has been given the power to develop and make safety recommendations which must also be made available to the public. When such recommendations are made to a Minister of the Crown, in most cases, they are addressed to the Minister of Transport - that Minister has a period of 90 days within which to reply in writing to the Board advising of the actions, if any, taken or proposed to be taken. If no action is to be taken, or if such action differs from that proposed by the Board, that Minister must give his reasons in writing. In all cases, the Minister must make his response available to the public.
8 Finally, the CASB Act has given a privileged status to certain types of evidence, mainly the cockpit voice recordings (CVR) and witness statements obtained by the Board. We are prohibited from releasing this privileged information or permitting it to be released to any person; however, the Board can make use of this information when it is considered necessary in the interest of safety.

Nevertheless, we are obliged, under certain circumstances, to release a CVR recording or a witness statement to coroners or civil courts. The coroner or the civil court must first make a determination, after an 'in camera' examination of the evidence, to the effect that, in the circumstances of the case, the public interest in the administration of justice outweighs in importance the privilege attached to the recording or the statement.

In the specific case of the CVR, the court or coronor must give a reasonable opportunity to the Board to argue against the production. So far, we have had a number of requests from coroners, and we have been quite successful in convincing them that production of privileged evidence should not be required.

In any event, the privileged sections of our act provide that recordings and statements cannot be used against their authors in any proceedings other than civil proceedings or in cases or perjury.

Like many other countries, Canada has enacted Access to Information and Privacy Acts. We have not yet had to face this issue, but it is our opinion so far that the privileged sections of our act would have precedence over the access to information legislation. For a better comprehension of the Canadian situation, I should mention that, in our country, there are more than 26,000 registered civil aircraft and that there are about 85,000 licensed personnel in civil aviation. The annual number of accidents averaged around 700, until the recent recession, when that number decreased to about 500. Unfortunately, the figures to date for 1986 indicate that this number will increase.

We have also started to investigate certain types of incidents, such as in-flight fires, engine failures, risks of collisions, etc., for aircraft weighing over 12,500 pounds. So far, the number of such incidents reported has reached only 100 per year, but, because our reporting system is still in its infancy, we expect that number to increase. Eventually, we hope to investigate such incidents for all commercial operations, whatever the weight of the aircraft. We should, therefore, reach approximately 1,000 investigations and reports per year.

The Board's structure comprises five branches: the investigation Branch, which is headed by the Director of Investigation, includes six regional offices across Canada; the Safety Engineering Branch, which consists of our very modern and advanced laboratory at Uplands Airport in Ottawa; the Safety Medicine Branch, which we have just started organizing; the Safety Programs Branch; and the Administration Branch. The Safety Engineering and the Safety Medicine Branches generally act in support of investigation activities. However, the Safety Programs Branch is operating somewhat separately, since it is charged with the analysis of safety deficiencies revealed by the investigations and with the study and identification of corrective measures. It is these corrective measures that become the basis of the Board's safety recommendations, which in effect are our end-product.

The Canadian government not only enacted a strong piece of legislation when passing the CASB Act, but it also provided adequate resources. Presently, we are authorized to utilize 193 person-years with a basic budget of some $15 million (Canadian dollars). In addition, a procedure was set in place to deal with unforeseeable major and costly investigations. We never imagined that we would need access to such special resources so soon after becoming operational and for such high amounts. Our resources had to be utilized to the maximum in order to deal with two of the worst airline disasters of the 1985 'Black Year,' and these were two of the most complex investigations from an international coopration and adaptation point of view.

Five months later, a chartered DC-8 crashed on take-off at Gander Airport in the Canadian province of Newfoundland. Unfortunately, here again all passengers and crew were killed. The 248 passengers were members of the United States Armed Forces seconded to the Multinational Force and Observers, an international peace force created as a result of the Camp David accord between Egypt and Israel. Immediately, certain media in the U.S. concluded that there was inadequate surveillance of charter operations by the Federal Aviation Administration (FAA) and that, in any event, the U.S. deregulation policy was the root cause of this accident. In addition, a U.S. congressional inquiry was launched into the chartering practices of the U.S. Army. As Canada was the State of Occurrence, we were faced with the responsibility of conducting the investigation of this accident in order to determine its contributing factors and causes.

With respect to the Air India accident, a number of countries contributed to the investigation, some only in the early stages and others throughout: India, Ireland, the U.K., France, the U.S., and Canada. It would be naive not to admit that, at the beginning, there were tensions existing between some of the participants, particularly with respect to their roles, responsibilities, and the sharing of the information process. Furthermore, the accident investigation procedures and expertise varied from country to country. However, after some hesitation, the group system was eventually set up, and it operated successfully.

One of the primary aspects of the investigation was the search for a possible recovery of the aircraft wreckage, in whole or in part, including its flight data and cockpit voice recorders. However, as important as it was to effect this recovery, the only certain conclusion to be drawn from the study of the evidence the recorders contained was that they had both ceased abruptly to operate. As to other indications they contained in their last second of operation, there eventually was no agreement reached between the various experts who examined them.

After this recovery, it became even more important to continue in earnest the underwater operations of mapping and photographing the wreckage, which was spread out over a very large area at a depth of about 7,000 feet. Our Board supplied the Canadian Coast Guard ship 'John Cabot,' and we rented one of the two existing SCARAB submersibles for a period of over five months. Eventually, after the structures group had analysed the photographs and videos obtained, it was decided to salvage certain specific pieces of wreckage. Again this was successfully achieved through the cooperation of the NTSB, India, and the CASB. This recovery, in combination with the floating wreckage which had previously been salvaged, led to firmer conclusions.

In the meantime, I had met personally in Cork, Ireland with Judge Kirpal who had been charged by the Government of India to lead the investigation and to conduct a public inquiry. We agreed the Indian investigators would come to Canada and visit security arrangements at the three Canadian airports involved. Furthermore, when in our country, they were supplied by the Canadian police authorities carrying out the criminal aspects of this investigation with voluminous information including copies of numerous witness depositions.

Gradually, a climate of greater confidence developed between our two countries' investigating authorities, and a number of our laboratory experts eventually worked closely with Indian scientists. There remained, nevertheless, the difficult issue of how to deal with the events that had occurred in Canada prior to the aircraft take-off. We had already agreed to participate fully in the public inquiry held by Judge Kirpal in New Dehli, India. Our Board decided to prepare a public submission to Judge Kirpal in which we would summarize and analyse the facts as we knew them and propose conclusions much as a lawyer would in his final argument before a court of law. We prepared this submission in the format of an accident report, and, in it, we dealt openly and fully with the events that had occurred in Canada and, more particularly, with the deficiencies we had identified with respect to security arrangements. I now understand that Judge Kirpal's report has been made public and that it generally reaches the same conclusions as our submissions.

I am confident that, in this specific case, we successfully resolved the difficult issue of a foreign country investigating another country's internal affairs. I doubt that the same circumstances will always be present and allow a solution such as the one we initiated, that is, identifying the deficiencies which had occurred in Canada ourselves. I should also add that our participation in this investigation resulted in our having to obtain the authority to spend $7 million Canadian in additional expenses.

The Gander investigation is in a certain way as complex, because two countries are directly involved - the U.S. and Canada - as well as an international peace force. The NTSB, as the U.S. accredited representative, helped in dealing with a large number of other U.S. interests, i.e., the FAA; the U.S. Army; Arrow Air, the operator; the representatives of the crew; McDonald Douglas, the aircraft manufacturer; and Pratt & Whitney, the engine manufacturer.

On the Canadian side, the Province of Newfoundland, the federal Department of Transport, and the RCMP were also involved. Add to this some 200 to 250 media representatives who converged on the site within hours of the occurrence, and you will have an idea of the task facing our investigators.

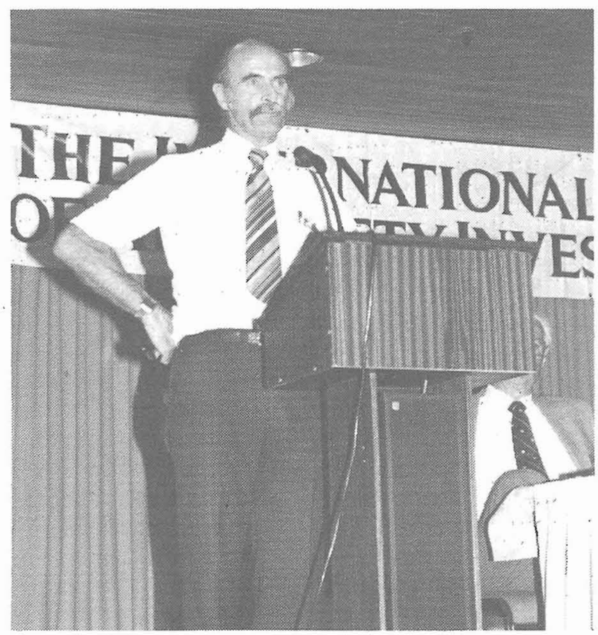
The securing of the site was effectively and quickly achieved and was not really a difficult operation. The first major problem to be resolved was that of the autopsy and identification of the 256 bodies. A Memorandum of Understanding was negotiated and signed, whereby the bodies would be transferred to what is probably the world's largest pathological centre, operated by the U.S. Army in Dover, Delaware. The autopsies and identifications were carried out under the direction of our Board's Director of Safety Medicine; a U.S. Army doctor was appointed by the Government of Newfoundland (a province of Canada) as a de factor medical examiner of that province with authority to issue death certificates. This arrangement worked very well to the complete satisfaction of all concerned.

With the help of the NTSB and the FAA, some of our Canadian investigators had access to and were authorized to copy a large number of documents in the Miami offices of the operator and the FAA. They also interviewed a large number of U.S. witnesses. Finally, when the public inquiry was held in Canada, 45 witnesses, most of whom were U.S. residents, were heard under oath. We had no authority by way of subpoena or otherwise to compel them to attend; however, these witnesses voluntarily attended the inquiry and agreed to testify. Only the Multinational Force claimed an international privilege for one of its main officers stationed in Rome, but that was eventually resolved through a series of written depositions. I am sure you will be interested to learn that one of the last phases for our investigation is currently taking place through simulator tests in Copenhagen. We hope to be able to send a draft report to the involved parties for their comments toward the end of this year or the beginning of next year.

One of the difficulties our Board will have to resolve in this draft report will be how to deal with the role of the FAA in the context of this accident. During the public inquiry our investigators merely established general facts with FAA witnesses and left it up to the NTSB representatives to explore certain areas in greater depth.

In some ways, we are facing the same dilemma that Judge Kirpal had to face in the Air India investigation. Should we, in the interest of safety and in order to fulfill our mandate, examine and discuss the causation chain further back than the immediate causes of the accident, assuming of course that we are able to determine them, or should we limit ourselves to those immediate causes?

Section 5.1 of Annex 13 provides that the State of Occurrence "may delegate the whole or any part" of an investigation to the State of Registry or the State of the Operator. Our Board will have to make a determination shortly with respect to these issues, although I must say that such determination will be greatly eased by the continuous cordial working relationships existing between the CASB and the NTSB.



Ron Chippindale, Chief Inspector, Office of Air Accident Investigation, Ministry of Transport, New Zealand, and 1986 Seminar Chairman makes some comments at the first coffee break.

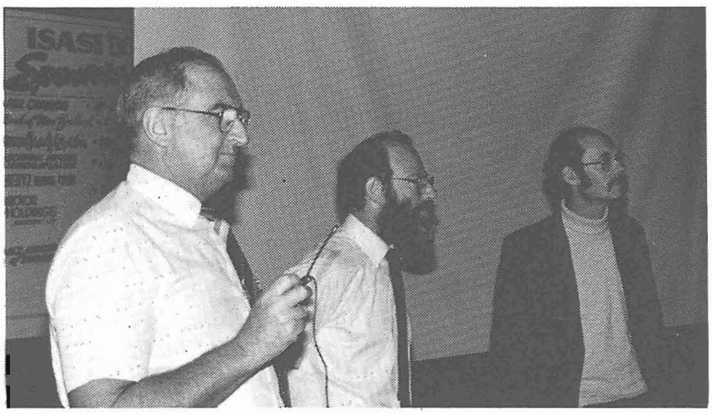
I have a number of questions that I would like to leave with you:

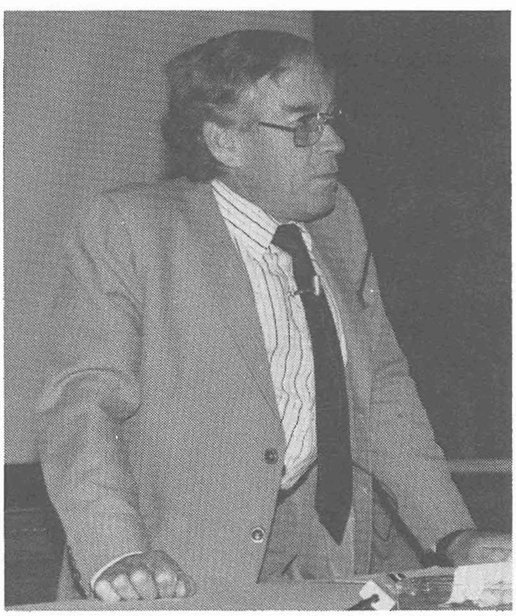
Should Annex 13 render mandatory the delegation of parts of an investigation and of the related partial report when those aspects of the investigation are clearly related to the internal affairs of another country? If so, should there also be assurances that an independent and impartial agency in that country will carry out such an investigation?

Furthermore, should not the granting of accredited representative status be mandatory rather than discretionary, as is presently the case, in favour of the State whose citizens have been fatally injured? Should not that status also be given if relevant events occur at an airport of a country where the accident aircraft lands and takes off prior to an accident flight?

One area in which the cooperation between Canada and the U.S. is very effective and important in the interest of safety is that of our mutual handling of safety recommendations. On the first day of our becoming operational, Jim Burnett, the Chairman of the NTSB, forwarded to me a number of recommendations which he stated our Canadian Board might wish to consider and issue in Canada in accordance with the CASB Act. These recommendations resulted from the investigation of an Air Canada DC-9 fire in Cincinnati, U.S.A. with a high loss of life. We duly studied the NTSB suggested recommendations, and, after some slight modifications, we formally issued them to the Canadian Minister of Transport for implementation in our country.

Early in the Gander investigation, we came to the conclusion that by using standard passenger weights for the U.S. soldiers, the crew had underestimated the take-off weight by at least 12,000 pounds. We issued interim urgent recommendations to our Minister of Transport, and we also sent them to the NTSB for its consideration. The NTSB adopted them and issued them to the FAA, which, in turn, immediately implemented them. Both the NTSB and the CASB are proud of the effectiveness of this procedure which truly meets the safety advancement objectives of accident investigations, even when there are international relations to be taken into account.





Criminal Liability of Aircrew

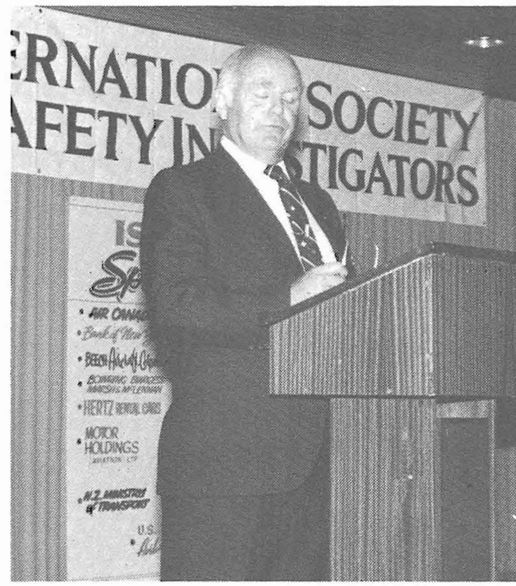
By Capt. R.H.J. Smith
President
International Federation of Air Line Pilots' Association

Mr. President, distinguished delegates, ladies and gentlemen, I would like you to join me in travelling back in time to the night of October 7th, 1979. You are sitting in the jump seat of a DC-8-62 which is operating as SWISSAIR flight SR 316, registration HB-IDE, enroute from Zurich to Beijing via Geneva, Athens and Bombay. Your off-time from Geneva was 1741 local and you are now enroute to Athens. Forty-five year-old captain Fritz Schmutz holder of an A.T.P.L. for 11 years with over 9,000 hours flying is in the left seat and 37 year-old first officer Martin Deuringer right seat, holder of an A.T.P.L. for 8 years, with 4,000 hours flying, is the flying pilot on this leg. The flight officer Peter Lienhard is off to your right, and behind you sit 144 passengers and 7 cabin crew.

It is now 1951 local hours and the crew contacts Athens Approach Control with ATIS information "OSCAR" as we reach 10 DME inbound to Didimon VOR at FL 210. Athens approach says that they will provide a radar line-up to runway 33R with an ILS to the outer marker with a visual circling approach to runway 15L to follow. The weather at Athens has been very changeable throughout the day and evening with CB's in the vicinity and light rain began to fall at 1920 local, increasing to moderate rain by 2000. The winds have been out of the east for most of the evening at 6 knots reported at 1500 hours but then they began to pick up and gradually peaked out at gusts up to 30 knots before beginning to decrease around 1900. The actual wind during the approach has, however, actually varied from 050° to 110° at 8 to 19 knots. Simultaneously with the flight crew's call to Athens Approach, KLM flight 811 (A B747) is rolling out on final approach and finds that the headwind they had been experiencing suddenly changes to a 5 knot tail wind.

The last runway friction measurement had been made at 1410 in the afternoon and it had been measured on runway 33. The report referred to the "FIRST SECTION" braking action as "POOR" with the second and third sections reported as "MEDIUM". The "POOR" braking action on the approach end of runway is attributed to a heavy build-up of rubber deposits from landings.

During the approach the reported winds vary from 070° at 14 knots to 090° at 12 knots over a five-minute period. You have now broken out of the clouds and have been cleared to tower frequency. Three minutes later you are turning onto a visual final with the VASIs in sight and the gear down and checked and flaps set at 35°. A final check with the tower indicates that braking action is still medium to poor and normal reverse is specified after touchdown and reduction of speed to under the maximum flight manual deployment speed.



Capt. R.H.J. Smith, President of IFALPA

The computed landing distance is 2120 meters which includes the wet runway correction factor, far less than the 2980 meters available for landing roll out after deducting the displaced threshold distance. The tower clears you to land. Fourteen seconds later the airspeed is noted as slightly high then back on schedule 9 seconds later. In another 9 seconds the aircraft is on the ground with spoilers deployed and 6 seconds later the engines are developing normal reverse power which continues for an additional 16 seconds. Thus far apparently a normal landing. Fifteen seconds later you see a band of red lights and the aircraft plunges past the end of the runway, transits the 65 meter overrun and plunges down a 4 meter embankment and across a road before coming to a halt. Fire immediately breaks out and engulfs the aircraft. The crew manages to get most of the people out of the aircraft but 14 persons lose their lives. The airport crash crew takes 45 minutes to respond and the fire rages out of control for several hours.

What went wrong during this apparently normal approach and landing causing it to end in disaster? We will come back to that later but first let us look at the findings of the Greek Accidents Investigation Bureau. They were:

1. The crew touched down the aircraft too late, at a speed higher than normal after a non-stabilized approach, and
2. The crew did not in time and fully apply the braking systems (wheel brakes and reverse), particularly the wheel brakes after a touch down under known adverse conditions, so that it was no more possible to stop the aircraft at least before the end of the overrun area.

Now comes the aftermath. The flight crew is charged with "manslaughter," "willful negligence" and "disruption of air traffic." The three-day trial that followed was conducted in a noisy and crowded court room and the verdict handed down literally in the middle of the night is "guilty" and the two pilots sentenced to five years and two months in prison each—their careers smashed with the bang of a gavel.

Let us now return once again to the night of the accident and try to gain a little better insight into what actually occurred from the information which was not available to the flight crew. A B707 and a DC-10 had landed just before your flight. The flight crew of the Olympic 707 was fortunate in having landed at a low gross weight but still reported runaway braking conditions as "the worst ever" and the Swissair DC-10 which had followed it had to land short on the displaced threshold and to brake early and heavily, just managing to get stopped. None of this was passed on to your flight. A Finnair pilot who landed some 30 minutes after the accident experienced so much difficulty in getting the aircraft stopped that he had to effect emergency stopping procedures and immediately telexed his airline to say that it was "the most slippery runway in his life" although he was accustomed to icy conditions. The runway was subsequently closed temporarily by the airport authorities as a result of the telex.

The U.S. Department of Defense's Aerodrome and Facility Directory effective for the time of the accident (but not available to the flight crew of course) had some interesting things to say about Athenai Airport and I quote '. . . aircraft use extreme caution when the runway is wet. . .", that "approach winds from 340° to 090° may be 50% to 100% greater than reported surface winds" and that "no decelerometer is available for RCR" readings.

An additional unreported factor in the accident was the non-standard runway lighting system in use. According to the ICAO standard, lights normally change from solid white to red and white 900 meters from the runway end and then to solid red at 300 meters. At Athens the transition from white to solid red occurs at 150 meters from the end and the fact is not registered in documentation readily available to flight crews.

Here we are some seven years and two appeals later and having gone through the exhaustive, expensive and time consuming appeals process in the Greek courts. Neither Captain Schmutz nor first officer Deuringer have flown since that fateful night. Captain Schmutz retired. The accident and the findings of the Accidents Investigation Bureau have been analyzed thoroughly by independent investigators outside of Greece and the results of the analysis were presented to the Hellenic judicial authorities as a part of the appeals process. The cost of all this to date now approaches some one-million U.S. dollars to the persons concerned, i.e. Swissair, The Swiss Air Line Pilots' Association (AEROPERS) and to IFALPA. The findings of this separate and independent investigation were subsequently presented to the appeals court which accepted the causal factors as wind shear and poor braking coefficient, then exonerated the first officer and reduced (but did not dismiss) the sentence of the captain. I might also point out that today the airport deficiencies reported for runway 15L/33R still include:

BRAKING ACTION — runway slippery when wet if rubber deposits not removed from touch-down zone.

RUNWAY 15L/33R — runway and threshold not visible at night until late on base leg. Runway markings indistinct if rubber deposits not removed; and

RUNWAY 15L — approximately 65 meters from the end of runway is a 4 meter drop onto a road running at right angles to the runway axis.

Gentlemen, as you can see, the trap remains set and awaiting the next victim. I hope that you are not riding in the jump seat during the next event.

Some of you may be aware of the happenings of that dismal night of october 7th and will, hopefully, have reflected on the impact of your profession and upon ours which arises from the offering up of criminal charges against flight crews as the result of an aircraft accident. Where is this process likely to occur? Any place! Have we experienced any real events elsewhere in the recent past? Yes! Definitely! The process is spreading rapidly. At present the Swiss are pressing charges against Egyptian pilots. The Swedes are pursuing Swedish pilots involved in a gear-up landing accident, the Somalian Government has preferred charges against Ethiopian pilots and Greece is pressing charges against both Swiss and German flight crews.

As an active L-1011 captain flying internationally with Air Canada, I can easily visualize that criminal charges may be levied against me in any nation I fly into even when the cause of the accident is wind shear—charges as varied as criminal negligence, manslaughter and "dangerous flying", even when the State has not seen fit to equip the airport with such rudimentary wind shear detection devices such as LLWAS and despite the fact that current technology permits the introduction of wind shear warnings directly into the cockpit for real time flight crew evaluation. Can and should the flight crew be held responsible when information of this kind is withheld? I think not. Flight crews *must* be provided with the tools that are available to the critical decision-making process.

Back to the basic problem. It seems that national attitudes toward the prosecution of flight crews on criminal charges following an accident tend to be influenced strongly by the type of legal system adopted by the State. It seems that States which use the "common law" system, i.e. one that is based on the British legal system, tend to be less likely to prefer such charges. For those states where the legal system is based on the Napoleonic code, that is to say the French and Latin American nations, there is a greater tendency to prefer criminal charges. That is to say that the pilot-in-command is often considered to be in the same category as the driver of a car or a train conductor. This displays a clear lack of understanding of the complexities of our unique profession and of the conditions under which we operate. The authority and responsibility of the pilot-in-command begin with the closure of the doors prior to flight and end when the doors are opened after completion of the flight. In between those times we are relatively isolated from systems which remain on the ground except through the link by radio which has its own constraints imposed by traffic density, line of sight in the case of VHF and the fact that voice communications are frequently misunderstood or misinterpreted. In other words we are pretty much on our own and must rely on our training and experience in coping with unforeseen eventualities. Throughout an in-flight emergency the aircraft continues to advance relentlessly and there is no place to pull over and park while we think things over. When the fuel supply is exhausted, the irrepressible forces of gravity will take over and the aircraft will come back to earth. There in lies some of the differences between the pilot profession and the others that judicial and bureaucratic authorities often attempt to lump us in with for convenience's sake.

We are trained professionals. Trained to react within the time and space constraints imposed on us by the very nature of the vehicle. The time available to analyze a situation and to react is often measured in seconds. In some States there is an apparent total lack of understanding within judicial circles of the profession and how it differs from other professions. As an example, in the instance of the Athens accident that I talked about earlier their judge thought that since the pilot in the right seat was flyiing the aircraft and in light of the fact that the brakes could only be applied from the left seat that the two pilots had actually changed seats after touchdown. My point, of course, is that those prosecuting, adjudicating and those defending in aviation related cases should be specially qualified as having a basic understanding of the air line pilot profession.

Gentlemen, I have taken you through a real-life occurrence and described to you the current difficulties faced by the air line pilot profession as it relates to criminal liability. I would ask you to re-think the subject with a view toward re-forming national opinion on the subject of the criminal prosecution of flight crews after an accident. We think that this is an educational problem and one that can be alleviated by the proper selection of concerned legal professionals to large degree. At the international level we firmly believe that the time has come to adopt an international protocol aimed at codifying the various and diverse national legal systems so as to provide a high degree of commonality as it involves the air line pilot flying international routes.

Perhaps some of you might say that you have heard this subject addressed before in a different venue. Perhaps so since it is a long-standing thorny issue which is getting worse, not better. Our own International Councillor, Mr. Olof Fritsch, who is also the chief of the ICAO Accident Investigation and Prevention Branch, has written an excellent article on the subject which was published in the August edition of the ICAO Bulletin. It focuses in on the issue of the use of information contained in accident reports for purposes other than accident and incident investigation and places emphasis on the provisions of ICAO ANNEX 13 standard which states that "the fundamental objective of the investigation of an accident or incident shall be the prevention of accidents and incidents. It is not the purpose of this activity to apportion blame or liability." We strongly support this international standard and seek a total separation of the accident investigation and judicial processes.

In closing let me once again mention the Athens case and I quote from captain Bud Leppard, Accident Analysis Study Committee Chairman at the time, and one of IFALPA's investigators in this notorious case.

"It is my fervent hope that the principal officers, the legal committee, and the member States of the Federation as a whole will be able to use this trial to bring public pressure to bear upon the various States so that no pilot will in the future be subjected to the incredible mistreatment which we observed in this case."

I thank you for this opportunity to address this meeting and would now ask for your questions and comments on the subject.

Aircraft Accident and Incident Investigation in the Context of the Australian Legal System

By P. E. Choquenot
Bureau of Air Safety Investigation
Commonwealth of Australia

Investigation

Let me say at the outset that accident and incident investigation in Australia has in the past, and I believe will continue in the future, to be based firmly on the basic principle annunciated in ICAO Annex 13, that:

> "The fundamental objective of the investigation of an accident or incident shall be the prevention of accidents and incidents. It is not the purpose of this activity to apportion blame or liability"

However, it would be unrealistic not to accept that, in the course of many investigations, other interests come into play. These other interests must be addressed firmly and fairly, but must not be allowed to affect the conduct of that or any future investigation.

As many of you would be aware Australia played a not inconsiderable part in the major 1970 revision of the ICAO Manual of Aircraft Accident Investigation and we have made significant contributions to the continuing development and amendment of Annex 13. As a consequence there are few if any areas of the actual investigation process in which Australia does not follow the ICAO recommended procedures.

Legal Position

The Australian legal system is based on its British traditions and the basic legislation which provides for aircraft accident investigation is the Air Navigation Act 1920 which adopted as its first schedule the Chicago Convention on International Civil Aviation. Delegates will recall that Article 26 of the Convention provides for the investigation of accidents. The Air Navigation Act was amended in 1984 to provide legal protection for evidence derived from cockpit voice recordings, and I will be dealing with that issue in detail later.

Flowing from the Air Navigation Act are Air Navigation Regulations (ANRs) which specify in detail the various aviation regulatory requirements. Part XVI of the Air Navigation Regulations - Accident and Incident Inquiry specifies the procedures and requirements for the investigation of accidents and incidents, both domestic and international, and the conduct of Boards of Accident Inquiry. The Bureau of Air Safety Investigation (BASI) is the body charged with the responsibility for the investigation of all accidents and incidents.

Because of our British legal traditions and conventions certain common law matters affect the conduct of investigations. Among the more important of these are

The processes of subpoena and discovery
Coronial inquests
Civil litigation processes

In addition, in more recent times, a number of enactments have been made in the area of administrative law which includes the Freedom of Information (FOI) Act. This Act also impinges on the investigation process and I shall deal with it first.

Paul Choquenot, Director, Australian Bureau of Air Safety Investigation

Freedom of Information (FOI)

The FOI Act basically provides that all documents held by Government Departments or Agencies are available to the public. The Act, however, contains a number of sections which allow for documents to be exempt from its provisions for various reasons. The particular exemption which affects access to material derived from air safety investigations is Section 38, which states

38 A document is an exempt document if there is in force an enactment applying specifically to information of a kind contained in the document and

prohibiting persons referred to in the enactment from disclosing information of that kind, whether the prohibition is absolute or is subject to exception of qualifications.

There is an enactment in the Air Navigation Regulations designed to avoid public disclosure of investigation information. It is intended to ensure a continuing flow of such information in future investigations.

Air Navigation Regulation 283

(1) A report or other document furnished to the Secretary that relates to an accident or incident that is, or has been, the subject of an investigation shall not be made public without the approval in writing of the Secretary

(2) The Secretary may, for the guidance of persons engaged in air navigation, publish such comments and recommendations relating to the causes or circumstances of any accident or incident, the subject of an investigation, as he considers necessary or desirable for the purpose of any similar occurrence in the future

Requests under FOI legislation for the whole of the investigator's report - which may include witness statements, transcripts, medical evidence and opinion matter have been denied on the basis that ANR 283 is a secrecy provision within the meaning of S38 of the FOI Act. Decisions to refuse access have been appealed unsuccessfully to the Administrative Appeals Tribunal (AAT) and the Federal Court.

Following rejection of the first appeal to the AAT, BASI decided to relax its position of total refusal of access, and we now release to applicants all the material in an investigator's report except that covered by Annex 13 para 5:12 ie

a statements from persons responsible for the safe operation of the aircraft;

b communications between persons having responsibility for the safe 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;

e opinions expressed in the analysis of information, including Flight Recorder information

Cockpit Voice Recordings

Cockpit voice recordings are a special and sensitive case. Their presence in an aircraft cockpit represents a unique invasion of a person's right to privacy in the workplace, and the opportunity clearly exists for self-incrimination.

Although the requirement to fit cockpit voice recorders was first introduced in Australia in 1961, the Australian Federation of Air Pilots strongly maintained that the recorders were fitted for safety investigation purposes and should not be available for possible use against flight crews in criminal, civil or disciplinary proceedings. A 20-year impasse on their availability in non-fatal investigations was finally broken in 1984 when the Government amended the Air Navigation Act to prevent indiscriminate disclosure of their contents, and provide protection from their use against flight crews in criminal, civil and disciplinary proceedings. Incidently, CVRs are required to be fitted to all turbine powered aircraft above 12,500 lb (5700 kg) MTOW, regardless of the type of operation and, from January 1987, all pressurised, multi-turbine powered aircraft of 11 or more places will be required to be retrospectively modified with CVRs. The CVR was fundamental in establishing the circumstances in which a Westwind 1124 aircraft crashed into the sea, at night, off Sydney last year, killing all on board.

Subpoena and Discovery

BASI cannot protect its files from disclosure to the Courts under these Common Law provisions. However, approaches to the Courts for orders to restrict access to investigation material to the Court and parties directly involved in the litigation have generally been successful.

Coronial Inquests

Because BASI has the statutory responsibility for the investigation of all aircraft accidents, when fatalities occur we are invariably required to assist the Coroner. The degree of BASI involvement varies greatly from state to state and from Coroner to Coroner. In some cases the public release Accident Report or a Statement to Assist by the Investigator-in-Charge, may satisfy the Coroner. But in other cases the Coroner may require the Investigator-in-Charge to provide evidence personally and the accident files may be subpoened. In the latter case we normally arrange legal representation to request that access to investigation information on file should be restricted to the Court. This approach, generally, has been successful. Depending upon the attitudes of Coroners, inquests are increasingly becoming fishing grounds for future litigants.

Civil litigation

I well recall that in an address to an Australian Aviation Law Society Seminar a couple of years ago, Don Madole made a point that "lawyers could not expect the Government investigation to provide them with a ready made case - it was a starting point only for their own legwork". I agree entirely with this view. Although the amount of litigation is increasing in Australia, I doubt that it will ever reach anywhere near the levels of the USA. I think this is primarily because of our legal system which requires that the client shall be responsible for his own legal costs unless they are awarded by the court. Consequently any legal actions are normally commenced after the field stage of the investigation has been completed and usually after the report has been released. We have had virtually no pressure from lawyers or their consultants for direct participation in investigations. Incidentally, we do not have any provision for an NTSB type public hearing, or for consultation with interested parties prior to public release of the Accident Report which is prepared inhouse by the investigation team. Our policy on participation is to allow interested parties who can provide specialist knowledge in the circumstances of a particular investigation to participate on the basis of their contribution towards establishing the causal factors. However their contribution must not be directed, in any way, towards the protection of sectional interests.

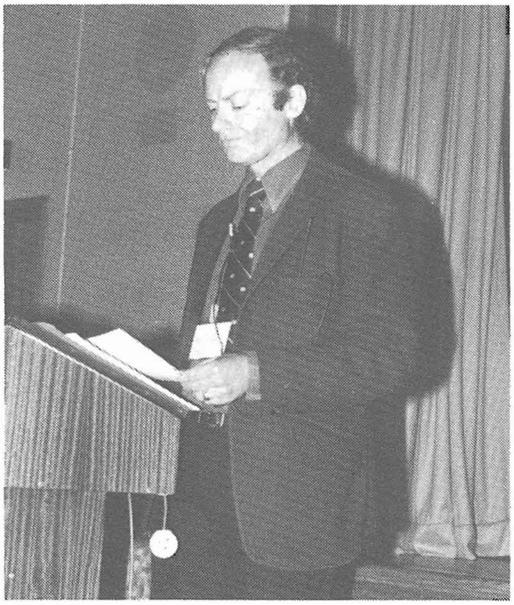
To assist parties who may have other interests, we will provide in addition to the official report, factual information including names and addresses of witnesses, and where destructive testing has been necessary, the factual elements of any specialist reports. The wreckage and other components are returned to the owner as soon as they are no longer required for our investigation purposes.

CONCLUSION

It can be seen that our investigations are clearly directed towards the general public interest in the enhancement of aviation safety, and while we will provide assistance to other interests, we take the view that this must not be allowed to interfere with our part in the continuing pursuit of a safer aviation environment.

Mr. David Adams, Australian Bureau of Air Safety Investigation in a joint presentation with Dr. Robert Lee.

Mr. Richard McKinlay, Accident Investigation Bureau, U.K. on "The International Investigation, How It Works In Practice"



Mr. Paul Mayes, Australian Bureau of Air Safety Investigation, on "The Specialist Support of Flight Recorders."

Accident to IAI Westwind VH-IWJ: Specialist Report of Simulator Experiments on Pilot Performance Under Unusual Instrument Conditions

By Dr. Robert Lee, BA, Ph.D.
Assistant Director, BASI

Introduction

The investigators of the accident to VH-IWJ considered that the pilot in the left hand seat, who was under check on the accident flight, may have been presented by the pilot in the right hand seat with a simulated emergency situation which left him with no direct instrument attitude reference. Further, under the environmental conditions on the dark night of the accident flight, and with the aircraft heading out to sea away from the lights of Sydney, the pilot under check would have had no external visual cues (such as horizon or texture gradient) by means of which he could determine the attitude of his aircraft.

In addition, the rate of turn indicator contained within the flight director on the left hand pilot's instrument panel was known to have been unserviceable at the time of the accident. Although the instrument was providing an accurate reading, it was operating in the reverse direction to normal. Thus, when the aircraft turned to the right, the instrument indicated a turn to the left, and vice versa. The check pilot was known to have been fully aware of this anomaly. The problem with the instrument had been previously mentioned to the pilot under check a week prior to the accident flight. Since then all his Westwind flying had been in aircraft other than VH-IWJ. There was no evidence that the anomalous rate of turn indicator had been discussed by both pilots or observed by the pilot under check in any briefings or pre-take off checks immediately prior to the accident flight. This would have been expected if the pilot under check had any recall of the instrument problem, particularly as he knew that the accident flight was to be a check flight on which he could expect to be given some difficult simulated emergencies. In the absence of any evidence to the contrary it was therefore considered likely that the pilot under check had forgotten about the anomaly by the time of the accident flight.

The likely nature of the simulated instrument failure, or 'limited panel', presented to the pilot under check was:

i) Failure of the flight director.
ii) Failure of the standby artificial horizon (by caging the instrument - failure therefore being instant).
iii) Physical masking of his own attitude instruments by the check pilot so that they were not visible to the pilot in the left hand seat.

Such an extremely limited panel, together with the total lack of any alternative attitude instrument reference, and the absence of any direct external visual attitude reference, places the pilot in a situation of maximum mental workload.

To fly the aircraft the pilot must mentally integrate the information from certain critical remaining instruments, such as the rate of turn indicator, airspeed indicator, vertical speed indicator, RMI, HSI, and standby compass, and translate this information into control inputs to achieve an intended effect - e.g. a particular rate of turn, or a change in the aircraft's attitude. The extent to which this intended effect is achieved, i.e. feedback on the effects of the control inputs, must be mentally computed by further integration of the changes, or lack of changes, in the remaining instruments. This information flow process is continuous.

The difficulties faced by pilots in this type of situation are a direct consequence of the human operator's fundamental limitations as a single channel, limited capacity processor of information. In all flying the pilot is a component of a closed loop man-machine system. In normal flying aircraft attitude information is provided to the pilot directly by the attitude indicator and by external visual reference. In contrast, a limited panel situation with no external visual reference adds another level of information processing to the task of the pilot. This is because, as explained above, the attitude information cannot be read out directly. It must be derived indirectly from the integration of the information from a number of instruments, none of which alone provides enough information to determine the aircraft's attitude. The additional level of information processing required to fly the aircraft in this situation substantially increases the mental workload of the pilot.

If one of the remaining instruments is displaying an invalid indication, the task demands on the pilot become even greater, because the anomalous information must either be ignored or accommodated into the pilot's information processing strategy. This presents a particular problem when the instrument has not failed completely but is operating normally apart from the direction of indication. Incorrect information is usually worse than no information at all. Attempting to accommodate the anomalous information creates a conflict in the pilot's overlearned information processing strategies - e.g. his scan pattern.

Even if the pilot becomes consciously aware of the anomaly, the correct information may still prove difficult or impossible to ignore, and the anomalous instrument may tend to capture the attention of the pilot whose control movements therefore become inappropriate to his intended objective (e.g. to position the aircraft on a new heading by means of a turn to the left). Substantial errors then build up and the resultant corrective action is also inappropriate, serving only to increase the original error. Finally the pilot may realise that his control movements are inappropriate, overcorrect, and thereby reverse the direction of the error.

Because of the lack of direct attitude information, considerable time is required for the integrative processing described above, allowing even greater discrepancies to build up while the decision process is taking place. In extreme situations the information processing demands of the task may overload the pilot's single channel. The situation will then 'get away from him'. Complete disintegration of performance is the final result.

The presence of stressors such as fatigue may considerably reduce pilot information processing capabilities, and consequently the ability of a pilot to cope adequately with an emergency situation which imposes a very high mental workload, such as a limited panel.

Pilots are trained to fly the aircraft on a limited panel, and even though the task is difficult for the reasons described above, it should be within the capabilities of a properly trained pilot, provided the remaining instruments are operating correctly. However, the specific effects on pilot performance of a reversed rate of turn indicator in an extreme limited panel situation were not known.

In order to obtain specific information on pilot performance in the limited panel/lack of visual reference situation described above, in particular when the rate of turn indicator operates in the reverse direction to normal, a series of experiements were carried out in a flight simulator which had basically the same flight director system as did VH-IWJ.

SIMULATOR EXPERIMENTS

1. OBJECTIVES

i) To obtain objective and subjective information on the performance of pilots when faced with a limited panel emergency in which all direct instrument and external visual attitude reference is lost; and,

ii) To determine the aircraft flight path following the onset of this emergency, under the following conditions:

Condition A - with the rate of turn indicator operating normally.

Condition B - with the rate of turn indicator operating in the reverse direction to normal.

Condition C - with the rate of turn indicator operating in the reverse direction to normal, but with the pilot fully aware of this anomaly.

2. METHOD

VH-IWJ was a IAI Westwind aircraft. The captain's instrument panel was equipped with a Collins flight director, model No. FCS 105 329B-8Y. There are no Westwind simulators in Australia. However, as stated above, the primary objectives of the simulator experiments were to assess the performance of pilots and its effect on their aircraft in a situation in which all direct attitude reference was missing. This overall aim was therefore not dependent on specific aircraft type, provided it was within the general category of a high performance civil jet. However, for application of the experimental results to the accident to VH-IWJ to be valid, the use of a simulator with an instrument configuration as close as possible to that of VH-IWJ was required.

A simulator which met both these requirements was the Boeing 707-338 simulator owned by the RAAF which is maintained by Qantas and located at the Qantas simulator facility at Sydney airport.

The B707 was equipped with a Collins FD-108 flight director. This instrument was closely similar to that on the left hand panel of VH-IWJ. The main difference was that the FCS 105 contains a rate of turn indicator within the flight director instrument display, whereas the rate of turn indicator in the B707 is a separate instrument located below and to the left of the FD 108 flight director display. Photographs of the relevant instruments for both aircraft are in Appendix A. Although slightly different in physical layout, the B707 instrument configuration conveyed the same information to the pilot as did the FCS 105 instrument of the Westwind.

As can be seen from the photographs, the rate of turn indicator in the B707 provided a considerably larger display than the Westwind rate of turn indicator. The angle of deflection of the pointer also provided some information redundancy in comparison to the FCS 105 'dot' display of the Westwind (see photographs). It was therefore considered likely that any difficulties encountered by pilots with the rate of turn indicator would be exacerbated in the Westwind in comparison to the B707.

Following a comprehensive briefing on the purpose of the experiments, both Qantas and the RAAF offered their full support and cooperation in the study.

The emergency conditions to be researched were based on information from the VH-IWJ accident investigation. The B707-338 simulator was inspected by BASI investigation, flight data recorder and human performance specialist staff who also held discussions with Qantas simulator engineers. As a result of these discussions modifications were made to the simulator and a configuration chosen to simulate more closely aspects of the Westwind performance, in particular the rate of roll. The modifications included the installation of a 7 channel pen recorder to record selected pilot and aircraft performance parameters. These will be described in detail later.

An initial study to evaluate, test and refine the experimental procedure was then carried out using a single B707 pilot as an experimental subject. Following this study an event recorder was added to the simulator to enable the experimenter to record the precise instant the emergency was presented to the pilot. Finally, on the basis of this initial study and after detailed consideration of all the accident factors involved, together with time and cost restrictions on the availability of pilot subjects and the use of the simulator, the final experimental method adopted was as follows:

For each experimental trial, the accident flight profile of VH-IWJ was replicated in the simulator from the start of the take off roll on runway 16 at Mascot up to the time the pilot in command was presented with the limited panel emergency. The profile consisted of the take off roll and climb on the SID (Standard Instrument Departure) flown by VH-IWJ until the commencement of the turn onto a heading of 357 degrees. This left hand turn commenced almost immediately after the imposition of the limited panel emergency.

On each trial the experimenter gave the pilot standardised instructions, a copy of which is at Appendix B. These instructions emphasised that the pilot had to maintain the SID under the emergency conditions. The trained reaction of RAAF pilots to this type of extreme emergency is to stabilise the aircraft on a constant heading, wings level, while they diagnose the emergency and determine the most appropriate recovery procedure. For the present experiment it was considered essential that the pilots attempt to maintain the SID following the emergency, as the accident investigators considered this to have been the most likely situation in the cockpit of VH-IWJ. If a pilot in the experiment tried to depart the SID while he sorted out the problem, the experimenter told him that due to conflicting traffic he had no option but to maintain the turn onto 357 as per the SID.

Beyond the point at which the emergency was presented, the aircraft's flight path was dependent upon the response of each individual pilot to the emergency while attempting to maintain the SID. (The flight paths of the B707 pilots in the emergency situation were later compared with that of VH-IWJ as shown by its flight data recorder).

In order to obtain a measure of consistency, or reliability, of pilot performance, each subject was given two 'flights' under Conditions A and B, these being the conditions of primary interest to the investigation. One flight was conducted under Condition C.

As all subjects were current B707 crew, no 'normal' orientation flight was given to the subjects prior to the experimental trials. This also approximated the situation on the accident flight of VH-IWJ, which was the first flight for the pilot under check after coming on duty. In experiments such as this, performance on earlier trials may affect that on later trials. These influences are termed 'order effects'. In other words, changes in performance may in part be due purely to the order in which the trials are presented as well as to any specific effects of the different experimental conditions on each trial. For example, earlier trials may provide subjects with learning of familiarisation with the experimental situation, factors which in themselves will result in improved performance on later trials aside from any changes brought about by the different conditions.

The standard method of dealing with order effects is to employ a counterbalanced experimental design. This means that half the subjects undergo the experimental trials in one order, and the other half perform the trials in the reverse order. Any order effects thus cancel each other out.

The experimental design initially adopted in the present study was to present Condition A then Condition B to half the pilots, and Condition B then Condition A to the other half. Condition C had to be performed last because its presentation earlier would obviously cue the pilots to the reversed rate of turn indicator in Condition B.

As the experiment proceeded, it became clear that if the highly trained military pilot subjects were going to lose control of the aircraft, (and very few of them did) they were most likely to do so under Condition B, where Condition B was presented first. Order effects were clearly so strong that two trials under Condition A greatly enhanced the ability of the subjects to perform Condition B. Consequently, in order to increase the probability of obtaining sufficient useful data relevant to the VH-IWJ accident from the small sample of subjects available for the simulator experiments, it was decided that all remaining subjects would receive Condition B first. In this study, the empirical requirements and the constraints on time, personnel and resources made a counterbalanced design impracticable. Further, the loss of control was clearly a low probability event even under Condition B, and its occurrence was obviously dependent upon Condition B being presented first. The use of an 'ideal' design would have effectively halved the already small sample size, and thus greatly reduced the probability of obtaining useful data in relation to the accident.

This situation was also closer to that of the accident flight where no 'practice' had occurred prior to the pilot being faced with the extreme emergency described above. The change in method was therefore considered acceptable.

A further slight modification to the experimental design was made as the experiment progressed. During the experiment most pilots deduced that the rate of turn indicator was operating in the reverse direction following the onset of Condition B, and commented to the experimenters accordingly. This knowledge effectively transformed Condition B into Condition C. When this occurred, there was clearly no requirement for the final trial under Condition C, so it was not carried out. If pilots were not aware of the anomalous instrument indication (or did not volunteer the information), the Condition C trial was carried out.

Prior to commencing the experimental trials in the simulator each subject completed a sleep log for the 24 hours prior to the experiment together with two subjective fatigue checklists. This was done to explore any relationships between fatigue state and performance, a factor which was considered to be of possible importance in the VH-IWJ investigation. Copies of the questionnaires are at Appendices C, D, and E. Following the experimental trials subjects completed a further comprehensive questionnaire on their experiences during the experiment. Of particular interest were the pilots' reports of difficulties they experienced in Condition B, the methods they used to determine attitude reference, and the visual scanning patterns they employed in doing so. A copy of this questionnaire is at Appendix F.

Subjects

The subjects used in the main study experiments were 8 RAAF B707 pilots from 33 Squadron RAAF Richmond. One ex-RAAF Qantas simulator instructor who was also in the RAAF Active Reserve and current on the B707 was used in the initial study.

The RAAF pilots, having been through the rigorous and comprehensive military pilot training system were considered to be better equipped to cope with more extreme emergency situations, such as the limited panel case of the present study, than pilots who had been trained under the civilian training system.

Details of all main study subjects are tabulated below (Table 1)

S	Age	Flying hrs Civ	Flying hrs Mil	Flying hrs Tot	Hrs B707	Hours last- 30 days	Hours last- 48 hrs	Flt crew status	Ratings	Major types flown
1	33	100	4700	4800	2000	45	5	CatB Capt	QFI;IRE; Rt check Capt	Macchi,C-130, B707
2	31	15	4000	4015	40	40	13	CatC Co-pilot	SCPL/clsl inst rtng	Caribou, BAC-111,B707
3	31	nil	4000	4000	1100	33	nil	CatB Capt	QFI	Macchi,HS748 T33,B707
4	33	nil	4600	4600	1600	26	5.7	CatB Capt	Check cpt Route chk capt,Sim instrctr	Iroquois, C-130,B707
5	41	150	8200	8350	400	7	7.5	CatC Capt	QFI,IRE	C-130,Viscount CV440,HS748, CT4,Winjeel, B707
6	28	150	3800	3950	300	40	9	Copilot	QFI	Caribou,DC-3 Macchi,T-33 B707
7	37	nil	5800	5800	400	20	nil	Copilot	Nil	Caribou,HS748 DC3,Canberra, B707
8	--	nil	6280	6280	517	31	nil	CatC Capt	QFI	DC3,C130,B707 Macchi,Winj.

All the RAAF subjects were highly experienced pilots. Their average number of flying hours was 5,224, with a maximum of 8,350 hrs, and a minimum of 3,950 hrs.

Apparatus

The simulator used was a Boeing 707-338 simulator manufactured by the Link Group of General Precision Systems Inc. equipped with a Vital 4, 2 window CGI (computer generated imagery) visual system. A GP-4 computer provided control of the simulator. The simulator was equipped with a three axis motion system. The experiment was carried out with the motion system on.

For the purpose of the experiment Qantas simulator engineers installed a 7-channel pen/paper tape recorder to record the following parameters:

a) Aircraft performance parameters:

1. Indicated air speed (IAS) - 0 to 512 kts.
2. Altitude - 0- 8192 ft.
3. Pitch - +180 degrees nose up to -180 degrees nose down.
4. Roll - +180 degrees right to -180 degrees left.
5. Heading - 0 to 360 degrees.

b) Pilot performance parameters:

6. Stick angle - 16 degrees aft to 16 degrees forward.
7. Control wheel angle -128 degrees left to 128 degrees right.

Another pen to the recorder was connected to a switch installed in the simulator to enable the experimenter to record the exact point in time at which the simulated emergency was presented to the pilot. For each trial in which the rate of turn indicator was operating normally (Condition A), one pulse was recorded on the paper tape. For the situation in which the rate of turn indicator was operating in the reverse direction (Conditions B and C) two pulses were recorded.

The simulator circuitry was modified to enable the experimenter to reverse the direction of operation of the rate of turn indicator display at any time by means of a switch on the Flight Engineer's panel, out of the view of the pilots.

So as not to alert the pilot to the anomaly under Condition B, the rate of turn indicator was allowed to operate normally for take off and the initial turn. It was reversed while the aircraft was on a constant heading, wings level, just prior to the limited panel emergency being presented to the pilot. Reversing the direction of operation of the instrument under these conditions had no effect on the instrument display - i.e. the pointer remained vertical. The anomalous indications thus did not occur until the aircraft commenced the left turn onto the heading of 357 degrees under the limited panel conditions.

To obtain a rate of roll closer to that of the Westwind, the simulator was configured very light. This was achieved by reducing the amount of fuel to zero, thereby reducing the inertia of the aircraft.

Each trial commenced at the start of the take off roll and terminated when the aircraft had either completed the turn onto the heading of 357 degrees successfully, or control of the aircraft had been lost and the aircraft crashed.

RESULTS

The main results were as follows:

• In the main experiment, two pilots completely lost control and crashed the aircraft on one trial under Condition B; the pilot used in the preliminary study also lost control and crashed the aircraft under Condition B - i.e. three of the nine pilots tested (33%) lost control and crashed, two on their first trial and one on his second.

In all of these cases:

— control was lost following commencement of what the pilot intended to be the left hand turn onto the SID heading of 357 degrees.
— the loss of control finally involved a steep bank to the right following the initial commencement of the left hand turn onto 357 degrees.
— the aircraft impacted the sea after a steep dive (greater than 50 degrees nose down) at a very high indicated airspeed (greater than 500kts). While coping with the extreme limited panel emergency no pilots attempted to reduce engine thrust and all crashed with climb power still applied.
— the final 5000ft of the descent to the point of impact took an average time of 12 sec (max 17 sec; min 8 sec).
— 6 of the 8 subjects in the main study on their first trial under Condition B entered a right turn following their initial turn to the left. Where a crash did not result, these pilot subjects turned back to the left and completed the turn onto the heading of 357 degrees.
— For these 6 subjects on trial 1 under Condition B, the mean time from presentation of the limited panel emergency to the commencement of a right hand turn (whether or not it followed a left hand turn) was 6.33 sec. (s.d.= 2.06 sec; min 4 sec, max 9 sec).

• All the RAAF pilot subjects were able to fly the aircraft onto the SID heading of 357 degrees successfully under Conditions A and C. All completed at least one successful trial under Condition B.

• Although all main study pilots completed at least one successful trial under Condition B, their performances were generally worse under Condition B than they were under Condition A. Particularly on the first trial under Condition B, performance was considerably degraded in comparison to Condition A. This decrement was clearly observable on the pen recorder traces in terms of an increased magnitude and frequency, or 'coarseness', of pilot control inputs under Condition B -primarily in roll. The reduced pilot performance was reflected in the recorded behaviour of the aircraft - for example in terms of altitude and heading deviations.

• Six of the eight pilots correctly deduced that the rate of turn indicator was operating in the reverse direction during their first or second trial under Condition B.

• Seven of the eight pilots reported that they used the rate of turn indicator in their limited panel scan, even when they knew it was operating in the reverse direction.

• No pilots perceived any instrument discrepancy prior to the onset of Condition B.

• Six of the eight pilots rated Condition A as "moderately difficult'; one 'very difficult'; and one 'easy'. In constrast, four pilots rated Condition B 'very difficult'; three 'moderately difficult'; and one 'easy'. (Note: Both ratings of 'easy' were made by the same pilot. This pilot lost control on one trial and had the most difficulty on the others. Consequently, his ratings may reflect a misinterpretation of the rating scale. Whatever the reason, their validity is considered doubtful in the context of the ratings by all the other subjects.)

• None of the pilots regarded the extreme limited panel emergency under any of the experimental conditions as a reasonable and realistic emergency with which to confront a pilot in an actual aircraft.

• With the instruments operating normally (Condition A only), half of the pilot sample considered the extreme limited panel emergency to be an acceptable exercise in a simulator. The remainder considered it unacceptable, even in the simulator.

• No conclusions could be drawn from the sleep log and subjective fatigue questionnaires. 6 of the 8 pilots responded that they could have used more sleep, including the two who lost control. One of the two pilots who lost control was still 'jet-lagged' after returning from crewing an extended overseas trip. Overall, this pilot displayed the worst performance of the entire group. It is probable that his performance was affected by fatigue, especially as it was so much worse than all the other subjects in terms of the magnitude and frequency of control inputs. However, there was no pattern across all subjects.

• All pilots had read of the accident to VH-IWJ in the press, but seven of the eight in the main study, and the pilot in the preliminary study, had no prior knowledge of the specific emergency. One pilot knew of 'a problem with the turn needle', and that 'the chap may have been practising limited panel'.

DISCUSSION

The results of the study showed that under the extreme limited panel conditions under Condition B, i.e. where the rate of turn indicator was operating in the reverse direction to normal, it was possible for a highly trained, experienced and current military pilot to completely lose control of the aircraft. Including the results of the preliminary study, three out of the nine pilots tested lost control and crashed on one trial under this condition.

For seven of the eight pilots in the main study, and the pilot in the preliminary study, the nature of the emergency was unknown; consequently, there was no prior knowledge to prepare them for or assist them in diagnosing and coping with Condition B.

Of considerable interest was the finding that, even where control was not finally lost, 6 of the 8 subjects in the main study entered a turn to the right very shortly after the emergency was presented to them on their first trial under condition B (mean time to beginning of RH turn = 6.33 sec.). This finding is counter-intuitive in that, with the rate of turn indicator showing a right turn when the left hand turn had commenced, it was considered that the pilot would naturally apply more left bank input to achieve the desired result. As a result, it was expected that if control were lost, it would involve an increasing bank to the left. The simulator experiments showed unequivocally that this was not the case.

Seven of the eight pilots reported that they used the rate of turn indicator in their limited panel scan, even when they knew the instrument was operating in the reverse direction. As one pilot put it: "When the T&B operated in the reverse sense the scan was the same, however the misleading T&B information took a little thought to rationalise." The pilot used in the preliminary study stated that he could not ignore the anomalous indication even when he had been made aware of it. In fact, he refused to continue to attempt to fly the aircraft under this condition.

The introductory remarks described the consequences of man's limited capacity single channel information processing system. The additional workload already imposed by the limited panel emergency is increased further under Condition B by the need to convert mentally the information from the anomalous instrument to the correct reading. If this workload exceeds the channel capacity of the pilot, 'load shedding' results. A typical form of load shedding is to focus attention on one, or only a few instruments.

As stated in the introduction, an anomalous instrument may prove difficult or impossible to ignore, or to accommodate into a pilot's overlearned scan pattern. It may capture the pilot's attention and he will respond to it as if it were operating normally.

In the present study, it is suggested on the basis of their questionnaire responses, observation of their performance and the theoretical considerations discussed earlier, that pilots in the experiments tended to focus attention primarily, but not solely, on the rate of turn indicator under the limited panel conditions. The rate of turn indicator is a high priority instrument in their limited panel scan when the instruments are operating normally.

None of the pilots had ever previously encountered the situation of Condition B. In this condition, when the rate of turn instrument was operating in the reverse direction, the additional processing required to diagnose, accommodate and mentally 'convert' the anomalous information overloaded their channel capacities, particularly in the time period immediately following the onset of the emergency. The result was an initial channelising of their attention on the rate of turn indicator. During this 'sorting out' period they responded to the rate of turn indicator as if it were operating normally. The initial left turn as per the SID was shown as a right turn by the rate of turn indicator. It was therefore rapidly corrected to an indicated left turn.

Consequently, an actual right turn (indicated on the rate of turn indicator as a left turn) was entered very shortly after the Condition B emergency, and was continued during the time taken for the pilot to diagnose the problem and devise a processing strategy to cope with the anomaly. Pilots who were successful in doing this then resumed the actual left turn (indicated as a right turn) once they had formulated this processing strategy. The three pilots who were unable to do so on one trial under Condition B continued on that trial in accordance with the indicated left turn, which was actually a right turn. Their control inputs became more extreme as these inputs appeared to be failing to produce the heading changes in the desired direction, i.e. to the left, as indicated by the RMI. The processing strategies of these pilots finally broke down completely as their instrument information conformed to no learned pattern: the instrument readings did not cross correlate, they made no sense. In trying to make sense of these readings the pilots' channel capacities became further overloaded. As a result their performances finally disintegrated, and they crashed the aircraft.

This consistent finding of a right turn proved to be most important because it provided an explanation for apparent flight path anomalies in the FDR recovered from the wreckage of VH-IWJ. The finding of a right turn under Condition B was applied to the VH-IWJ data analysis, and the resultant flight path was then consistent with the FDR information up to the end of the valid recorded data. (see accident report.)

It should be noted in applying the results of the B707 studies to the analysis of the accident to VH-IWJ, that they were obtained in a situtation in which the pilot subjects were very highly trained and the rate of turn instrument display of the B707 was less difficult to interpret than that of VH-IWJ. In spite of this, three pilot subjects lost control and crashed the aircraft on one trial under Condition B. It is therefore considered that if the pilot of VH-IWJ had been presented with the extreme limited panel situation represented by Condition B in this study, he would have been faced with a more difficult situation than the B707 subjects; further, he would have been less well equipped to cope with the emergency because his training was not to the very high level of the military pilot subjects used in the experiments.

Dr. Robert Lee, Australian Bureau of Air Safety Investigation, in a joint presentation with David Adams, "Human Factors—The Psychological Support."

CONCLUSIONS

The main conclusions drawn from the results of this study were:

• It is possible for a highly trained, experienced and current military pilot to lose control completely and crash his aircraft when faced with an extreme limited panel emergency in which all direct external visual and instrument reference is lost, and the rate of turn indicator reads in the reverse direction to normal. (On the basis of the small sample used in the present study, the empirical probability that a pilot would lose control on one of the two trials under Condition B was $p=0.33$.)

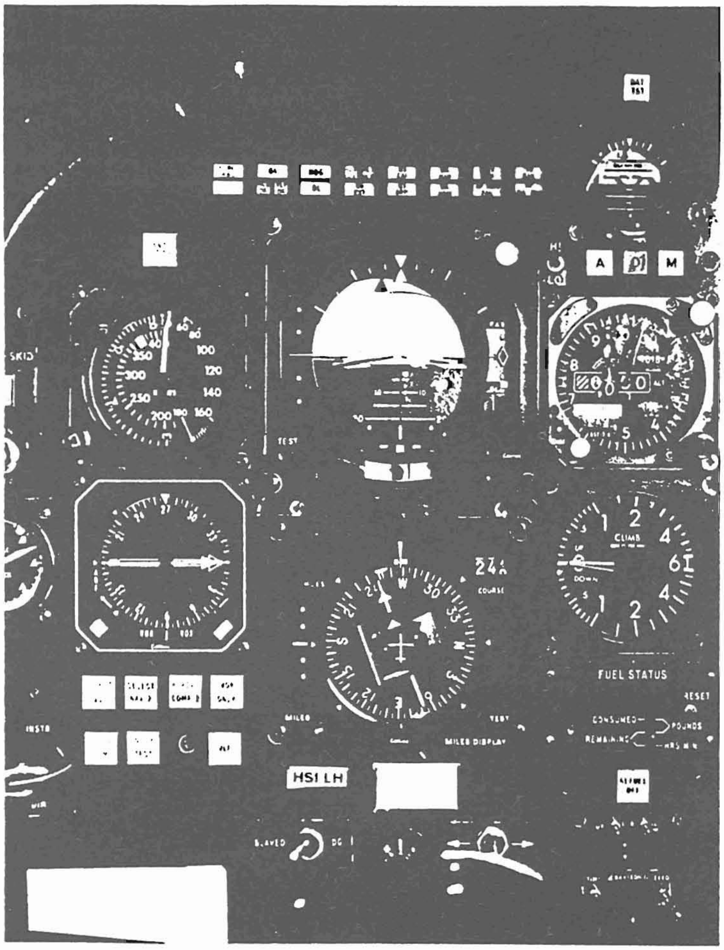
• Immediately following the *first* onset of this emergency situation, the initial effect on pilot behaviour of the reversed rate of turn indicator is consistent across all such pilots, whether or not they ultimately crash the aircraft. At first, the instrument is responded to as if it were valid, even though it is clearly in conflict with other instruments such as the RMI. If the pilot is then unable rapidly to revolve and adapt to the conflict between the rate of turn indicator and the other instruments, he will continue to focus, (or 'channelize'), his attention solely on the invalid rate of turn indicator and respond accordingly, in which case he will inevitably lose control of the aircraft.

• Once control is lost, the aircraft descends extremely rapidly in a very steep dive to impact.

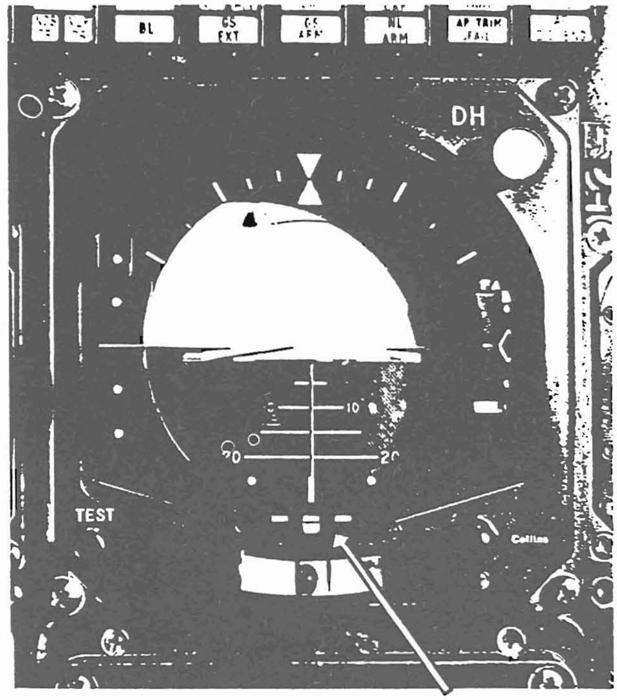
• Although they consider the task difficult, it is possible for highly trained, experienced and current military pilots to maintain control and fly their aircraft in this extreme emergency situation, but their flying performances are degraded in comparison to the same emergency when the rate of turn indicator operates normally.

• Highly trained, experienced and current military pilots are all able to maintain control of their aircraft under the same extreme emergency situation without undue difficulty when the rate of turn indicator operates normally.

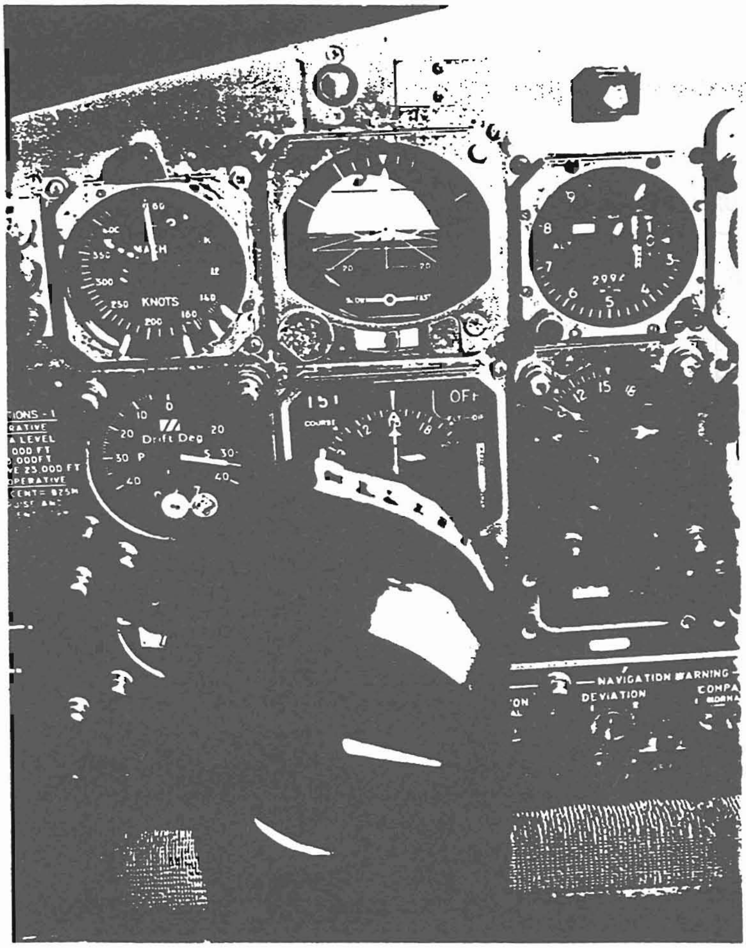
• The extreme limited panel emergency with the rate of turn indicator reading in the reverse direction is not an acceptable emergency exercise with which to confront a pilot in either a real aircraft or a simulator.



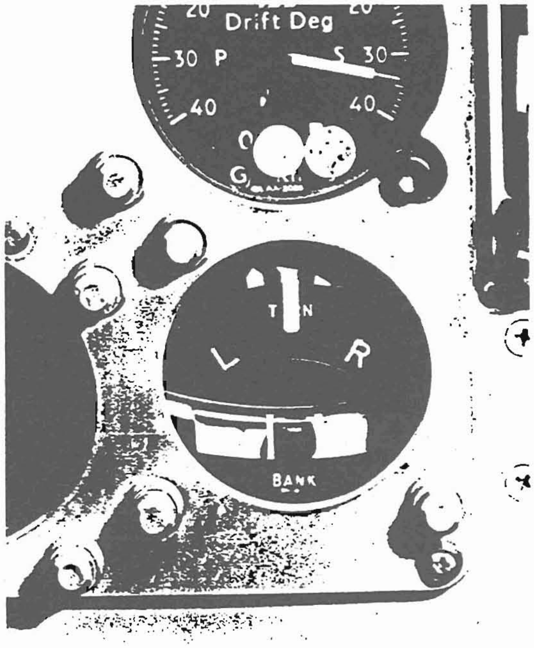
APPENDIX A.1
VH-IWJ INSTRUMENT LAYOUT



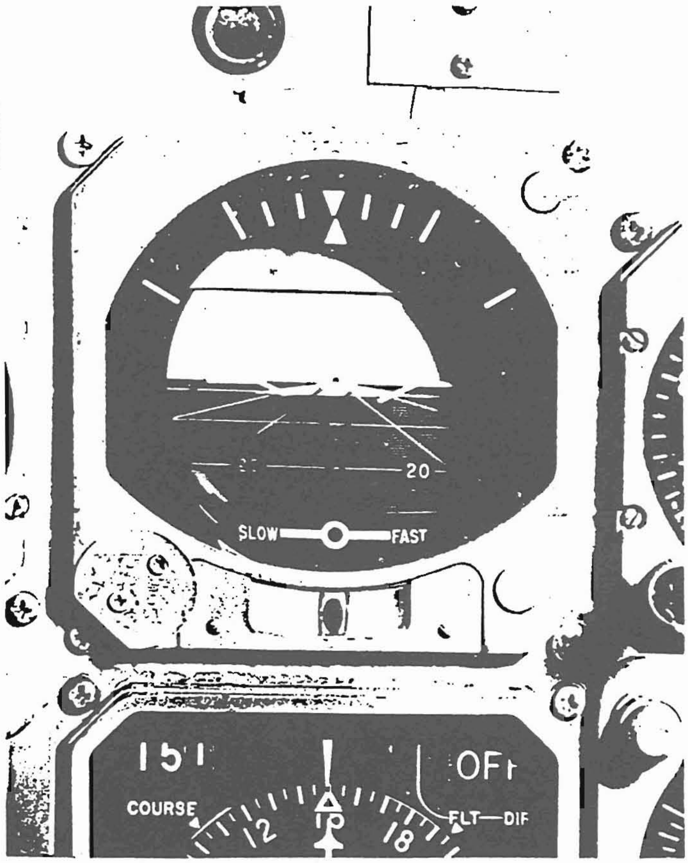
APPENDIX A.2
VH-IWJ FLIGHT DIRECTOR



APPENDIX A.3
B707 INSTRUMENT LAYOUT



APPENDIX A.5
B707 RATE OF TURN INDICATOR



APPENDIX A.4
B707 FLIGHT DIRECTOR

APPENDIX B

1) STATEMENT MADE AT 5.5 DME SYDNEY:
"OK WE'LL JUST DO SOME EMERGENCY FLIGHT INSTRUMENTS NOW."

2) INSTRUCTION GIVEN IF THE PILOT ATTEMPTED TO DIVERT FROM THE SID;
"DUE INBOUND TRAFFIC, MAINTAIN THE SID."
THIS INSTRUCTION WAS REPEATED IF NECESSARY.

APPENDIX C

SLEEP LOG

IDENTIFICATION NUMBER	DATE	TIME	DUTY

1. On the chart below draw a horizontal line through the squares corresponding to the half hour periods during which you were asleep during the last 24 hours. Put an X in the square corresponding to any half hour period during which you recall waking up for 15 to 30 minutes.

DAYTIME

0900 1000 1100 1200 1300 1400 1500 1600 1700 1800 1900 2000

NIGHT TIME

2100 2200 2300 2400 0100 0200 0300 0400 0500 0600 0700 0800

2. How much trouble did you have going to sleep last night? ☐ NONE ☐ SLIGHT ☐ MODERATE ☐ CONSIDERABLE	Time to fall asleep? _______MINUTES	3. How many times do you recall waking up last night? ________
4. How rested do you feel? ☐ WELL RESTED ☐ MODERATELY RESTED ☐ SLIGHTLY RESTED ☐ NOT AT ALL		5. Do you feel that you could have used more sleep? ☐ YES ☐ NO
6. Today's Mood? ☐ VERY POOR ☐ POOR ☐ AVERAGE ☐ GOOD	Number of dreams recalled? __________	7. Hours of work in last 24 hours? ________

(Note especially reasons for loss of sleep, such as duty, noise, cold, personal, etc.)

APPENDIX D

IDENTIFICATION NUMBER	DATE	TIME	DUTY

Choose one of the seven statements below which best describes your present feelings. How you feel right now.

(1) Feeling active and vital; alert; wide awake.
(2) Functioning at a high level, but not at peak; able to concentrate.
(3) Relaxed; awake, responsive, but not at full alertness.
(4) A little foggy; let down; not at peak.
(5) Foggy; slowed down; beginning to lose interest in remaining awake.
(6) Sleepy; woozy; prefer to be lying down; fighting sleep.
(7) Almost in reverie; sleep onset soon; losing struggle to remain awake.

APPENDIX E

SUBJECTIVE FATIGUE CHECKLIST		DATE
NUMBER	NAME (Last, First, MI)	CODE OR CASE NR.
RANK	TEST IDENTIFICATION	

INSTRUCTIONS: Make one, and only one (✓) for each of the ten items. Think carefully about how you feel right now.

ITEM NR.	BETTER THAN	SAME AS	WORSE THAN	STATEMENT
1.				VERY LIVELY
2.				EXTREMELY TIRED
3.				QUITE FRESH
4.				SLIGHTLY POOPED
5.				EXTREMELY PEPPY
6.				SOMEWHAT FRESH
7.				PETERED OUT
8.				VERY REFRESHED
9.				FAIRLY WELL POOPED
10.				READY TO DROP

REMARKS

APPENDIX F

BUREAU OF AIR SAFETY INVESTIGATION

PILOT:

AGE:

1. TOTAL FLIGHT EXPERIENCE (IN HOURS): i) ARMED FORCES
   ii) CIVIL AVIATION
   TOTAL
2. CURRENT FLIGHT CREW STATUS: (e.g. Captain (Cat A, B, C, D); Copilot)
3. ADDITIONAL RATINGS - e.g. QFI
4. MAJOR TYPES FLOWN:

5. OTHER TYPES OF AIRCRAFT ON WHICH CURRENTLY ENDORSED:
6. TOTAL TIME ON B707:
7. TIME SINCE LAST FLIGHT IN B707:
8. NUMBER OF HOURS FLOWN IN THE LAST 30 DAYS, 60 DAYS, 90 DAYS:
9. NUMBER OF HOURS FLOWN IN LAST 48 AS A CREWMEMBER:

CONCERNING TODAY'S SIMULATOR EXERCISE:

10. HAVE YOU EVER PERFORMED THE SIMULATED EMERGENCY EXERCISE BEFORE (i.e., manoeuvres without any direct instrument or visual attitude reference and in some cases with invalid instrument displays)
11. IF YES - HOW OFTEN?
    - HOW LONG SINCE THE LAST OCCASION?
12. ON THE FOLLOWING SCALE, RATE THE DEGREE OF DIFFICULTY OF THE PARTIAL PANEL MANOEUVRE: (circle the appropriate number)

i) instruments OK	ii) instruments invalid
1 - very easy	1 - very easy
2 - easy	2 - easy
3 - moderately difficult	3 - moderately difficult
4 - very difficult	4 - very difficult
5 - impossible	5 - impossible

13. DESCRIBE THE METHOD BY WHICH YOU ATTEMPTED TO MAINTAIN ATTITUDE REFERENCE (INCLUDE DETAILS OF YOUR SCAN PATTERN, SPECIFIC INSTRUMENTS REFERRED TO, AND RATE THOSE INSTRUMENTS IN ORDER OF PRIORITY OF IMPORTANCE IN PERFORMING THE EXERCISES - 1. INSTRUMENTS OK, AND 2. INSTRUMENTS INVALID)

14. WERE YOU AWARE AT ANY STAGE OF DISCREPANCIES IN THE INSTRUMENT DISPLAY:
    i) PRIOR TO THE EMERGENCY
    ii) DURING THE EMERGENCY

15. IF SO, AT WHAT POINT DID YOU BECOME AWARE?
    - HOW DID YOU BECOME AWARE?

16. WHAT WAS THE DISCREPANCY? (IF ANY)

17. WHAT PRIOR KNOWLEDGE DID YOU HAVE OF -
    i) THE SUBJECT ACCIDENT
    ii) THE SPECIFIC EMERGENCY

18. WHAT WERE YOU EXPECTING AFTER BEGINNING THE FIRST TAKE OFF ROLL?

19. DID YOU REGARD THE SIMULATED EMERGENCY AS A REASONABLE AND REALISTIC EMERGENCY WITH WHICH TO CONFRONT A PILOT?

	a) instruments OK	b) instruments invalid
i) in the simulator	yes/no	yes/no
ii) in the aircraft	yes/no	yes/no

20. PLEASE MAKE ANY OTHER COMMENTS ON YOUR REACTION TO THE TASKS YOU WERE ASKED TO PERFORM IN THE SIMULATOR.

THANK YOU FOR YOUR ASSISTANCE

Investigation of Failures In Wooden Aircraft Components

By M.J. Collins, BE, MSc (Cranfield)
Scientist, Wood Technology Division

Summary

An account is given of the New Zealand Forest Research Institute's involvement in assisting with the investigation of failures in wooden aircraft components. The methods used are described, and a new technique being developed for determining the age of wood fracture surfaces in outlines.

A. Introduction

The New Zealand Forest Institute (FRI) is the research division of the New Zealand Forest Service.* In its three Divisions the FRI covers all aspects of forest growing and wood use.

The writer's present position in the Timber Engineering Laboratory of Wood Technology Division, coupled with an earlier career in airworthiness engineering in the New Zealand Ministry of Transport, has provided a useful link between the needs of air accident investigation inspectors and the investigative resources of the Institute.

In relation to its population, New Zealand has a large fleet of wooden aircraft on its register comprising gliders, amateur built aircraft and older aircraft with wooden structures. Since 1971 when the first investigation into a wood aircraft component was undertaken at FRI, a total of 10 investigations have been reported on, comprising aircraft in all the above categories. See Appendix 1.

Following an initial investigation by an aircraft accident inspector, our services have been called on where:

1. there has been a confirmed in-flight structural failure, or
2. an in-flight structural failure has not been eliminated from the accident scenario.

In the first case, the reasons for the failure are investigated and in the second, an attempt is made to determine whether there was any likelihood of an in-flight failure.

**To become the New Zealand Ministry of Forests from April, 1987*

B. Methods of Investigation

Following a decision to involve the Institute, the air accident inspector provides a summary of the circumstances surrounding the accident together with reports, drawings, photographs, and components from the wreckage. In some circumstances a visit is made with the inspector to see the reassembled salvaged wreckage. Such visits and discussions are invaluable in focusing the investigation on areas of greatest relevance, while at the same time allowing all possibilities to be considered. Care is taken not to bias the view of the outside consultant towards any opinions that the air accident inspector may have formed himself in the initial investigation, whilst still drawing attention to all features of relevance.

An examination of the complete wreckage, if made, seeks to establish the sequence of break up and the mode of failure of the major components. If these are established the investigation then moves on to the individual suspect components.

An examination of components can include any of the following:

1. **Compliance with drawings**
   Size of components and species of material are checked. Species is checked by wood anatomists in our Wood Materials and Biotechnology section by microscopic examination.

2. **Wood Quality**
   The prime indicator of wood quality is density, measured as the amount of wood substance (oven dry weight) in a given volume (volume at 12% moisture content). Other indicators are ring width and percentage of latewood (summer wood) within the annual ring. Strength tests may be performed on samples if sufficient material is available.

   Any of these measurements may be included in material standard specifications and if so, such specifications are used as a guide as to whether the material is suitable. If standards are not available the results are compared with published data on timber properties.

3. **Wood decay**
   If decay is suspected a microscopic examination by a wood mycologist will detect any fungal hyphae present.

4. **Glueline quality**
Glueline failures are commonly seen in wooden aircraft wreckage. Where the joint has failed as a result of poor assembly techniques, this is often apparent from a visual inspection showing shiny glue that has never been bonded, brush marks or low percentage wood failure. Intact gluelines adjacent to the failure site may be tested in shear to determine strength and percentage wood failure.

Glues may be identified by chemical analysis. Some early urea formaldehyde glues suffered fro progressive crazing which is immediately apparent under the microscope and causes a loss of strength.

5. **Mode of failure**
Wood fracture surfaces can indicate whether the component failed in tension, compression following by tension, or bending. If in bending, the direction of bending failure is often apparent. In one investigation, sound samples of the wing skin were tested in tension and bending, at various angles to the grain, for comparison with fractures found in the wreckage.

Fracture surfaces found in the wreckage or from strength test specimens may give an indication of wood quality. Brash "carrotty" failures are typical of low strength wood, particularly in sitka spruce, whereas "stringy" fractures generally indicate good quality wood. Decay and preliminary overstressing in compression also lead to brash failures.

C. A New Tool for Investigations

On several recent occasions, the question has been asked: "Was this fracture present in the component before the accident or is it the result of crash damage?"

There is no established technique for answering such a question but preliminary results from a recent attempt to develop such a fracture surface dating technique are encouraging.

The work so far has been done on radiata pine surfaces and depends on the identification of a particular oxidation product of the wood resin acids. The method has been proposed and investigated by Dr. Robert Franich of the Institute's Wood Materials research field after discussion of the problem of aging wood surfaces with the author.

The technique relies on the use of the Gas Chromatograph Mass Spectrometer (GCMS), an extremely sensitive analytical tool for identifying and measuring minute quantities of organic compounds.

An account of the method and results so far is given in Appendix 2. Further development of the technique to give quantitative results on particular timber species will require funding beyond the internal resources of the Institute. A developed technique could be expected to be of value in forensic science generally and not just aircraft accident investigation.

Acknowledgements

The writer acknowledges the assistance and advice received over the years from officers of the New Zealand Office of Air Accident Investigation, with whom it has been a pleasure to work; Messrs. Ron Chippindale, John Goddard and Jack Leech. The continuing support of the technical staff of the Timber Engineering Laboratory and others throughout the Institute is a vital component in the investigations. Dr. Robert Franich enthusiastically investigated the possibilities of aging wood fractures when the problem was discussed with him.

APPENDIX 1

List of aircraft accidents for which the assistance of the New Zealand Forest Research Institute has been requested

Date of Accident	Aircraft identification	Summary of findings of FRI investigation
1970	Fox Moth ZK-AKM	Wing spar boom joint examined. Casein glued sitka spruce and walnut facings. Passed all tests.
1973	Harvard	Hickory control columns. Strength of 3 columns tested appeared inadequate. Wood quality okay.
1977	Dart 17 ZK-GEE	No evidence of in-flight wing failure.
1978	Druine D31 ZK-CJD	Timber and glue quality in wing okay. Evidence of heavy landing on under carriage leg.
1978	Sirocco MJ5 ZK-DAF	Wood and plywood quality adequate. Gluelines poor.
1981	Auster JIB ZK-AWI	UF gluelines in spar booms badly crazed and weak.
1982	Schleicher KA6 ZK-GBF	Failure of wing spar/fuselage fitting in wing. Poor design, maintenance and manufacture.
1874	Pirat SZD30 ZK-GJO	Pattern and type of wing failures indicative of flutter.
1986	Tiger Moth DG82A ZK-ALX	No evidence of in-flight structural failure.
1986	Tiger Moth DH82 ZK-BFH	Propeller hub failure. Species identified as being suitable. Wood quality adequate.

APPENDIX 2

A case study

Aircraft:
Schleicher KA6 ZK-GBF

Failure:
Lower wing spar boom root fitting pulled out of spar due to shear failure on either side of bolt row.

Investigations:

1. Species *(Pinus sylvestris)* and density (460 kg/m^3 nominal at 12% mc) greater than European average at 434 kg/m^3. No specification for aircraft use available.
2. Fungal decay. None detected.
3. General appearance of fracture. Grey iron stains present adjacent to bolt holes showed brash fractures.
4. Corrosion present on bolts led to small diameter increases.
5. Scanning electron microscope examination showed debris in cell cavities of fracture surface. May have indicated an old fracture.
6. Glueline quality. Lower spar boom fracture adequate as little exposed glueline. Upper spar boom fractures showed low percentage wood failure and thick gluelines indicating unsatisfactory glueline quality. Away from fracture some delamination and unsatisfactory gluelines were found in lower spar boom.
7. Paint protection. Paint coats on ends of spar boom inadequate to protect against water uptake if accidentally wetted.
8. Distortion of section. Gluelines curved in fractured section. Section tapered by 1 to 2 mm. Sawing along glueline resulted in cut closing up indicating residual stresses in laminations.

Findings:
Internal stresses, rusting bolts and distorted section indicated poor maintenance and exposure to wetting possibly combined with poor moisture content control of individual laminates at the time of layup and glueing. Lack of an adequate paint coat on end grain would increase water uptake. Splitting forces generated by rusting bolts and internal stresses in wood reduced strength of joint to below design strength. Possible contributions were weakening of wood by iron staining, and the close bolt spacing (3 bolt diameters between centres). After the FRI investigation it was revealed that the manufacturer had sometime previously promulgated "an important modification" to reinforce the spar root. This had not been incorporated in this aircraft.

The Airline: A Massive Pool of Expertise

By Joseph Galliker
Senior Flight Safety Officer
Air Canada

Introduction:

As accident investigators, you realize there are occasions during an aircraft accident investigation, you wish you had a complete list of all the experts available at your fingertips. Experts in highly specialized fields; experts that perhaps are not ordinarily required. You are probably already relying on a list of contacts, that you worked with in the past. Perhaps you don't have a list at all. As you well know, no investigation is ever the same. The process may be standard, but the extent of an aircraft accident investigation varies.

The Problem:

There is usually a substantial difference investigating a light aircraft versus a modern, large airliner. Statistics show that year after year a lot more light aircraft accident investigations are conducted than that of large sophisticated aircraft, such as airliners. The everyday requirement for technical and specialized experts, therefore, is not as great as it would be, if one had to conduct an investigation involving a complicated aircraft. So, what if suddenly a need for experts arises that is beyond the normal everyday list of contacts? What if you need a second or even a third opinion on findings? How much of an effort would it be for you to find and make contact with the required experts? How does one know that a certain expert even exists?

It is difficult to search for experts and assistance during the course of an investigation, when the workload is already high. Especially in airliner accident investigations, your office most likely will need assistance from outside sources.

To find such an expert can be time-consuming and difficult, especially on short notice. It would, therefore, make sense to have a list of available experts prepared in advance. ICAO, the International Civil Aviation Organization, already provides such a list in the Aircraft Accident Investigation Manual. This list indicates which countries could provide certain expertise. This list is, however, fairly broad and only lists main areas. It is the only list of experts in existence to my knowledge, and ICAO is now in the process of updating it.

As a Flight Safety Officer and Aircraft Accident Investigator for a major airline, I find that airlines really are a massive pool of expertise in many areas. Working

Captain Joseph Galliker

with Civil Aviation Accident Investigation teams, manufacturers and independent investigators, it has come to my attention that the awareness of this pool of experts is not always recognized and not used as much as it could be. I have also found that investigators sometimes have had difficulties in finding and contacting the expert within the airline.

The Solution:

A solution to finding additional experts and making quick contact may well be by contacting the Flight Safety Department of an airline. The titles of departments vary from airline to airline but contacting either the Flight Safety Officer or the Director of Flight Safety, would be your best bet to get quickly to the right person.

The Flight Safety department in an airline is usually an autonomous unit and free of any aegis of another department. They report directly to the Chief Executive Officer, or in small companies it is perhaps a Safety Committee with members drawn from suitable persons from either Operations or Engineering. Again, this Committee has direct access to the Chief Executive Office when the occasion demands it.

The Flight Safety Department has many functions to perform, including investigations. In the event of an in-house investigation, they call on experts from within the Company who can assist in tracing the possible causes to a conclusion. Where their own aircraft accident is investigated by the Civil Aviation, the Flight Safety Department often provides the liaison between the airline and the Civil Aviation Accident Investigation team.

Major airlines are big organizations; it is difficult for an outsider to see or understand the airline's organization and who is who within the airline.

This is why I would recommend if you are looking for expertise from the airlines, to make contact with the Flight Safety Officer long before an accident occurs. A visit to his office during "peace time" would probably establish this contact. Informal discussion could establish what expertise the airline has to offer, how the Flight Safety Department would like to be contacted on a 24-hour basis. Later when the need arises for an expert from a non-interested party or a party that is not involved in the accident to be investigated, the Flight Safety Officer would be already aware of what your basic needs are. By then, perhaps, even a rapport of mutual trust has been established.

Many Experts are available:

I made a survey among approximately 20 major airlines throughout the world to find out what their views and policy is on the subject of providing expertise. I found that all the surveyed airlines would be quite willing to provide experts to civil aviation accident investigation teams and possibly others, such as manufacturers and insurance underwriters. Some would charge a fee, others not, depending on the circumstances. The list of experts available from these airlines varies, depending on the size of the operation and maintenance facilities. Most airlines can provide experts in the area of Flight Operations, Engineering and Maintenance.

I have looked around my airline and compiled a list of available experts. The list is quite long in our case. Besides the obvious experts available from within a major airline, such as Powerplant, Airframe, Aircraft Performance Engineers, Metallurgists, Chemists, there are others.

For example, in In-Flight Service there are experts available for cabin crew procedures, flight attendant training, and passenger and crew catering. Persons monitoring the quality of the food to ensure that there is no chance of food poisoning, which could cause accidents. Cabin operations, safety in the cabin, manning and scheduling of crews, ensuring that the duty hours are not exceeded. In the event of an accident where insufficent crew rest is suspected, experts such as Crew Manning and Scheduling Managers may provide valuable opinions. Perhaps also an aviation medical officer, who is also available within most of the major airlines. A person that is looking after occupational health, employee health and rehabilitation would be another expert available in the area of human performance. There are, of course, many specialized engineers when we're talking Airframe and Systems, especially today with the modern aircraft systems. Avionics experts, for example, are perhaps hard to come by for certain aircraft types and systems at the civil aviation accident investigation team level. An engineer in an airline is a person that does not design systems, but monitors the operation and the maintenance of these systems and perhaps gets involved in modifying them. He would certainly be an expert witness in the area of how the system functions and is maintained by the airline. He is also a valuable expert in the area of system troubleshooting, etc.

Then there is the Flight Data Recorder Analysis. Some airlines have their own playback facilities for voice and data recorders, others do not. A data analysis specialist would be quite familiar reading the data that has been retrieved. Analyzing such data and voice recorders, as he does on a daily basis, makes him an expert in this field. Such an expert could provide a valuable second opinion on an incident. The playback centre within my airline, for example, does have the latest pictorial display equipment, where one can see the data displayed on the cockpit instruments. This is certainly a timesaving tool.

In Flight Operations, besides experienced line pilots, training pilots, and supervisory pilots, there are also ground school instructors that develop training packages for pilot training programs. They would possibly be of value in analyzing someone else's training package. There are simulator technicians that maintain simulators. Simulators could be used in accident investigation by perhaps tying in flight data, retrieved from a flight data recorder, into a simulator computer to reconstruct the flight. United Airlines, in Denver, for example, is quite advanced in this area, and although this technique has not reached perfection yet, it can be useful in the reconstruction of landing accidents.

Flight Dispatchers are experts in the area of manual or computerized flight planning. Most airlines still have dispatchers.

Not to be forgotten is the Passenger Service Expert, in accident investigations, where the passenger welfare aspect is to be evaluated. They develop procedures for passenger and baggage handling and maintain passenger records.

Ramp services, aircraft services. Aircraft are being pushed back, and manoeuvered on the ramp and accidents do occur during these manoeuvers. Procedures exist within the company and are tied-in with the airport's rules and regulations. Such persons as Aircraft Ramp Operation Managers develop and maintain these procedures. There are also Company Communication and Operation Centers, nerve centers that are located at main stations. These centers usually maintain records of aircraft movements, either electronically stored or on paper. In the event of an accident, the Manager of such a center would be able to provide such information as actual departure times from the ramp. There are station managers that oversee the aircraft and passenger service at the station level. They are experts in their own field as they oversee passanger, baggage and cargo handling at the airport.

I mentioned cargo. Internal cargo handling procedures are laid down by a person within the airline that is familiar with cargo loading and acceptance procedures. Depending on the size of the airline, developing and maintaining of procedures are usually distributed among three or four positions. In smaller operations it may be just one person that handles all areas. In accidents involving hazardous material, airlines could provide specialists familiar with all aspects of handling Hazmat.

Aircraft maintenance certainly is of great interest to an investigator. There are so many departments in aircraft maintenance that it is difficult for an investigator to know who is who. Knowing who does what and what records are available can be quite difficult when time is in short supply. Quality Control Inspectors. These Inspectors are experienced, licensed or certified mechanics, with long time aircraft maintenance experience. They are experts in the area of aircraft systems maintenance and quality control. Maintenance records are stored by Maintenance. There is the Maintenance Training Department that can explain the functioning of systems to an investigator and provide technical manuals, training aids, and mock-ups. Line maintenance troubleshooters have good knowledge on how systems function. Certified technicians for avionics, airframes, systems and powerplant are not to be forgotten. They are the ones that maintain the aircraft every day.

There there are the overhaul shops. The Foremen and Technicians in these shops are experts in repairing units of avionics, electrical, instrument, hydraulics, and landing gear systems. In accidents, where a system breakdown is suspected, a component teardown will have to be done in a planned and controlled way (motors, control boxes, etc.). A good place to perform this is in an area where the suitable test equipment is available such as the shops where these components are normally maintained. These shops can provide test equipment that is designed specifically for unit testing and troubleshooting and can become very useful to the investigation team. Unit teardown should also be photographed or video-taped when tests are being done, especially where smoke or other reactions are to be witnessed. For this, airlines may have an Audio Visual Department that can provide video and photographic services right on the spot; efficiently and inexpensively.

Consider airlines also for the aircraft wreckage recovery task. Many airlines have their own recovery specialists. They are trained maintenance technicians or engineers that have access to airline recovery equipment within their own airline or an interline pool. These experts are rare, and not too many are available within most countries. They can provide expertise in planning the wreckage removal, and provide management of such an operation.

Well, not to be forgotten is the Safety Officer. He conducts in-house accident investigations (accident prevention via accident investigation). He can assist in aircraft accident investigation, as most have obtained education and practical experience in this field.

What Airlines Do Not Like:

As mentioned before, airlines would like to interface with aircraft accident investigators in an organized and coordinated way. What they do not like is when investigators come into hangars, shops, and offices via the air side and talk directly to mechanics or foremen without formally "checking in" at the front door. This, not because the airline has anything to hide, but for security reasons, and to ensure the investigator gets the right information. In this day and age, security is a major concern for all airlines and it is important for companies to know who they have on their premises and what their purpose is.

What Airlines Do Like:

Again, as mentioned earlier, the airline's favourite way to make contact with investigators is through their Flight Safety Departments or Flight Safety Officers or any person or department with which pre-arrangements have been made. This way liaison between investigators and the airline's shops and experts can be arranged and coordinated in a timely manner. Once these arrangements and contacts have been made, investigators would be able to move on the premises either with an escort or on their own. This procedure can be time saving and productive for both the airline and the investigators. Its use is recommended not only when searching for experts, but also when the airline is the party to be investigated. In many airlines, the Flight Safety Department also has the responsibility for handling the accident for the Executive Officer and is, therefore, the recommended contact for the Investigator-in-Charge.

I hope I have provided you with some insight into how today's airlines may be of assistance to the investigator and how to best approach them, or perhaps I should say, how to scratch them in the right place.

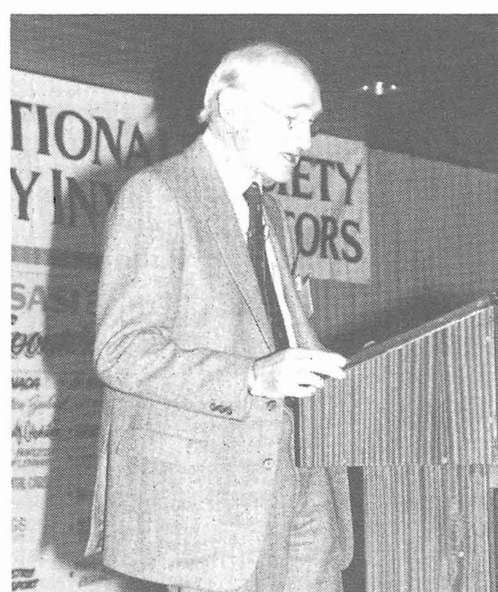
Thank you,

LIST OF EXPERTS
(that may be available from airlines)

ENGINEERING:

Powerplant:	Powerplant Powerplant Accessories Auxiliary Power Units (APU) Powerplant Performance Testbed Technicians
Airframe & Systems:	Airframe Hydraulic Systems Landing Gear Flight Controls Electrical Avionics Cabin Interior System Interior Furnishings
Operations:	Aircraft Operations Aircraft Performance
Metallurgy:	Metalurgist Chemist
Flight Recorder Data Analysis:	Playback Facilities for voice recorders and for different types of recorders. Data Analysis Specialists.
Aviation Medicine:	Aviation Medical Officer Occupational Health Employee Health & Rehabilitation
In-Flight Service:	Experts in: Cabin Environment Procedures Training Catering Cabin Operations Manning & Scheduling Cabin Safety Operations Supervisors Crew Records Centres
Flight Operations:	Line Pilot Training Pilot Supervisory Pilot Ground School Instructor Simulator Technician Flight Dispatcher Crew Records Centres
Passenger Service:	Passenger and Baggage Handling Procedures Passenger Records Passenger and Baggage Security
Aircraft Services:	Aircraft Ramp Operations Procedures (Loading and Maneouvres) Company Communication and Operation Centres Station Managers
Cargo:	Cargo Loading and Movement Procedures Cargo Operations Training Hazmat Acceptance Procedures Hazmat Training for Employees
Aircraft Maintenance:	Quality Control (Inspection) Aircraft Maintenance Records Maintenance Training Line Maintenance Support (i.e., Troubleshooter, Communications) Licenced or Certified Technicians for: Avionics, Airframes, Systems and Powerplant Foremen and Technicians in unit overhaul shops: Avionics Electrical Instruments Hydraulics Pneumatic Landing Gear and Tires Sheet Metal Painting Cabin Interiors Carpentry and Machine Shops
Aircraft Load Control:	Aircraft Load Calculations (computerized and manual)
Computer Services:	Passenger Records Storage Aircraft and Maintenance Maintenance Electronic Records
Aircraft Recovery:	Aircraft Recovery Specialists Aircraft Recovery Equipment Access to Airline Recovery Equipment Pool
Photography:	Photographers Confidential Development of Films Video Camermen Video Editing
Aircraft Accident Investigators:	Flight Safety Officers

Contact the above via the Airline's Flight Safety Office or their Flight Safety Officer.



Mr. Geoffrey C. Wilkinson, Chief Inspector of Air Accidents, Department of Transport, U.K. on "The Role of the Accredited Representative In The International Forum."

Aircraft Accident Reports In Litigation: Review and Analysis

By Joseph T. Cook*

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Joseph T. Cook

I. Introduction

Aircraft accidents, by their very nature, raise the interest and indignation of us all. The sudden and swift manner in which death can come to a large number of innocent people causes each of us to stop and ponder the causes of air tragedies. Since World War II the flying public has become increasingly confident of the safety and security associated with commercial aviation. Perhaps it is this confidence that adds to the shock and anguish that accompanies a major accident.

The growth of the electronic media adds to public awareness in a manner not contemplated just twenty years ago. Today, television's everpresent eye brings color pictures of tragedy into the homes of millions around the world as dessert following the evening meal. Especially in America, this increase in awareness has placed a greater burden on those individuals charged with the investigation and correction of problems in the aviation industry. Furthermore, litigation intended to aid victims of crashes is publicized by that same media, and perceived as a means of punishing "wrong doers."

The purpose of this paper is to bridge the gap between those who investigate aviation accidents and produce investigation reports, and those who use these accident investigation reports in litigation. My emphasis includes the three major types of accident reports: United States Civil, United States Military, and reports of the International Civil Aviation Organization (ICAO).

With respect to each type of report, I will review the following: releasability, or procedures for requesting the reports; usability, or how each report is used in trial preparation; and lastly admissibility, or what limitations exist when using accident reports during trial. My goal is to provide an overview of the agencies entrusted with aircraft accident investigation and to provide a guide for evaluating the usefulness and limitations of each type of report during the discovery and trial phase of litigation.

II. U.S. Civil Aircraft Reports

Responsibility for conducting independent investigations of civil aircraft accidents, and formulating safety improvement recommendations within the United States rests with the National Transportation Safety Board (NTSB). This five-member board was established by statute in 1966 to promote transportation safety. 49 U.S.C. § 1901(1).

The Board is charged with the investigation and fact finding, as well as the determination of probable cause(s) of any:

(A) aircraft accident which is within the scope of the functions, powers, and duties of the Board;
(B) highway accident in cooperation with the States;
(C) railroad accident in which there is a fatality;
(D) pipeline accident in which there is a fatality or substantial property damage;
(E) major marine casualty, except one involving only public vessels in navigable waters or territorial seas of the United States;
(F) other accident which occurs in connection with the transportation of people or property which, in the judgment of the Board, is catastrophic, involves problems of a recurring character or would otherwise carry out policy. [49 U.S.C. §1903(a)(1)].

The specific duties of the NTSB as regards civilian aircraft accidents are stated in 49 U.S.C. § 1441 as follows:

(1) Make rules and regulations governing notification and report of accidents involving civil aircraft;
(2) Investigate such accidents and report the facts, conditions, and circumstances relating to each accident and the probable cause thereof;
(3) Make such recommendations to the Administrator (Secretary of Transportation) as, in its opinion, will tend to prevent similar accidents in the future;
(4) Make such reports public in such form and manner as may be deemed by it to be in the public interest; and
(5) Ascertain what will best tend to reduce or eliminate the possibility of, or recurrence of, accidents by conducting special studies and investigations on matters pertaining to safety in air navigation and the prevention of accidents.

Further, the investigative authority of the NTSB is not limited to major disasters. Under 49 C.F.R. § 830.5, the operator of any aircraft is required to notify the NTSB immediately, and by the most expeditious means, when any aircraft accident, or any of the following aircraft incidents occur:

(1) A flight control system malfunction or failure;
(2) Inability of any required flight crewmember to perform normal flight duties as a result of injury or illness;
(3) Inflight fire;
(4) Failure of structural components, or of a turbine engine, excluding blades or vanes;
(5) In-flight aircraft collision.

A. Releasability (Requesting Reports)

1. NTSB Procedures

a. Major Disasters

With respect to major disasters, following initial notification of an accident, the NTSB designates an investigator-in-charge and dispatches him to the accident site to conduct and control the field investigation. 49 C.F.R. § 831.7. The investigator heads up a team of other investigators who examine specific areas of the accident, i.e., operations, structures, powerplants, etc. The team is supplemented by individuals from government agencies, companies, and associations whose employees, functions, activities, or products were involved in the accident. The purpose for the additional team members is to provide qualified technical personnel to assist in the field investigation. 49 C.F.R. § 831.9(a).

The team cannot consist of any persons who represent insurers or potential claimants. 49 C.F.R. § 831.9(c). Yet, on the other hand, the team normally includes the Federal Aviation Administration (FAA) [49 C.F.R. § 831.9[d] and may contain members of the Airline Pilots Association and manufacturer representatives. These additional team members participate in the investigation despite the fact that they are typically involved as defendants in any subsequent litigation.

This approach has been criticized in the past and raises questions of inherent fairness and the possibility of built-in bias in the investigation process. *See*, Pezold; "National Transportation Safety Board - A Critical Review of Information Availability", 42 *Journal of Air Law & Commerce,* 363 (Win. 1976).

The operator of the aircraft is charged with the task of prohibiting the disturbance or removal of any wreckage, mail, or cargo from the accident site until the NTSB or FAA representative take custody thereof and begin the field investigation. 49 C.R.R. § 830.10.

The field investigation team is divided into working groups based on expertise and concentrates on evidence gathered from either human or material sources. After their initial assessment of the accident, each working group prepares a brief report and submits it to the investigator-in-charge. From the working group inputs, the investigator-in-charge prepares a factual report which is subsequently reviewed by each member of the team and sent to the Director, Bureau of Administration. 49 C.F.R. §§ 801.30, 801.31.

A public hearing follows the field investigation to create a public record of the facts, conditions and circumstances relating to the accident and assist the NTSB in determining cause or probable cause of the accident. 49 C.F.R. § 845.2. The hearing is intended to be a fact finding tribunal rather then one based on an adversary relationship. 49 C.F.R. § 845.2. Again, as with the field investigation, no insurers or potential claimants may participate as questioners in the public hearing. 49 C.F.R. § 845.13(b). However, this privilege of participating in questioning is generally extended to manufacturers, airline representatives, and the FAA. The only stated requirement for selection to the hearing panel is listed in 49 C.F.R. § 845.13(a) as follows:

> [T]hose persons, agencies companies, and associations whose participation in the hearing is deemed necessary in the public interest and whose special knowledge will contribute to the development of pertinent evidence.

Additionally, it is of interest to note that the manufacturers, based on their expertise, are often charged with the detailed post-crash teardown of the component parts of an accident aircraft. This process presents a tempting conflict of interest within the investigative team.

A conflict arises as the team attempts to effectuate the NTSB policy of minimizing future aircraft accidents. As stated by Pezold;

> [A] choice must necessarily be made between the conflicting interests of two groups, those of the flying public-at-large. . ., and those of the individuals killed or injured in having access to information required to fix liability.

Clearly, the NTSB, in following a method of investigation that excludes potential plaintiffs and includes potential defendants in the decision and analysis process, makes basic assumptions of corporate behavior in light of public interest. These assumptions as to the public policy interests of potential defendants may be questionable.

b. Other then Major Disasters

Fatal crashes involving general aviation aircraft are ordinarily investigated by a single NTSB field investigator, without an on-scene "team" and without a public hearing. To the extent that a team is formed, it usually consists of an FAA representative and representatives from manufacturers and the operator. Technical assistance from NTSB headquarters is available, but in a limited and delayed basis as compared to major disaster assistance.

These investigations and the reports they generate are considerably less detailed than major disaster reports, and on occasion could be called cursory. As with major disasters, only potential defendants participate; but unlike the major cases the bright spotlight of public and media attention does not penetrate, or stir-up, the dull bureaucracy.

c. FAA vs. NTSB

Due to limitations in manpower and time, the NTSB has traditionally delegated the investigative function of certain aircraft accidents to the Federal Aviation Administration (FAA). The specific areas in which delegation of authority is most likely include the following:

(1) Agricultural aircraft, whether fatal or non-fatal accident
(2) Restricted category aircraft (firefighting, forestry, experimental, homebuilt, etc.) whether fatal or non-fatal accident
(3) Helicopters, when accident is non-fatal
(4) Fixed wing aircraft having a gross takeoff weight of 12,500 pounds or less, when accident is non-fatal

Notwithstanding the above categories, NTSB retains authority for:

(1) Accidents in which fatal injuries have occurred except special use aircraft
(2) Accidents involving aircraft operation in accordance with Part 135 of the Federal Air Regulations (Air Taxi Service)
(3) Midair collisions
(4) Accidents involving aircraft operated by air carriers authorized by Certificate of Public conveyance. 49 C.F.R. § 800 Appendix (b).

Whenever the FAA performs the investigation into an aircraft accident, the FAA investigator sends his report to the local NTSB field office for review and examination. At the NTSB's discretion, the report may be returned to the FAA investigator for further investigation. Once complete, the report is forwarded to the Board's main office in Washington where it is analyzed and the final version of the report is prepared and made available.

2. Content of Reports

The final NTSB approved report is designed to include all information gathered pertinent to the determination of the cause or probable cause of the accident. The report will usually contain the following information:

(1) A listing of the file contents
(2) Logistical details and any basic information on the crash date, location, nature of the flight, flight crew, aircraft and equipment type, property damage, weather conditions, crew statements, etc.
(3) A narrative by the investigator-in charge which ties together the documentation in the report package
(4) Witness statements
(5) Wreckage diagrams and debris indexes
(6) Pertinent weather reports
(7) Transcripts of cockpit voice recorders, flight data recorders, ATC pilot-controller conversations, ATC radar tapes, and other relevant radar computer printouts
(8) NTSB generated documents or charts plotting aircraft location, altitude, airspeed, configuration, time, etc.
(9) Reports, charts, diagrams, and exhibits produced by each working group in its particular area of investigation
(10) Reports conducted by outside laboratories, firms, and associations commissioned by the Board
(11) Schematics, drawings, diagrams, memoranda, specifications, airworthiness directives, and operating limitations of the aircraft in question, and/or any of its component parts
(12) A Release of Wreckage Form
(13) Photographs taken by investigators.

The extent of the complexity of the report is determined by the complexity of the accident, the equipment involved, and the intricacy of the details of the accident. Further, with major crashes, in addition to the final report, the NTSB "docket" includes transcripts of any hearings that were conducted.

When using these reports it is important for the litigator to ensure that all wreckage is accounted for and that the evidence matches the conclusions. An unaccounted for wing-tip, for example, could make the difference between a mid-air collision or structural failure determination.

3. Obtaining Reports

NTSB accident reports, to include the report of the investigator-in-charge as well as the Board's final report of probable cause(s), can be ordered by forwarding a request stating the accident date, location, and aircraft registration or flight number to the following:

Public Inquiries Section
National Transportation Safety Board
800 Independence Ave., S.W.
Washington, D.C. 20594
Tel: (202) 382-6735

Transportation accident files and transcripts of public hearings involving air carriers are retained for fifteen years, while other transportation files are retained for seven years then destroyed. 49 C.F.R. § 801 Appendix.

To obtain reports written by the Federal Aviation Administration, the request needs to be made through the NTSB at the above address. Alternatively, an attempt can be made through either of the following:

Federal Aviation Administration
AHQ-300 Federal Aviation Accident Report
800 Independence Ave., S.W.
Washington, D.C. 20591

or,

Freedom of Information Office
Office of Public Affairs
Federal Aviation Administration
800 Independence Ave., S.W.
Washington, D.C. 20591

B. Usability (Trial Preparation)

1. Statutory Limitations

The specific statutory limitation to the use of NTSB accident reports during litigation is found in 49 U.S.C. § 1441(e), which states:

> No part of any report or reports of the NTSB relating to any accident or the investigation thereof, shall be *admitted as evidence* or *used in any suit* or action for damages growing out of any matter mentioned in such report or reports (emphasis added).

It would appear upon reading the clear language of the statute that information in NTSB reports would not be available during trial or during the preparation for trial. However, there have been no cases which have found the statute to be a total bar to the use of reports during pre-trial discovery. Thus, graphs, charts, photos, flight data recorder transcripts and read-outs, and other documents are widely used during depositions and other discovery.

In fact, Federal Rules of Civil Procedure (FRCP) Rule 26(b)(1), clearly allows use during pre-trial discovery. Rule 26(b)(1) states in part:

> It is not grounds for objection that the information sought will be inadmissible at the trial if the information sought appears reasonably calculated to lead to the discovery of admissible evidence.

2. Depositions

With respect to testimony from NTSB investigators, 49 C.F.R. § 835.5 prohibits the direct testimony of Board employees in court actions but does allow a Board employee to testify at a deposition. However, § 835.5(c) states that Board employees are authorized to testify only once in connection with any investigation they have made of an accident. These rules are strictly adhered to. Further, the statute encourages multiple parties in lawsuits to coordinate their discovery schedule so that all interested parties may engage in a single deposition.

C. Admissibility (During Trial)

1. Statutory Limitations

Judicial decisions have interpreted the restriction of 49 U.S.C. § 1441(e) in a narrow manner. That is, as covering only the portions of an accident report which set forth the Accident Board opinions and statements as to the probable cause of the accident. *Berguido v. Eastern Airlines, Inc.,* 317 F.2d 628 (3rd Cir. Pa. 1963), *cert. den.* 375 U.S. 895, 84 S.Ct. 170, 11 L.Ed.2d 124 (1963).

An early case which found that testimony given by a witness before the Civil Aeronautics Board (CAB) (the predecessor to the NTSB for accident investigation) was not privileged and could be used to refresh the witness' recollection or impeach his testimony in a trial proceeding. *Ritts v. American Oversea Airlines,* 97 F.Supp. 457 (S.D.N.Y. 1947). While the *Ritts* decision applied to testimony, it was one of the first cracks in the armor of privileged communication associated with federal aircraft accident investigations.

In a series of cases in the late 1940's and early 1950's, the concept of privilege for aircraft accident reports was further eroded. In. *Tensey v. Transcontinental and Western Air, Inc.,* 97 F.Supp. 458 (D.D.C. 1949), the court drew a distinction between the conclusions of the investigators and the factual information contained in the report by allowing the plaintiff access to mandatory reports. Two years later, in *Universal Airlines v. Eastern Airlines,* 188 F.2d 993 (D.C. Cir. 1951), the court found that where the investigation is the sole source of evidence available to the parties as to the location of wreckage, the report must be made available. Again, testimony directly or indirectly reflecting opinions of the Board were considered inadmissible by the *Universal* court.

Modern rulings have continually expanded the *Universal* approach. As expressed in *Berguido v. Eastern Airlines, Inc., supra,* 317 F.2d 628.

> The primary thrust of the provision [§ 1441(e)] is to exclude [Board] reports which express agency views as to the probable cause of the accident.

Further, the *Berguido* court found testimony relating to personal observations of the Board investigator about the scene of the crash and the subsequent condition of the plane was admissible because it was not "within the ambit of the privilege."

Another aspect of *Berguido* is that the court ended the distinction drawn in *Ritts* between investigator's testimony and their reported findings. This distinction was seen as policy of form rather than substance by the court. The pivotal holding was that opinions expressed in the report were no longer granted absolute privilege. Only those opinions which addressed probable cause of the accident were required to be excluded from litigation.

A balance must be found by the courts while considering the interests of individual litigants against the NTSB's desire to have full and frank disclosure to prevent future accidents. Recent case history shows the scale has tipped in favor to the litigant as more and more investigative information is excluded from privilege and included in legal proceedings. Investigative information embodied in specific documents of an analytical nature have even been admitted into evidence under exceptions to the hearsay rule. *American Airlines, Inc. v. United States,* 418 F2d 180 (5th Cir. 1969). However, a recent case supported the exclusion of the conclusions made by the NTSB in its accident report by stating that 49 U.S.C. § 1441(e) forbids use of conclusory sections. *Travelers Ins. Co. v. Riggs,* 671 F2d 810 (1982, CA4 VA).

2. Hearsay

Under the basic rules of evidence, accident reports, if offered at trial, could be objected to on hearsay grounds. According to the FRE, Rule 801(c), hearsay is any statement that meets two requirements: the statement must be offered to prove the truth of the matter it asserts. Thus, under existing law, hearsay is an out-of-court statement offered in evidence via the testimony of someone who heard it, or via the documentary embodiment of the statement if written, offered to establish the facts recounted in the statement.

As mentioned, if offered at trial, portions of an accident investigation report may be deemed hearsay as the report contains statements made out of court and offered in court to prove the truth of the matter they assert. In fact, when the court looks at the investigation report, it is actually reviewing the investigator's statements made secondhand through a document. The hearsay problem faced by the court is twofold: the hearsay aspect of the original investigator's statements, and the hearsay aspect of the document itself. Therefore, we may be forced with hearsay within hearsay. The FRE allow for the admissibility of hearsay within hearsay provided that each level of hearsay falls within a statutory exception to the hearsay rule. FRE, Rule 805.

Consequently, each portion of the accident report must pass muster under an exception. One of the more important exceptions to the hearsay rule is articulated in FRE, Rule 803 (8): the Public Records and Reports exception. Rule 803 (8) excludes from the hearsay limitation the following:

> Records, reports, statements of data compilation, in any form, of public offices or agencies, setting forth (A)... (B) matters there was a duty to report, ...or (C) in civil actions and proceedings...factual findings resulting from an investigation made pursuant to authority granted by law, unless the sources of information or other circumstances indicate a lack of trustworthiness.

The public records and reports exception provides for the inclusion of accident reports as evidence during litigation provided they reflect sufficient trustworthiness and there is no indication that the report was prepared with any improper motive.

In two cases which involved the same types of reports, that is, military accident reports, the courts found that the prior experience of the investigators may add to or subtract from the weight given the report, but does not affect its admissibility. *Fraley v. Rockwell International Corp,* 4 Fed Evid Rep 1172, 470 F.Supp. 1264 (D.C.S.D. Ohio, 1979) and *Sage v. Rockwell International Corp,* 4 Fed Evid Rep 1502, 477 F.Supp. 1207 (D.C.D. NH, 1979).

FRE Rule 403 calls for the exclusion of relevant evidence on the grounds of prejudice, confusion, or waste of time. According to the rule, the factors that a judge must consider prior to a determination of admissibility of an "evaluative report" by a government agency include: "(1) [T]he timeliness of the investigation...; (2) the special skill or experience of the official...; (3) whether a hearing was held and the level at which conducted...(4) possible motivation problems..."

The party challenging the admissibility of any report on the above grounds carries the burden of proof and must come forward with some evidence to substantiate the objection. *Melville v. American Home Assurance Company,* 584 F2d 1306 (3rd Cir. 1978).

With reference to an FAA Airworthiness Directive relating to the mechanical safety of an aircraft involved in a accident, the *Melville* court stated:

> The directives constituted *factual findings* resulting from an investigation made pursuant to authority granted by law within the meaning of the public records exception to the hearsay rule, despite the facts that they *contained certain scientific and technical opinions* (emphasis added).

While the apparent contradiction in the above statement is clear, the court went on to explain that the public documents exception establishes a presumption in favor of admissibility unless circumstances surrounding the preparation of the document indicate a lack of trustworthiness. The establishing of these adverse circumstances is the responsibility of the side that objects to the documents admissibility.

In sum, it appears that barring conduct of an investigation by a grossly inexperienced investigator, or highly dubious circumstances concerning a report's credibility, the majority position of the courts in the United States today is that investigation reports are, for the most part, admissible with the exception of those specific portions of the report that deal with cause or probable cause of the accident.

III. U.S. Military Accident Reports

The process by which the armed forces conduct an aircraft accident investigation and assemble a subsequent report is, for the most part, similar among the various services. The process is however quite different in scope and procedure from the civil investigative activities of the NTSB.

A. Releasibility (Requesting Reports)

1. Military Procedures

Each branch of the military service uses a dual accident investigation and report generating process. While the exact terminology and titles of reports may differ from service to service, there are basically two separate reports possible following each accident:

- Safety or Technical Report, known as the Safety Mishap Investigation Report,
- Collateral or Legal Report, known as the Aircraft Accident Investigation Report.

Following a military aircraft accident, a safety oriented board of investigation is formed with the sole purpose of future mishap prevention. *Air Force Regulation (A.F.R. 127-4,* Ch. 1, ¶ 1-1a (Feb. 1982). The military viewpoint is that the success of this future oriented endeavor depends upon candid statements and observations of personnel involved in the mishap. In order to obtain full disclosure, safety investigators promise witnesses that their testimony will be used only for mishap prevention. Thus, the services feel a witness will freely provide testimony that is incriminating or against their personal interests.

If obtained during the safety investigation, the following types of information are protected by governmental privilege from release outside command and safety channels: witness testimony; inputs from contractors received under the promise of confidentially; the safety investigator's opinions, deliberations, and communications; life science reports; and other nonfactual portions of the safety mishap report. *A.F.R. 127-4,* Ch. 2 ¶ 2-5 (Feb. 1982).

Concurrent, or soon thereafter, to the establishment of the military Safety Mishap Investigation Board, a second board may be established. This board is titled the Accident Investigation Board. *A.F.R. 110-14,* ¶ 1b (May 1984). As compared to the forward looking accident prevention objectives of the safety mishap board, the accident investigation board functions as a method to obtain and preserve evidence for claims against the government, litigation, disciplinary and administrative actions, and for other possible purposes. *A.F.R. 110-14,* ¶ 2a(2) (May 1984). When the "collateral" or "legal" report is complete, it is forwarded up the chain of command for appropriate editing, screening, and approval by senior officers. As a result, this second report presents a sanitized and generalized view of the accident.

The legal report does however contain factual excerpts from the safety or "mishap" report such as photos, wreckage distribution diagrams, maintenance records, weather documents, etc. Normally, barring national security issues, this legal report is available, at a reasonable cost, to anyone who requests it.

While each branch of the armed services gives the reports a slightly different title, they basically follow the same procedures with respect to releasability of reports.

a. Safety or Technical Reports

The Army will release selected portions of the safety report to the public. But this information is limited to component teardowns and other non-privileged or nonconfidential factual information.

The Navy titles their safety report the Mishap Investigation Report (MIR). This report is considered to be privileged and consequently no portions will be released to anyone who does not serve in an accident prevention capacity within the Navy.

The Air Force uses the same title as the Navy: MIR. However, the Air Force approach toward releasability is similar to that of the Army. For those portions of the safety report that the Air Force considers privileged, or confidential for national security reasons, even a request for release under the Freedom of Information Act (FOIA) will not obtain the report.

The report is divided into two parts. The opinions, conclusions, and recommendations of the board are placed in Part II and are considered privileged from disclosure. Part I contains factual material which is generally releasable. *A.F.R. 127-4,* Ch. 12.

b. Legal or Aircraft Accident Investigation Report

For all the branches of the armed forces the legal report is conducted independently, and for different purposes, from the safety report. In some cases the board may consist of only one officer who is given access to those non-privileged aspects of the safety report, if complete. However, in all cases the final report is passed through the legal arm or Staff Judge Advocate (SGA) Officer of each respective service for review and editing.

As a result the legal report in each service suffers from a credibility problem. The reports may provide a generalized overview of events but should not be relied upon for specific and detailed information.

2. Obtaining Military Reports

The individual branches of the armed services regard portions of the safety or technical report as privileged. Therefore, it is recommended that any request for copies of these documents be made directly to the Safety Center for the branch of the armed forces from which an accident investigation report is desired under either the Federal Rules of Civil Procedure (FRCP), Rules 26 (b) and 34, if the military is a party to the action, or under FOIA, 3 U.S.C. ¶ 552, if the military is a non-party to the action.

The addresses for each branch of the military from which reports may be requested follows:

Army: Safety Reports;
Commander, U.S. Army Safety Center
Attention: PESC-ZL
Fort Rucker, Alabama 36362
Legal Reports;
Office of the Judge Advocate General for the installation which investigated the incident, or,
Department of the Army/DA-JA-ZA
Office of Judge Advocate General
The Pentagon
Washington, D.C. 20310
Navy: Safety Reports;
Naval Safety Center
NAS Norfolk, Virginia 23511
Legal Report;
The Office of the Judge Advocate General for the installation which conducted the investigation, or
Department of the Navy/NJAG-OO
Office of Judge Advocate General
The Pentagon
Washington, D.C. 20310
Air Force: Safety Reports;
Headquarters AFISC/DADF
Norton Air Force Base, CA 92409
Legal Reports;
The Office of the Judge Advocate General for the installation which investigated the incident, or,
Department of the Air Force/JA
Office of Judge Advocate General
The Pentagon
Washington, D.C. 20310

If the request is made under the FOIA, it must describe the records sought [5 USC § 552 (a)(3)(A)], and should clearly articulate the fact that the request is being made under the FOIA. The letter should also remind the appropriate branch of the service that the 1974 FOIA amendments require release of all segregable non-exempt portions of the document. Further, the Act indicates that a reply should be expected within ten days. 5 USC § 552(a)(b)(A)(i).

Occasionally, the request will be honored in part when the non-confidential, "reasonable segregable," portions of the report can be disclosed. 5 USC § 552 (b). However, it is not uncommon for the request to be denied completely on the grounds that the report is non-segregable, and either non-disclosable on national security grounds [5 USC § 552 (a)(3)(A)].

Occasionally, the request will be honored in part when the non-confidential, "reasonable segregable," portions of the report can be disclosed. 5 USC § 552 (b). However, it is not uncommon for the request to be denied completely on the grounds that the report is non-segregable, and either non-disclosable on national security grounds [5 USC § 552 (B)(1)], or strictly privileged as "agency memoranda" [5 USC § 552 (B)(5)], and not subject to availability under the FOIA.

B. Usability (Trial Preparation)

1. The Freedom of Information Act

A FOIA request is likely to be unsuccessful in producing a complete copy of a military safety report. Case history indicates that when the military has invoked the "agency memoranda" exception, it has consistently been upheld. The branches of the armed forces have traditionally maintained that guarantees of confidentiality are essential to obtaining honest and candid post-crash information on which to base corrective action. The Supreme Court has conceded that the purpose of the agency memoranda exception is to encourage open and frank discussion within agencies of proposed administrative action. *EPA v. Mink,* 410 U.S. 73, 93 S.Ct. 827, 35 L.Ed.2d 119 (1973). In another case, the Fifth Circuit upheld the Navy's refusal to release any portions of the MIR. *Cooper v. Department of the Navy,* 558 F.2d 274 (5th Cir. 1977).

When a government agency refuses to release documents under one of the exceptions to the FOIA, the agency must submit affidavits of sufficient detail to the Court explaining why non-disclosure is warranted. The Court gives great weight to these affidavits, and barring evidence of bad faith, or vague and sweeping justifications for exemption by the agency, the Court "need not go farther to test the. . .agency, or to question its veracity. . ." *Bell v. United States,* 563 F.2d 484 at 487 (1st Cir. 1977). Additionally, an *in camera* inspection is entirely within the discretion of the Court, and "when the agency meets its burden by means of affidavits, *in camera* review [has been held to be] neither necessary nor appropriate" *Hayden v. NSA,* 608 F.2d 1381, at 1387 (D.C. Cir. 1979). The use of *in camera* inspections dates back two decades to *Machin v. Zuckert,* [114 U.S.App. D.C. 335, 316 F.2d 336 (D.C. Cir.), *cert. den.,* 375 U.S. 896, 84 S.Ct. 172, 11 L.Ed.2d 124 (1963)]. *Machin* involved a subpoena issued to the Secretary of the Air Force to produce an accident mishap investigation report for use in litigation to which the United States was not a party. The court refused to order the production of any testimony, deliberations, or recommendations of policy present in the report. However, any factual findings of Air Force personnel were releasable, according to the court. The court ordered an *in camera* inspection of the reports made by individuals of the Air Force to determine what should be released.

The most recent case to involve a FOIA request for documents produced during an accident mishap investigation is *United State v. Weber Aircraft Corp.* [465 U.S. 792, 79 L.Ed.2d 814, 104 S.Ct. 1488 (1984)]. Again, the Air Force was not a party to the original action; however, as a result of one of the original parties requesting documents from the Air Force during pretrial discovery and the Air Force refusing, the action was eventually taken to the United States Supreme Court. After affirming the validity of the *Machin* ruling, the *Weber* ruling states:

> [R]espondents' contention that they can obtain through the FOIA material that is normally privileged would create an anomaly in that the FOIA could be used to supplement civil discovery. We have consistently rejected such a construction of the FOIA. See *Baldridge v. Shapiro,* 455 U.S. 345, 360, n. 14, 102 S.Ct. 1103, 1112, n. 14, 71 L.Ed.2d 199 (1982);. . .

On the other hand, where the agency invokes the national security exemption, a formidable barrier to obtaining "privileged" portions of any report is raised. In this situation, obtaining the information is most likely impossible since there is a built-in common-law presumption of integrity on the agency's part. However, the armed forces do not take this position for standard safety reports. The exception does remain a viable option in those cases where national security is truly a factor.

The use of the FOIA in discovery appears, therefore, to be limited to those situations where the government agency is a non-party to the action. Where the agency is a party to the action, a discovery request made under FRCP, Rules 34 and 26(b), which provide for party discovery, are superior. However, an FOIA request, followed by an FOIA suit, may be helpful to indirect discovery, by producing a list of the material contained in the "privileged" mishap investigation report. The index of privileged documents which is produced in the refusal to release, once obtained by counsel, can then provide a concrete checklist for ensuing production requests. Courts have consistently upheld this type of activity. *Vaughn v. Rosen,* 484 F.2d 820 (D.C. Cir. 1973), *Mead Data Central, Inc. v. Department of the Air Force,* 566 F.2d 242 (D.C. Cir. 1977).

2. Production Requests

FRCP, Rule 34(a) states: "[a]ny party may serve on any other party a request (1) to produce and permit the party making the request,. . ., to inspect and copy, any designated documents. . .which consiste or contain matters within the scope of Rule 26(b). . ."

FRCP, Rule 26 (b)(1) provides that "[p]arties may obtain discovery regarding any matter, not privileged which is relevant to the subject matter involved in the pending action,. . ." Presumably, mishap investigation reports conducted by the military would be discoverable in a civil action against the government unless exempt on some grounds of privilege.

The determination of what is privileged and what is not, is not left to the discretion of the Secretary of the service involved. As expressed in *Machin, supra,* documents in question may be submitted to the court for an examination *in camera.* The *Machin* court specifically stated that "certain portions of the report could be revealed without in any way jeopardizing the future success of Air Force accident investigation."

It appears that in litigation against the government all segregable portions of a military accident mishap safety report would be available to counsel through a standard production request, with the exception of the following:

(1) Military information involving national defense
(2) Confidential witness statements (although names and addresses must still be made available)
(3) Discussions, conclusions, opinions, and recommendations of military policy.

To determine what may be released and what may not, an *in camera* review may be a useful and valuable tool since each disputed portion of the safety report can be individually reviewed in light of the arguments presented.

3. Waiver of Privilege

When a branch of the armed forces submits a copy of a safety report to the manufacturer, or any other non-military, non-government agency, the service may, of consequence, have waived its right to claim privilege. In *O'Keefe v. The Boeing Company,* 38 F.R.D. 329 (D.C.S.D. NY 1965), the court held that the Air Force's delivery of a copy of its Mishap Investigation Report to the Boeing Company constituted a waiver of the Air Force's rights to claim absolute privilege. As such, the court held that the plaintiffs could require the Air Force to produce the reports that were in the hands of the manufacturer. The court went on to conclude, however, that the request to produce need be honored only insofar as it would produce records of facts and fact finding, not "opinions, speculations, recommendations, or discussions of Air Force policy contained in the same statements, reports, and formal reports." *Id* at 334.

In short, the law would appear to support the disclosure of all fact finding information that the appropriate branch of the military supplies to a manufacturer. Thus, it is always advisable for counsel to include in a request to produce documents directed to the manufacturer, a request to produce complete copies of any accident investigation reports conducted by any branch of the military, and any documents, witness statements or other attachments thereto.

C. Admissibility (During Trial)

The evidentiary restrictions inherent with hearsay as previously discussed in dealing with NTSB reports, are even more applicable in the case of military reports.

While there are no apparent statutory restrictions to the use of military reports, as there are with NTSB investigation reports as embodied in 49 U.S.C. 1441(e), the hearsay objection may be more applicable and the public documents exception may be inappropriate if the evidence indicates a lack of trustworthiness.

As was noted in *Fraley, supra,* the courts are aware of the importance of the investigator's competence in evaluating the trustworthiness of the accident investigation reports. *FRE,* Rule 803(8). Trustworthiness is a consideration of particular value in challenging the admissibility of military reports, since the expertise in their preparation does vary considerable, and the reports are frequently prepared by officers and other personnel with little or no previous accident investigation training or experience.

The problems inherent in military mishap reports as to the inconsistent expertise of the investigators, problems of obtaining the reports and their questionable status as admissible evidence, argues for a greater dependence on the myriad of other, more reliable discovery tools of interrogatories, depositions, and production requests in the preparation and trial of military aircraft accident cases.

IV. International Civil Aviation Organization (ICAO) Reports

A. Reliability (Requesting Reports)

1. ICAO Procedures

When an aircraft accident occurs in a nation that is a member of the International Civil Aviation Organization (ICAO) (61 Stat. 1160, Apr. 4, 1947), the accident report procedures are governed by the ICAO Convention Treaty. The country in which the crash occurred is strictly responsible for the investigation and may stray from any of the recommended ICAO investigatory procedures as it determines necessary. As a result, each ICAO report may vary considerably from country to country and from accident to accident.

a. ICAO Manual of Aircraft Accident Investigation

As stated in Chapter 1 of the *ICAO Manual of Aircraft Accident Investigation* (Fourth Ed.):

> The fundamental purpose of inquiry into an aircraft accident is to determine the facts, conditions and circumstances pertaining to the accident with a view to establishing the probable cause thereof, so that appropriate steps may be taken to prevent a recurrence of the accident and the factors which led to it.

In stating the purpose for inquiry, the *Manual* goes on to state that the inquiry should not be accusatory in nature, but instead should aim for the remedial action of prevention as opposed to punishment. It states: "[T]he assessment of blame or responsibility. . . is normally the prerogative of the judicial authorities of the State concerned."

In certain cases the country involved may choose not to produce a report, while in others, the investigation might be open to participation by any interested nation.

ICAO procedures indicate the importance of regulations within each State to immediately notify that nation's accident investigation authorities of an aircraft accident. Further, the ICAO Convention treaty governs the manner of investigating, reporting, holding hearings, and preparing reports and documents. Under ICAO procedures, international accident investigation and reporting follows the same basic format used by the NTSB. However, the quality of the final result may vary considerably in detail depending on the locale and the nation in which the accident occurs.

When an accident occurs in an ICAO member state and involves an aircraft registered in another contracting state, the state where the accident occurred is charged with immediate notification of the state of registry and the state of manufacturer of the aircraft. *ICAO Treaty,* Annex 13, Chapter 4. The Treaty assumes that each member state has adopted the appropriate regulations to ensure that local and national authorities will send the notification quickly, as well as dispatch law enforcement and investigation officials to the scene of the accident to facilitate rescue and medical operations as well as secure the wreckage.

ICAO procedures call for the most simple and effective means of notification. Additionally, the state of location of the accident has the responsibility to determine whether an investigator-in-charge or a Board of Inquiry is required.

Specific requirements for the investigation-in-charge are delineated in the *Manual.* The emphasis is on a trained individual who possess the skills of dedication, diligence, patience, an inquisitive nature, and a working knowledge of aviation. Typically, in a major crash, the investigator-in-charge, or Board of Inquiry, appoints a number of experts to comprise a Group or panel within the total investigation. Specific Groups include: Operations, Weather, Air Traffic Services, Witness Statements, Flight recorder, Structures, Powerplants, Systems, Maintenance Records, Human Factors, and Search and Rescue. *ICAO Manual of Aircraft Investigation,* Chapter 11.

b. Types of Reports

The investigative procedures utilized by the various groups during an ICAO investigation are similar to those used by the NTSB in a major crash within the United STates. Each group of the team begins by fact finding and information gathering, reports are complied and submitted to the investigator-in-charge or Board of Inquiry. Annex 13, Chapter 6, of the ICAO Agreement lists four types of reports which may be required for any one occurrance. They include:

- The Preliminary Report
- The Final Report
- The Accident/Incident Data Report
- The Summary of the Final Report

(1) The Preliminary Report

The Preliminary Report consists of whatever basic factual and circumstantial information is available during the first three to four weeks of the investigation. This report is required within thirty days of the date of the accident and copies are provided to the State of Registry, State of Manufacture, and to the ICAO. For accidents involving lightweight multi-engine or any single engine aircraft, the ICAO is not required to be an addressee on this report.

(2) The Final Report

The Final Report is a synthesis of the report of the investigator-in-charge. If the accident required a group approach to the investigation, the Final Report represents a consolidated report based on the individual reports from the various groups.

The Final Report is divided into four main sections which include:

- Factual Information
- Conclusions
- Safety Recommendations
- Appendices

The information in the Final Report includes findings together with the substantiating information derived from the investigation and analysis procedures. This reports represents the embodiment of the investigative process.

(3) The Accident/Incident Data Report

The Accident/Incident Data Report provides accurate and complete information on the accident. This computerized report simply indicates the overall investigation is complete and the Final Report has been approved by the appropriate authorities of the State conducting the investigation. It is basically a compilation of statistical information gathered in the course of the investigation and is designed to provide a brief, non-narrative, summary of all relevant findings and conclusions.

(4) Summary of the Final Report

The purpose of the Summary of the Final Report is not to replace the Final Report, but instead to summarize the Final Report in a convenient and uniform format to be readily included in the *ICAO Aircraft Accident Digest* for dissemination to all contracting states. This report may or may not be completed. Annex 13, Chapter 6 requires the state conducting the investigation to prepare and submit a Summary of the Final Report to the ICAO when the information in the report is of "exceptional value" to the promotion of safety.

2. Obtaining Reports

The Summary of the Final Report is sent to the Secretary General for the Accident Investigation Group (AID) of the ICAO at the following address:

The Secretary General, Attention AIG
International Civil Aviation Organization
P.O. Box 400, Succursale:
Place de l'Aviation Internationale
1000 Sherbrooke Street West
Montreal, Quebec, Canada H3A 2RS

A copy of this Summary is obtainable from the ICAO through the above address by written request.

Two items of interest must be kept in mind with respect to the Summary. First, by its very nature it is only available for exceptional or highly spectacular accidents. Second, the quality of the summaries will vary depending on the diligence and dedication of the individual investigators and states involved.

Copies of the Final Report or the Summary of the Final Report may also be obtained from the State that conducted the investigation by contacting the appropriate agencies within that state's government.

History teaches that the willingness of different nations to make their reports available to the public varies. Many nations refuse to permit public disclosure of their reports, and others adopt a case-by-case disclosure policy. The ICAO will not contravene the wishes of a member nation, nor will investigative agencies of assisting states. Sometimes, the details are just not available directly, and alternatives, that is private investigations must be conducted.

B. Usability (Trial Preparation)

The uses of ICAO investigative reports in trial preparation presents no greater restrictions than the use of NTSB or military reports previously discussed. There are no statutory limitations which address these reports directly. However, as indicated, obtaining copies may present some difficulty, especially for those reports where a summary of the final report has not been filed with the accident investigation group of the ICAO.

C. Admissibility (During Trial)

During trail, ICAO reports present the same evidentiary limitations as NTSB and military reports. In fact, in the area of trustworthiness, these reports present similar problems to the military safety mishap or technical report. As with military reports, the presiding judge would be required to address the capabilities of the investigator-in-charge and the motives apparent in the report when determining admissibility.

Specific hearsay objections could be made, however, the public records exception, FRE 803 (8), would again be applicable. This is true especially when considering the problems of obtaining factual information from remote areas of the world, policy would argue for admitting those portions of the report which represent pure fact finding due to the limited availability of data from other sources.

Those portions of an ICAO report which clearly state opinions or conclusions of the Inquiry Board or the investigator-in-charge as to probable cause would most likely be held inadmissible. This view would be consistent with the 1977 Federal Rules Decision in *Complaint of American Export Lines, Inc.* which stated, "evaluative conclusions or opinions. . . do not come within the exception to the hearsay rule pertaining to factual findings." 73 F.R.D. 454 (D.C.S.D. NY 1977).

The litigator should be prepared to argue the issues of trustworthiness and manufacturer bias when addressing ICAO reports. The degree of expertise of investigators varies from country to country and from accident to accident, thus making the job of assessing reports very difficult. Further, aircraft manufacturers play a larger role in the analysis aspects of ICAO reports than they do in NTSB reports. Therefore, the questions of built-in bias and conflict of interest are more prevalent. However, using the same logic of the *Farley* and *Sage* courts, *supra*, the potential problems with ICAO reports should go to their weight during trial rather than their admissibility.

V. Conclusions

It is clear that accident reports, from whatever source, can provide the litigator with a valuable source of data to review the accident, plan future discovery, and develop an approach to litigation. Official reports compile a large amount of data in a small package. However, the inherent dangers present in these reports call for caution in the possible overreliance on their formal character. Accident reports, whether NTSB, military, or ICAO should be evaluated with the same scrutiny as any other piece of potential evidence.

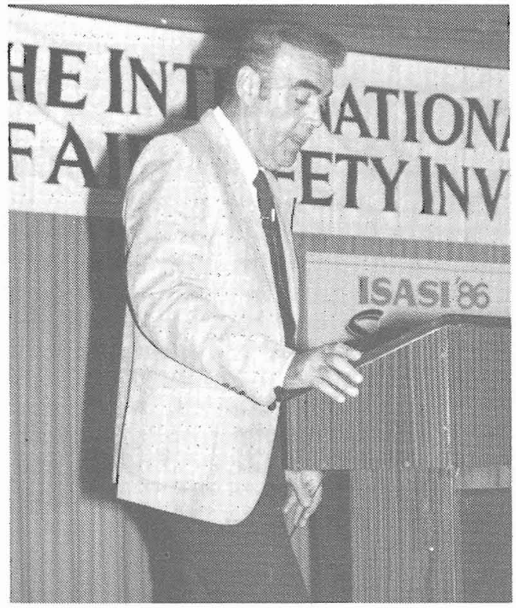
The continued use of manufacturers and interested agency representatives in the accident investigation process needs to be balanced by representation by other interested parties. The legal prohibition on the use of opinions and conclusions present in reports during litigation, makes the continued exclusion of these parties questionable. If the stated objective and purpose of the investigation is objective analysis for the purpose of accident prevention, and only factual data is admissible during trial, the inclusion of additional parties of interest in the investigative process could have little bearing on the final result.

The attorney who plans on using accident reports during litigation needs to be aware of the various investigative approaches followed by different agencies. More specifically, the litigator needs to know the strengths and weaknesses of each type of report.

The investigator, on the other hand, must be aware of the potential legal use of the report produced as a result of an investigation. The burden is on the investigator to ensure the accuracy of each fact presented. Further, assumptions and speculation must be clearly labeled as such. The duty of the investigator-in-charge must include questioning the report and data submitted by manufacturer and agency representatives to ensure an unbiased thorough analysis has taken place.

The recent trend toward an increase in admissibility of official accident reports by the judiciary, in an attempt to foster the discovery of the truth, places a greater responsibility on both the aviation litigator and the aviation investigator. While, at times, the short term goals of each may appear divergent, their long term goals remain the same: that of increasing air safety for the general public and increasing air safety consciousness for the entire aviation industry.

Mr. John Rawson, Chief, Accident Investigation Division, FAA, on "The Cooperation & Adaptive Process"



Terry Armentrout, Director, Accident Investigation Bureau, NTSB, on "The Shuttle Challenger Accident."

Security of Aviation in the Air Accident Prevention and Investigation Fields

By Trevor J.C. Joy

Introduction

It is a sad situation we find in aviation in these so called enlightened days. Aviation, which each year moves hundreds of millions of persons by air with a safety record which cannot be matched, finds itself a target for almost every violent terrorist group wishing to publicise their cause or gain some advantage.

The same publicity which inevitably follows these attacks not only acts as a catalyst for other like incidents, but also plants the seed in the minds of the mentally deranged person where it may well manifest itself as an irrational attack on some aviation target.

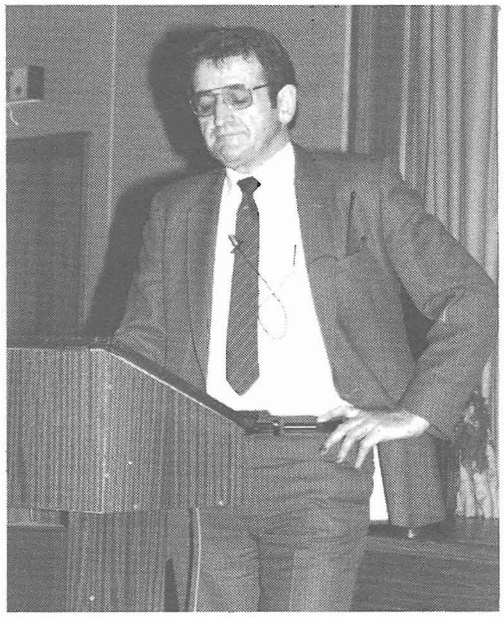
In addition to being a popular target aviation generally and aircraft in particular are highly vulnerable.

Security measures applied diligently to every aspect of an aircraft departure can almost guarantee the security of any flight from damage or hijack initiated by some person on board.

With the popularity of aviation being based on speed, comfort, facilitation and economics, "total" security as an ongoing situation is almost totally prohibitive.

How popular would airline passenger travel be if full body strip searches, full and detailed hand and hold-stow baggage searches, full catering and aircraft stores inspections, total aircraft anti-sabotage searches before loading was required, backed up with the very visible deployment of armed guards for every departure from every airport were required? I suggest to you that apart from the passenger resistance this would cause, the cost in aircraft through the loss in utilisation with aircraft turnaround times extending from 1.5 hours to perhaps eight hours and the massive cost in manpower and equipment would alone destroy the economic advantages of air travel as we know it today.

Further, if the threat and the cost of counter measures reached the "total security" situation, perhaps the economics of the major wide bodied aircraft would have to be reviewed against the possible loss of the lives of hundreds of persons and the time taken to security prepare such aircraft for departure.



Trevor J.C. Joy

Without "total security" is it possible to smuggle a weapon or device on board a scheduled passenger flight which is capable of bringing the aircraft down?

The answer is quite simply, YES.

The security applied must always be finely balanced against the threat factor. That factor is infinitely variable. All security, whether it is applied directly through security staff or security procedures applied by the operator or the pilot-in-command is designed to create a situation where the risk of the weapon or device and/or the offender being discovered is sufficiently great to deter the offender in the first place.

Because security is not total, the possibility of the investigatory talents of Air Accidents Investigators being required in the aftermath of a major or minor incident is always very real. Following is a hypothetical situation which you may consider has value as a study.

Guide to Security

The Scenario

A B727 of October Airlines operates Hawaii, Samoa, Fiji, Auckland, Noumea, Hawaii on a regular weekly basis. It is a popular service acting as a feeder to major intercontinental services to Australia, North America and Europe.

One hour 30 minutes out of Auckland, bound for Noumea it disappears after a brief MAYDAY call is received. The call indicated that there had been an explosion on board followed by a loss of control. There is no radar coverage.

There are 110 passenger and 3,000 kilograms of freight on board.

In the absence of any other information sabotage is suspected.

The Investigation

You commence your investigation at Auckland International Airport. The aircraft had only been at that airport for a period of one hour 20 minutes. The area where the aircraft had been parked was in a well secured area and a guard was nearby during the boarding.

You note on doing an on-site inspection that a number of airline ground staff do not wear airport identity cards and although their airport identity cards are checked as they report for duty, their lunch boxes and other minor items are not subject to inspection. You note this as a possible weakness in the system.

Passenger screening is of a good standard and the security staff involved have recently had refresher training in identification of explosives. There had been a crew change at Auckland. Upon checking at the hotel where the crews stay-over you discover that most crews staying at the hotel bring out their baggage when asked to clear their rooms and are in the habit of leaving these unattended in the hotel lobby. Another weakness is noted. You are later relieved to discover that crew baggage is screened at Auckland although you are still a little concerned when you note that the examination of the crew baggage is of a casual nature.

Catering supplies have been taken on at Auckland supplied by the agent airline. You inspect the catering procedures discovering that the food is prepared and packed in a good secure situation with responsible staff employed. On checking the route from the flight kitchen to the aircraft you discover that the slow highloader vehicles travel along a stretch of public road, where traffic delays are common. The driver of the vehicle for the October Airlines flight recalls he had to wait 10 minutes in traffic while enroute on the day in question. Another weakness is noted.

During the turnaround at Auckland the aircraft was not subjected to any anti-sabotage search. Customs advise that while they checked out the aircraft it was quite possible that some item had been left in the aircraft which they would not have noted. You note that a device may well have been planted on board well prior to the aircraft's arrival at Auckland. External areas had not been inspected other than in normal engineering and flight crew pre-take off checks. Another weakness.

Interviews with the crew who brought the aircraft into Auckland reveals that two young men wearing white overalls were found on board the aircraft when the cabin crew re-boarded the aircraft in Nandi, Fiji. The steward concerned advised that one of the men had remarked that they had been checking the galley. Although this was unusual the steward thought nothing more of it. The men were in the vicinity of the rear galley.

Upon checking this matter out at Nandi, these persons could not be located, although the airline agent considered that it was possible that his staff could have been doing a check. A security inspection of the areas around the international terminal revealed reasonably good security. However, it was noted that a gate guard was inattentive. He was noted to leave his post on two occasions, once for a meal and on another occasion to relieve himself. Another weakness identified. Turnaround time at Nandi had been only one and a half hours. A check with the officials at that airport revealed that no anti-sabotage search had been carried out there, thus leaving the possibility that an explosive device could have been introduced on board at that point or could have been placed there at an earlier point.

Your investigations now take you to Samoa. Here it was discovered that only 10 passengers boarded at that point. Again the turnaround was very brief and an aircraft guard was in attendance at all times. On discussing the situation with security officials you discover that among the 10 boarding passengers were two controversial V.I.P.'s. These persons were given an official farewell. Their well wishers came out onto the apron to see them off. Security officials noted that gifts were handed over at the last minute. Neither the V.I.P.'s, their hand baggage or the gifts were security inspected. This gave you cause for serious concern about the two officials because, while having the support of many of the Samoan public, there was a small faction in their society which strongly resented them and had protested violently against their visit to the islands. Further trouble was expected when they visited other islands in the Pacific. A very serious concern identified.

On to Hawaii. Here you discover that the aircraft had been out of service for two days for maintenance before doing the Pacific run. Your inquiries reveal that the interior of the aircraft had been thoroughly examined and the engineering check was such that any device would have been discovered. Security and Police officials were able to confirm that because of the V.I.P.'s which would be boarding in Samoa, special guard arrangements had been taken from the time the aircraft left the engineering base. However on checking the passenger/traffic staff, it became apparent that a passenger who had checked in for the flight had failed to board. Because of a passenger miss-count this fact was not discovered until after the aircraft had departed. No other airports had been notified. When the passenger was identified it was discovered that his baggage had been checked through to Noumea. Another cause for very real concern.

Considerations

Thus on this one flight I have raised some seven hypothetical situations which placed the aircraft at unnecessary risk. There is nothing unusual about any of them. All are common place throughout aviation except in the highest risk and most heavily guarded aircraft and airports. In the course of my travels both within New Zealand and overseas these and other similar weaknesses are noted. You may rest assured that if such weaknesses are apparent to the professional security chief they are at least equally obvious to the terrorist or criminal. As you are professionals in your areas of expertise so to is the professional terrorist.

In the event of you or your compatriots ending up with the task of investigating an aircraft incident that gives the appearance of being based upon sabotage or the like I suggest you enlist the assistance of a professional security official. He will read the security aspects of airports, airlines, crews and ground staff as surely as a thoroughly trained air accident investigator will read the impact marks of a propeller in soft ground.

In going through that scenario I have touched on but a few of the matters which would need to be considered as possible weaknesses which may have resulted in an explosion. There are many others. A few more "weaknesses" which would need to be considered are:

- An airline employee placing a device on board as a result of a threat of violence to him or his family at any of the airports.
- Device introduced at any one of the departure points through cargo.
- Device introduced through the mail system.
- Device introduced through passenger hand baggage having been missed in screening.
- Insurance claim fraud through life insurance.
- Accidental explosion arising from smuggled explosive.
- Surface to air missile attack (accidental or intentional).

These are but a few.

Conclusion

Finally, the opportunity to present this paper to another professional group dedicated to the safety of aviation is a pleasure. I hope that in drawing your attention to these matters and what I have described as "weaknesses" you may find them thought provoking at some time in the future should you or your colleagues be faced with a problem of this nature. Perhaps also by passing on to you these thoughts you may well find the opportunity to encourage better security in your own countries and airlines.

The threat to aviation from the terrorist and the mentally deranged has never been greater.

Thank you.

In NTSB Investigations, Public Disclosure of Accident Information is Examined

By Stephan J. Corrie
Senior Air Safety Investigator
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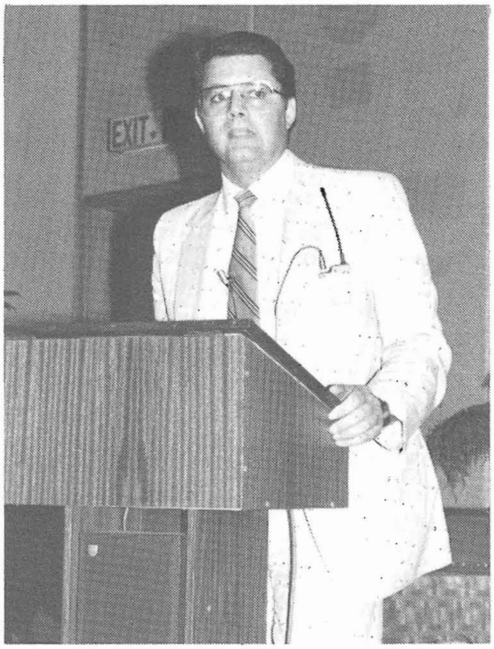
(The views expressed in this paper are solely those of its author and not necessarily the views of the NTSB.)



Stephan J. Corrie

Introduction

Of particular interest and debate today in the conduct of aircraft accident investigations is public disclosure of investigation information. Particularly the evidence provided by individuals or parties who give evidence, and their rights to confidentiality and possibly immunity. It is recognized that aircraft accident investigations are governed by the laws and rules of individual States throughout the world, and therefore, fundamental differences exist between these States as to how the investigations are to be accomplished.

In the United States, aircraft accident investigations are conducted by the National Transportation Safety Board (NTSB), sometimes referred to as the Board, an independent agency of the Federal government. Having derived its formation from the origins and misfortunes of aviation in the U.S., its authority has been solidly based on important milestones brought about by the country's democratic foundation and the public's right to know the business of its government. In order to understand and appreciate this development, the following background discussion is offered.[1]

Background

The origins of civil aircraft accident investigation in the United States today can be traced to six legislative milestones:

- The Air Commerce Act of 1926
- The Civil Aeronautics Act of 1938
- The Civil Aeronautics Board of 1940
- The Federal Aviation Act of 1958
- The Department of Transportation Act of 1966
- The Independent Safety Board Act of 1974

The Air Commerce Act was the first law passed by the Congress to govern civil aviation and it provided for Federal government investigation of civil aircraft accidents. This action took place long after U.S. air carriers had already started domestic and international operations. Following the death of a congressman in the crash of a DC-2 in May 1935, the Civil Aeronautics Act of 1938 was created as a result of political intervention in the Federal investigation of the accident. The Act established within the Department of Commerce the Civil Aeronautics Authority, designed to be an independent agency to regulate civil aviation. Three departments were formed within the Authority, of which one was the Air Safety Board responsible for the investigation of accidents.

Then in 1940, the Department of Commerce reorganized its responsibilities in aviation and formed two separate agencies to remedy the fact that the investigatory board did not have the power to change any safety rules; it could only make recommendations for such changes. Thus, the Civil Aeronautics Board (CAB) and the Civil Aeronautics Administration (CAA) were formed. The CAB took over all the functions of the previous Civil Aeronautics Authority and those of the Air Safety Board. In its exercise of economic, rulemaking, and investigative functions, the CAB was independent of the Secretary of Commerce. The CAA took over the operational functions of the office of the Administrator (responsible for airways facilities, air traffic control, and other operational functions) including the enforcement of air safety regulations.

Not until 1958 were safety rulemaking and accident investigation truly separated. This was brought about by several midair collisions, the most notorious of which was the collision over the Grand Canyon on June 30, 1956, between a United Airlines, Douglas, DC-7 and a Trans World Airlines Lockheed 1049A. Public concern over these accidents forced the Congress to pass the Federal Aviation Act of 1958. As a result, the Federal Aviation Agency (FAA) was created to assume all rule-making and certification responsibilities and the additional tasks previously assigned to the CAA. The economic rule-making and accident investigation responsibilities were kept within the CAB in addition to the review of airman appeals from FAA certificate actions and denials.

Eight years later, the Congress passed the Department of Transportation Act of 1966. This Act reorganized the regulation of transportation and included, among others, the Federal Highway Administration, the Federal Railroad Administration, the Coast Guard, and the Federal Aviation Administration (FAA). To this date, the FAA has not regained the independence it had under the 1958 Act as a result of this reorganization. Also, the DOT Act created the National Transportation Safety Board, a new agency independent of the DOT except for administrative support.

In addition to some subtle pressure exerted on the Board by the Executive branch, the crash of the Turkish DC-10 near Paris in March 1974, and the subsequent investigation highlighted the lack of appropriate response by the FAA to the Board's safety recommendations. The investigation revealed that the Turkish DC-10 accident could have been prevented had the FAA implemented the recommendations the NTSB made following its investigation of an earlier DC-10 incident which involved a similar cargo door failure. As a result, the Congress passed the Independent Safety Board Act of 1974 which made the Board completely independent of any other Federal agency of the U.S. government.

The primary function of the Board is to promote safety in transportation. In aviation, the Board is responsible for the investigation, determination of facts, conditions, and circumstances and the cause or probable cause of all civil aircraft accidents. The Board makes safety recommendations to Federal, State, and local agencies, and interested persons which are "...calculated to reduce the likelihood of reoccurrence of transportation accidents. It initiates and conducts special studies and special investigations on matters pertaining to safety in transportation, assesses techniques and methods of accident investigation, evaluates the effectiveness of transportation safety consciousness and efficacy in preventing accidents of other Government agencies, and evaluates the adequacy of safeguards and procedures concerning the transportation of hazardous materials." The Board also makes rules and regulations governing the notification and reporting of accidents. It has the authority to hold public hearings, sign and issue subpoenas, administer oaths and affirmations, and to take depositions in connection with investigation of accidents.

NTSB REGULATIONS

REFERENCE: TITLE 49 CFR PARTS 800-899

PART 800 –	ORGANIZATION AND FUNCTIONS OF THE BOARD AND DELEGATIONS OF AUTHORITY
PART 801 –	PUBLIC AVAILABILITY OF INFORMATION
PART 802 –	RULES IMPLEMENTING THE PRIVACY ACT OF 1974
PART 804 –	RULES IMPLEMENTING THE GOVERNMENT IN THE SUNSHINE ACT
PART 821 –	RULES OF PRACTICE IN AIR SAFETY PROCEEDINGS
PART 826 –	RULES IMPLEMENTING THE EQUAL ACCESS TO JUSTICE ACT OF 1983
PART 830 –	RULES PERTAINING TO THE NOTIFICATION AND REPORTING OF AIRCRAFT ACCIDENTS OR INCIDENTS AND OVERDUE AIRCRAFT WRECKAGE, MAIL, CARGO, AND RECORDS
PART 831 –	AIRCRAFT ACCIDENT/INCIDENT INVESTIGATION PROCEDURES
PART 845 –	RULES OF PRACTICE IN TRANSPORTATION ACCIDENT/INCIDENT HEARINGS AND REPORTS

Figure 1

Rules and Policies

The Board's rules shown in Figure 1 pertain to aviation. However, for the purposes of this discussion, only 49 Code of Federal Regulations (CFR) Parts 801, 804, 831, and 845 will be used.

By Statute, the NTSB is required to make its investigation reports public; however, in a manner as may be deemed by it to be in the public interest, Part 801, Public Availability of Information, sets forth the details on what information is routinely available, the cost of the material and how it is to be obtained. More importantly, by law the Board is required to make any piece of information available to the public, except for certain internal documents. According to 49 USC 1905, Section 306(a) of the Act:

> Copies of any communication, document, investigation, or other report, or information received or sent by the Board, or any member or employee of the Board, shall be made available to the public upon identifiable request, and at reasonable cost, unless such information may not be publicly released pursuant to subsection (b) of this section.
>
> Except, the Board shall not disclose information obtained under this title which concerns or relates to a trade secret referred to in section 1905 of title 18, United States Code, except that such information may be disclosed in a manner designed to preserve confidentiality—
>
> 1. Upon request, to other Federal Government departments and agencies for official use;

2. Upon request, to any committee of Congress having jurisdiction over the subject matter to which the information relates;
3. In any judicial proceeding under a court order formulated to preserve the confidentiality of such information without impairing the proceedings; and
4. To the public in order to protect health and safety, after notice to any interested person to whom the information pertains and an opportunity for such person to comment in writing, or orally in closed session, on such proposed disclosure (if the delay resulting from such notice and opportunity for comment would not be detrimental to health and safety).

Furthermore, the law stipulates, "No part of any report of the Board, relating to any accident or the investigation thereof, shall be admitted as evidence or used in any suit or action for damages growing out of any matter mentioned in such report or reports. 49 USC Sec. 1903(c) [Sec. 304(c)].

Enactment of Public Law 97-309, of October 14, 1982, concerning the cockpit voice recorder provided; in part:

> Notwithstanding any other provision of law, the Board shall withhold from public disclosure cockpit voice recorder recordings and transcriptions, in whole or in part, of oral communications by and between flight crew members and ground stations, that are associated with accidents or incidents investigated by the Board: Provided, that portions of a transcription of such oral communications which the Board deems relevant and pertinent to the accident or incident shall be made available to the public by the Board at the time of the Board's public hearing, and in no event later than 60 days following the accident or incidents: and provided further, that nothing in this section shall restrict the Board at any time from referring to cockpit voice recorder information in making safety recommendations.

In 1966 as an amendment to the information section of the Administrative Procedures Act, the Freedom of Information Act (FOIA) was enacted. Its purpose was to "...open administrative process to the scrutiny of the press and general public." It requires that, "...information held by Federal agenices must be made available to the public unless it comes within one of the nine categories of matters that are specially exempt from public disclosure." Since the Act does not absolutely forbid disclosure of all exempt matters, this in effect means the agency has some discretion in matters of disclosure but, it is recognized that, "...records which cannot be disclosed without impairing rights of privacy or important government operations must be protected from disclosure."

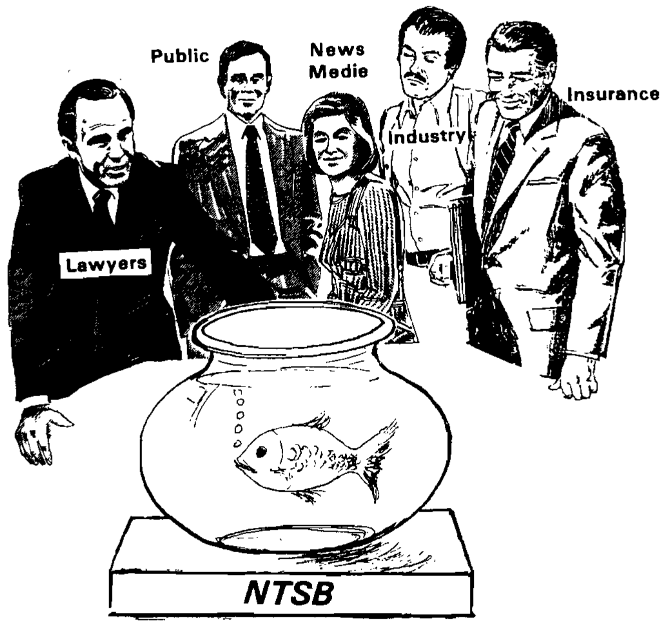


Figure 2

For the foregoing reasons, the Board filed a difference with paragraph 5.12 of Annex 13, "Disclosure of Records," which provides for withholding information when the State conducting the investigation considers disclosure of certain records might have an adverse effect on the availability of information in the investigation or in any future investigation. In its March 16, 1981, response, the U.S. stated:

> Full exchange of information is vital to effective accident investigation and prevention, and the United States supports in principle measures designed to facilitate development and sharing of information. However, a determination by an agency of the United States that disclosure of one of the specified types of records might have an adverse effect on the availability of information in a current or future investigation would not necessarily bar disclosure under the United States Freedom of Information Act or in connection with actions for damages stemming from an accident. Thus, no guarantee can be provided that this paragraph can be honored in all instances.
>
> It is not anticipated that we will be able to comply fully with 5.12 in the future.

The U.S. was not alone in our position. Several other States also filed similar differences with paragraph 5.12. These were, Australia, Austria, Canada, Federal Republic of Germany, Japan, New Zealnad, South Africa, Sweden, and Switzerland.

The position and limitations of the Board on disclosure matters involving foreign accidents investigations were underscored as a result of its participation as the State of Manufacturer in the crash of the Turkish DC-10 accident. During the investigation, a court in California had ordered the Board to produce records it had obtained from the French investigation authorities. The Board had no choice but to produce the records at the consternation of the French authorities. Although they understood the Board's predicament, needless to say it has taken a great deal of time to repair the damage and renew our relationship with our French counterparts.

Then in 1976, the "Government in the Sunshine Act" was enacted. It was declared that the public was entitled to the fullest practicable information regarding the decision-making processes of the Federal government while at the same time the rights of individuals should be protected. In the case of the Board, the public is invited to attend its open meetings, but not to participate. There are grounds, too numerous to mention here, on which meetings may be closed or information withheld. Suffice it to say, that matters which are specifically exempt by law, affect national security, involve crimes, constitute an invasion of personal privacy, etc. are grounds for nondisclosure. A separate vote from each Board member is required before a closed meeting can be held or information withheld.

Part 831.5 provides a process by which persons can request that information be withheld from public disclosure. By written declaration, any person can object to disclosing ". . . information contained in any report or document filed, or of information obtained by the Board, stating the grounds for such objection." The Board would rule on an objection based on the exemption criteria in the FOIA and provided its release is not found to be in the public interest.

Also, Part 831.9 provides for the participation of parties ". . . whose employees, functions, activities, or products were involved in the accident or incident and who can provide suitable qualified technical personnel to actively assist in the field investigation." However, no designated party to the investigation ". . . shall be represented by any person who also represents claimants or insurers. Failure to comply with this provision shall result in loss of status as a party." Part 831.11, provides, upon approval of the investigator-in-charge, the release of information by parties to their respective organization necessary for purposes of prevention or remedial action. "Under no circumstances shall such information be released to unauthorized persons whose knowledge thereof might adversely affect the investigation." Part 831.11 permits release of only factual information as it develops during the on-scene investigation through the Board Member present, the representative of the Board's Office of Government and Public Affairs, or the investigator-in-charge.

Both Parts 831 and 845 provide for the right of any person questioned by the Board to be ". . . accompanied, represented, or advised by counsel or by any other duly qualified representative."

The FAA Act of 1958 and the Independent Safety Board Act of 1974 provide for any court in the U.S. to issue an order requiring any person to appear before the Board to give evidence. Failure to appear would be considered contempt of the court and may be punishable. Also, the Act provided that no person shall be excused from testifying or producing documents on the ground that the testimony or evidence may tend to incriminate him or subject him to a penalty or forfeiture; provided that the witness shall not be prosecuted or subjected to any penalty or forfeiture for matters about which he is compelled to testify. However, the Act was amended in 1970 with the enactment of Title II of the Organized Crime Act. This amendment restricted immunity from testifying only to criminal prosecution instead of any penalty or forfeiture which had been interpreted to include airman certificate actions.

Any order by the Board compelling testimony and thus granting immunity first requires determination by Board representatives that the testimony is necessary in the pbulic interest. If it is, the matter is brought before the full Board for final determination. If the Board determines that an order should be issued, it is transmitted to the U.S. Department of Justice for approval. If approved, the matter is referred to the appropriate court for enforcement.

Board Practices

Although the Board's rules provide for and encourage interested parties to submit their views and recommendations as to the proper conclusions that should be made as a result of their full participation in an investigation, it is the Board's policy and practice not to permit parties to review and comment on a draft of the full report, to include the analysis, findings, conclusions, and probable cause. The parties already take an active part in the on-scene investigation and public hearings, participate in technical review meetings and occasionally review and comment on the factual portion of the final report, and can submit their views to the Board for consideration. Therefore, in the Board's view, their participation in the analysis of the accident is ". . . not likely to enhance significantly the accuracy of the report." Also, making the complete draft of the report available to the parties would probably complicate the Board's right to withhold it from an FOIA request before it is adopted by the Board. There is also the possibility that such a practice might encourage leaks to the news media.

In most accident and incident investigations the Board's investigator-in-charge or group specialists prepare analysis reports to assist the Board in arriving at its findings and determination of probable cause. These reports are for official use only and not made available to persons outside the Board. To date, the Board has been successful in blocking efforts by litigants to force it to make analysis reports available.

When the Board assigns an accredited representative to participate in a foreign investigation, it is the policy of the Board that the representative return to the U.S. without notes and documents which have not already been approved for release by the State of Occurrence because the Board cannot always protect such information from disclosure. However, this policy makes it awkward and difficult for investigators to assist the State of Occurrence in their on-going investigation activities. For this reason, it has been necessary on occasion to maintain investigation files at the Embassy of the State of Occurrence.

Although the Board investigates several thousand accidents each year, it has encountered relatively few cases where public disclosure of information or the rights of individuals became a problem. Some cases were more difficult to handle than others. In some instances the Board chose not to use confidential information or provide immunity. The following are a few investigation cases which provide some insight into how the Board handled these matters in the past.

Case No. 1:

On March 5, 1969, a PRINAIR, deHavilland Heron, on a regularly scheduled air taxi passenger flight from St. Thomas, Virgin Islands, to San Juan, Puerto Rico, with 17 passengers and 2 crewmembers aboard, was vectored into the side of a mountain under IMC conditions while attempting to make an ILS approach to runway 7 at the San Juan International Airport. See Figure 3. All of the occupants on board received fatal injuries and the airplane was destroyed in the accident. "Following the transfer of control from San Juan Air Route Traffic Control Center to San Juan Approach Control, the flight was given an erroneous position report. Indications are that the flight complied with the subsequent radar vectors and altitude assignments until the accident became unavoidable."

Figure 3

In its determination of probable cause, the Board stated, "...the vectoring of the aircraft into mountainous terrain, under IFR conditions, without adequate obstruction clearance altitude by a controller who, for reasons beyond his control, was performing beyond the safe limits of his performance capability and without adequate supervision."

A supplemental human factors team, dispatched to San Juan to conduct the controller interviews, dealt with the human factors aspects and sensitive issues in this case. They had determined that the suitability of the controller involved was questionable since he had been referred to a psychiatrist and a psychologist after having been identified through a nationwide controller screening test (16 Personality Factors Test) to have a psychiatric disturbance resulting in a high anxiety level and a very low stress tolerance.

A meeting was held between Board investigators and FAA representatives in order to arrange for the use of some of the sensitive evidence in the Board's report and to protect as far as possible the controller's rights to privacy. It was decided that a confidential summary of the medical and psychological reports on the controller would be prepared by an FAA medical doctor for the Board's use.

During review of the final report by the Board, a Member questioned whether the Board could accept and approve the report based, in part, on the confidential information and the nature of the accident. The Member believed that the Board's work should be based on a public record and not a confidential one. This apparent contradictory position was resolved by the recognition of the fact that the probable cause of the accident could be based on the existing public record without having to make public the confidential records of the controller. The member believed that after having decided the meaning of the probable cause, it was found that it could be supported by the existing public record. He maintained that like any administrative agency the Board is endowed with expertise in matters in which it has statutory authority. He concluded that, the Board can analyze the evidence before it and reach conclusions based solely upon its technical expertise, or on matters of a psychiatric nature.

Comment:

It appears the staff did not apprise the Board of the confidential nature of the investigation and request a ruling before the draft report was prepared. Also, this decision by the Board was made before the FOIA really took hold.

Case No. 2:

On April 12, 1969, a Cessna 310N, en route from Albuquerque, New Mexico to Riverside, California, crashed while being radar vectored for an instrument approach to the Municipal Airport at Riverside. All five occupants on board were killed and the airplane was destroyed.

The Board had determined that the radar controller involved had misidentified the airplane by accepting a non-transponder target of another airplane for the twin Cessna. The controller had issued a turn and an altitude instruction which resulted in the airplane flying into the side of Cucamonga Canyon about 16 miles north-northwest of the airport. The Board found that there was sufficient information and indications available to the controller to point out the errors, but he failed to notice his mistake.

During the public hearing in connection with the accident, the involved controllers refused to testify. The Board stated its following position:

> While it has the power to compel such testimony, if it is deemed necessary to the investigation, such action would grant immunity to the controllers. In this instance, the Board said a review of the record revealed that while detailed testimony of the controllers would probably have provided a more complete record, their written statements, with corresponding interviews, the transcription of radio communications, the testimony of others, and other available data were sufficient to determine probable cause. Consequently, sworn testimony would not be taken.

Comment:

Since the existence of the NTSB, this provision of the law has not been used. The procedure, as previously described, is cumbersome and time consuming. The Board has been fortunate over the years to have obtained the cooperation of parties and witnesses to provide information.

Case No. 3:

In an attempt to depose seven Board investigators stemming from their participation in an accident involving Saudi Airlines, Lockheed L1011, Riyadh, Saudi Arabia, August 19, 1980, plaintiffs had subpoenas issued by the U.S. District Court of the District of Columbia on September 22, 1981 for depositions to take place on October 21, 1981. The Board was successful in avoiding the testimony of its investigators at that time.

The Board argued that it was the ICAO Council's intent, in Section 6.13 of Annex 13, to protect the objectivity and quality of the safety investigation from outside interests until the investigation can be completed and a final report issued. That, the Kingdom of Saudia Arabia was the State of the Occurrence, and responsible for the investigation and release of information. That in order for the Board to carry out its Congressional mandate of promoting transportation safety, it was essential that the Board participate in foreign investigations to provide for an uninhibited exchange of information expeditiously, and that, in order for the Board's participation to be successful, it must abide by all portions of the Annex. Otherwise, premature or unauthorized release of information by the Board during such participation would adversely effect its ability to participate in future foreign investigations.

Furthermore, the Board argued that the Plaintiffs' need to obtain the Board investigators' testimony, "...must be balanced against the foreign policy and transportation safety considerations..." At that time the investigators were directly involved in the investigation. The Board's previous attempt to solicit the Kingdom of Saudia Arabia's approval to allow the deposition to take place was denied.

As a result of another procedural matter (inconvenient forum motion) the case was dismissed prior to the court's decision on the merits of the Board's motion.

Case No. 4:

In a deposition proceeding stemming from an accident of a Cessna which crashed on July 9, 1980 in which the four occupants were killed, the Plaintiff brought a contempt action against the Board's investigator-in-charge of the accident who refused to answer questions concerning his conversations with the investigator from the defendant aircraft manufacturer.

The Plaintiff put forth the argument that the manufacturing representative, "...may have expressed an opinion as to the cause of the accident" in these conversations. The investigator refused to answer based on Part 835.3(b), which forbids Board employees from giving their opinions regarding a particular accident, but allows them to testify about factual information. The Plaintiff argued that the question solicited only factual information.

The case was removed to a Federal court where it was determined that the witness' refusal to answer was pursuant to the Board's rule and undisputable. That his refusal to testify was predicated on his reliance on the Board's regulations and was"...any the causal connection required between charged conduct and asserted official authority..." and the government's case was affirmed in the Ninth Circuit, Court of Appeals.

Proposed Rule Changes

The Board has recognized how its position with respect to Section 5.12 of Annex 13 has on occasion affected adversely its participation in foreign accident investigations. Therefore, in June 1986, during appropriation hearings before the Congress, the Board proposed an amendment to the Independent Safety Board Act which would permit the Board to withhold information and records until such time as the State of Occurrence has released its final report, specifically authorized the release of certain information, or two years after the accident whichever occurs first.

Since the Congress had not yet ruled on the proposed amendment, the Board in August 1986 had to reaffirm its previous position on disclosure in response to an ICAO amendment to Section 5.12.

Conclusions

The openness with which aircraft accident investigations are conducted in the U.S. is consistent with its democratic principles. The Board is a public agency doing the public's business and therefore is responsive to its needs. Although there are provisions for handling sensitive information uncovered in an investigation, it could be difficult to withhold it from disclosure before investigators have had an opportunity to determine its importance in the cause of the accident and to determine the steps to be taken in dealing with the information. The Board insures that the individual's rights to privacy are protected as much as possible within the established rules and the law.

The need to use confidential information or the need to compel testimony must be reviewed in light of other evidence before deciding that such information is essential to the investigation. Available evidence may be sufficient to determine the cause of the accident and may help prevent its reoccurrence. Equally important is that the use of confidential information should result in some practical application in the prevention of accidents. If it cannot meet these tests, then its use becomes highly questionable and fruitless. There is no simple procedure or magic in handling such matters. Each accident must be evaluated on its own merits. This appears to have been the Board's manner in handling such matters in the past and is expected to continue in the future.

The Board's position on disclosure of information in foreign investigations remains unchanged for the present time. It will continue to make every effort to prevent unauthorized disclosures of accident information and will continue to cooperate with investigation authorities to withold information when possible. If the Congress grants the Board's proposed amendment to the Independent Safety Board Act, ICAO will be promptly informed.

References

1. Adapted from "Civil Aircraft Accidents Investigation in the U.S.", by Gerard M. Bruggink, published in the International Journal of Aviation Safety.
2. United States Federal Statutes and NTSB Regulations.
3. "Administrative Law," Vol. 2, Mezines, Stein, and Gruff.
4. NTSB, "Report On Proceedings," Aviation Accident Investigation Symposium, April 26-28, 1983, Springfield, Virginia.
5. NTSB Aviation Accident Reports.

The Role of the Pilot Association in Accident Investigation

By Captains Richard B. Stone, Louis McNair, and
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In most of the countries throughout the world, the airline pilots' organizations assist in the investigation of airline accidents. Many countries establish this formal working relationship in written policies. Aircraft accidents involving foreign carriers come under the provisions of the International Civil Aviation Organization (ICAO). ICAO, an outgrowth of the United Nations, provides specific directions to its signatory States (countries) on the matter of aircraft accident investigations which occur in a State which may not be that of the operator, manufacturer nor State of Registry of the aircraft. The specific manual dealing with this type of accident investigation is entitled ICAO Annex 13. Annex 13 provides that the State of Registry may appoint an investigator (accredited representative) and advisors to the field investigation, in order to assist as appropriate, as well as gather accident prevention information.

Captain Dale L. Leppard

IFALPA

The International Federation of Airline Pilots Associations (IFALPA) is a worldwide organization, with a membership of 63 Member Associations which in turn represent some 60,000 pilots. IFALPA has as one of its prominent charters the issue of air safety, along with interests of industrial concern. Each year IFALPA sponsors an Annual Conference of its Member Associations, at which the majority of issues are related to air safety.

Each Association within IFALPA has a group of aircraft accident investigators, variously trained in one or more accident investigation courses throughout the world, or having broad experience in investigation in their own country. IFALPA maintains a list of currently qualified, trained and experienced accident investigator representatives, who may be assigned to represent IFALPA within the State in which an accident occurs.

There are a number of pilot associations that are not members of IFALPA. In the case of an accident involving a carrier whose pilots are represented by one of these associations, an IFALPA investigator might still act as the advisor to the accident investigation authority.

ALPA (USA)

The Air Line Pilots Association (ALPA) in the United States of America represents 34,000 members from 49 carriers. A considerable portion of the resources of ALPA are directed toward air safety and some 300 airline pilots act as national safety representatives, with many other pilots acting as local safety representatives. Each pilot group has an accident investigation team which works directly with the National Transportation Safety Board (NTSB) in the event of an accident. ALPA trains members of these accident investigation teams in a formal three-day course. The course itself is primarily focused on the methodology employed by NTSB, but also covers ICAO Annex 13 accidents. Attachment #1 is an example of the curriculum of the ALPA Accident Investigators Course. The course changes periodically as needs change but most of the course remains intact.

The Airline Pilot Accident Investigator

The airline pilot accident investigator has a unique quality he brings to the accident investigation process—

he is usually the only pilot at the site who is a line pilot. Many times company or management pilots will be assigned roles as accident investigators, but rarely are *they* active as line pilots or do they have the experience or training as accident investigators. Line pilots have timely knowledge of the air traffic control system, nuances of procedures and equipment, specific knowledge of the operator's style of operation and are conversant with the abbreviated language of the cockpit. A knowledgeable line pilot accident investigator who knows one or more members of the crew and is current on the aircraft can be of great benefit in the readout of the cockpit voice recorder. Many times the pilot accident investigator is a specialist in a particular field (i.e. information relating to aircraft performance, human performance, hazardous materials, meteorology or cockpit voice recorders).

The question of special interest is always of concern in dealing with an aircraft accident. The pilot investigators are accused of protecting the crew, the company investigators are accused of protecting the company, the airframe manufacturer investigators are accused of protecting the manufacturer and so on. While there may seem to be conflicting interests for the investigator who is not a member of the investigative authority, one soon finds that competing interests are offset by other members of the investigation team who bring their own individual bias to the investigation. The best methods of avoiding these conflicts is to have trained and experienced investigators representing all parties. In the authors' view this apparent conflict resolves itself at the accident scene, for soon most investigators realize that prevention of a similar accident is the critical focus rather than the protection of a special interest. *An individual investigator* protecting his own group's interest is soon found out and discredited. This type of individual is not unknown in accident investigation circles and is dealt with accordingly. A biased investigator will receive perfunctory treatement and his suggestions will be viewed as less than objective.

ICAO Annex 13 Accident Investigations

When an accident occurs outside of the home country (ICAO State, if a signatory nation), the only way the pilot association may participate is as an advisor to the Accredited Representative of his government's accident investigation division. Since the Accredited Representative may deny advisor status, and has on occasion, to the pilot association representative, it behooves the pilot association to offer experienced and respected pilot investigators as advisors. In these authors' opinion the following qualities should be considered for any pilot investigator who may be assigned to an Annex 13 accident:

1. He must know and understand the investigative practices of his own State.

2. He must have a good and recent working relationship with investigators who act as accredited representatives.

3. He must appreciate the sensitive nature of foreign investigations in that different principles, procedures, customs or laws may be followed.

4. He must exhibit a strong technical background in the specific accident aircraft or special field of expertise required for that accident investigation.

Some examples of Annex 13 Accident Investigations

On December 13, 1973, an Iberia DC-10 touched down in the approach lights of runway 33 at Boston, Massachusetts, USA. The aircraft sheared the right main landing gear on an embankment and then continued onto the runway, causing substantial damage. Of the 153 passengers and 14 crew that were on board, two passengers and one flight attendant were injured seriously. This was one of the first windshear accidents in which the multi-parameter digital flight data recorder provided valuable information which allowed post-accident analysis of aircraft performance and effects of the windshear wind field.

One of these authors (R. B. Stone) was assigned by ALPA headquarters to act as the IFALPA representative. Since the accident occurred in the afternoon, the NTSB was able to dispatch a team immediately from Washington, and the first organizational meeting was to be held early that evening. The IFALPA representative arrived just before the organizational meeting was to begin, and found that the three flight crew members were about to be interviewed. After consultation with the NTSB Investigator-in-Charge (IIC), the crew interview was delayed for two reasons. First, the interpreter was to be a member of the Spanish Embassy until it was pointed out that he had no knowledge of the operation of an aircraft. Instead a technical interpreter (Iberia pilot) was dispatched from Spain who had both English and Spanish skills, and who was familiar with operation of the DC-10. Thus, investigators were able to conclude accurate and complete interviews the first time. The second reason was that the IFALPA representative pointed out that inaccurate information or emotional damage was a risk if the crew was debriefed too quickly or before a large group. Both the IIC and the IFALPA representative had observed this when an FAA controller was interviewed the night of another accident. The controller felt personally responsible, though his contribution to the accident sequence of events was negligible. IFALPA representatives continued to assist the NTSB throughout the accident investigation process with the gratitude of the Iberia Pilots Association.

At approximately 1903 hours Eastern Daylight Time on June 2, 1983, an Air Canada cabin crew discovered a fire in one of the rear lavatories. The Air Canada DC-9, Flight 797, landed at Cincinatti, Ohio, USA, some 17 minutes after the discovery of the fire. An ensuing cabin fire caused the deaths of 23 passengers who were unable to exit the aircraft because of the heavy smoke and fire. The cause of the fire was never determined, though the location was clearly in the immediate area of the lavatory. Two of these authors (R. B. Stone and D. L. Leppard) were dispatched to the accident scene, in order to assist in the investigation. The US IFALPA representatives were able to brief the accident investigator representatives of the Canadian Air Line Pilots Association (CALPA) on the policies of investigations within the US. Shortly thereafter, CALPA was named as an Interested Party to the investigation and both Canadian and US pilot investigators worked together for the balance of the investigation. Air Canada was allowed participatory rights as an interested party, while the Canadian Transportation Board was allowed participation as ICAO accredited representative. The supervision of all the Canadian accident investigators remained a responsibility of the ICAO accredited representative. The accident investigation was itself a model of cooperation between two governments and two pilots associations.

Mr. Seth Anderson, NASA, on human factors in aircraft accidents.

In summary, the accident investigators from the professional pilots' associations are a valuable asset to any investigation since they are the only ones who are familiar with the actual cockpit conditions and or decisions. Additionally, many of these pilot investigators possess special expertise which may be of exceptional value to the investigation. IFALPA Member Associations are cognizant of their responsibilities in accident investigation and select, as well as train, their investigators accordingly.

Inspection and Testing

By J.D. Whitehurst
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New Zealand

Introduction

As a metallurgist who has been involved in providing technical support in many investigations of air accidents over the years, it is suggested that the following questions should now be addressed:

1. Is the competence of personnel engaged in the inspection and testing of aircraft adequate, and what improvements are possible?
2. Is there an adequate channel of communication between materials technologists involved in accident investigations and those people in a position to act on information forthcoming from such investigations?

These questions will be amplified and discussed, with reference to past investigations which may also serve to illustrate some of the metallurgical techniques used.

The Quality of Inspection and Testing

The methods used for inspection and non-destructive testing (NDT) vary from straightforward visual examination through to the employment of very complex high technology techniques.

For these more sophisticated test methods, manufacturers and maintenance operations have invested considerable funds in equipment and the personnel using it are necessarily well trained and experienced. Any inexperienced personnel would perhaps be unable even to begin to perform such tests because they would be unaware of the functions of the many controls involved. So for the applications of advanced forms of NDT such as eddy current and ultrasonics, there should be no problem with the competence of personnel. This tends to be verified by past examples of aviation failure investigation in that none come to hand where a defective component had allegedly been tested before the accident by such test methods.

For the simpler methods of NDT such as magnetic particle inspection (MPI), and dye-penetrant inspection (DPI), however, this is not the case. The examples below are intended to support this proposition. It is believed that the problem is not that the NDT methods itself is lacking, but that the technology is so simple in today's "high tech" world that its implementation is taken for granted and is delegated to the lowest possible level of personnel in many cases.

Of course, no one is perfect, and there is another aspect to the problem. That is the soundness of the quality assurance systems themselves, and in the examples given it could be that either a) NDT was performed, but a defect was missed, or b) the quality assurance system omitted the execution of a test.

Connecting Rod Small End A connecting rod failed in service by fracture at the small end which then allowed release of the gudgeon pin, causing extensive subsequent engine damage. Figure 1 shows the original fracture surface after carefully unfolding the steel. Three different fracture features are revealed, a dark area at one side, a smooth area in the centre, and a crystalline area at the other side.

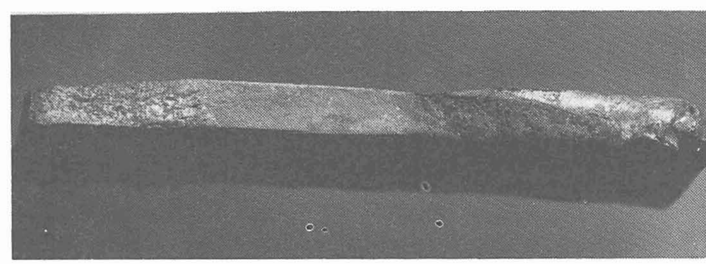

Figure 1. Conrod small end fracture surface.

Visual and scanning electron microscope (SEM) fractographic examination showed that the dark area had been a manufacturing defect present from the early stages of manufacture. The smooth area was a fatigue crack which had propagated in service from the manufacturing defect. The crystalline area corresponded to the final overload failure of the component when its remaining sound cross section was evidently reduced below that necessary to carry the in-service loads.

Thus the basic cause of conrod failure was the undetected presence of a manufacturing defect. This metallurgical defect was confirmed by metallography, showing how and at what stage in the manufacturing process it had occurred. This type of defect is by no means rare or unpredictable. Rather, it is a problem which can occur at any time in any forged component. Parts for aviation do not have exemption.

MPI performed by a trained and certified operator would be a suitable NDT method, searching for laps, folds, and heat treatment cracks, all of which can be expected from time to time.

Undercarriage Axle Figure 2 shows the fracture surface of a high tensile steel axle which failed in the undercarriage of a airliner in service. Failure was by brittle fracture initiated by fatigue cracks. These axles have a history of deterioration due to corrosion pitting, and this example had been reworked by grinding and buildup with chromium plating as a result of such prior deterioration.

The cause of the fatigue cracks was identified by SEM fractography and metallographic sections as being many small pits and cracks under the chromium plating which had acted as stress-raisers in this notch sensitive steel, to give fatigue crack propagation.

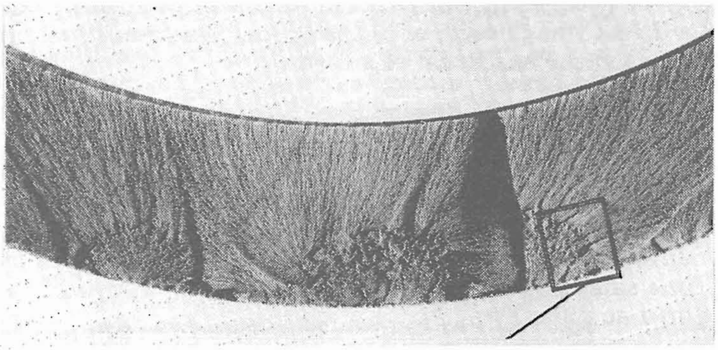

Figure 2. Axle fracture surface.

The intergranular nature of the fatigue crack initiation areas indicated a hydrogen or corrosion assisted mechanism, but regardless of that, the micro sections through the initiation areas revealed that chromium had penetrated into pits and cracks which were present at the time of plating, after grinding and after (perhaps) NDT in the form of MPI. Figure 3 shows this unusually clear evidence of the undetected defects after rework.

Again, MPI would have been a perfectly appropriate NDT method, performed by a trained and certified operator in a situation where grinding cracks and incomplete removal of prior damage should be readily predicted as a possibility.

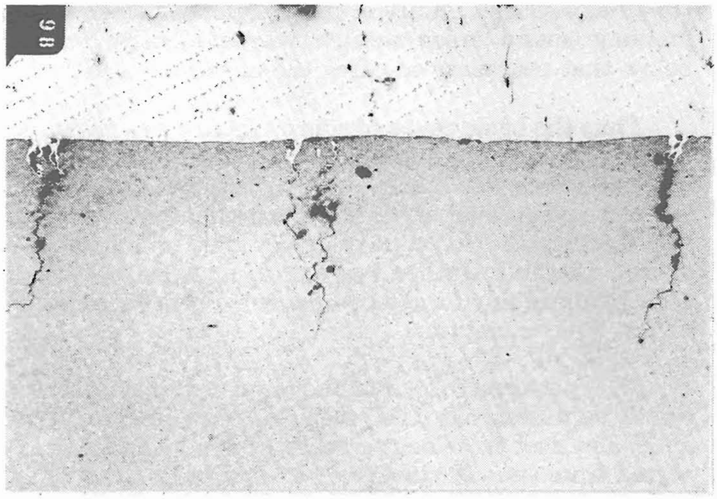

Figure 3. Microsection of chromium in defects.

Helicopter Structural Connecting Lug The lug on the end of a strut which supports the tail boom of a helicopter failed in service causing an accident. Figure 4 shows the failed lug which had fractured in two places. The fracture along the axis of the fitting had a fibrous appearance whereas the other fracture had propagated by fatigue and then finally failed in ductile overload as a result of the reduced load supporting section.

The interesting and informative feature of the fibrous fracture was the presnece of red colouration. Although insufficient red material was available for analytical confirmation, it was suggested that it was red dye from a prior application of dye-penetrant inspection, there being no other logical explanation for its presence.

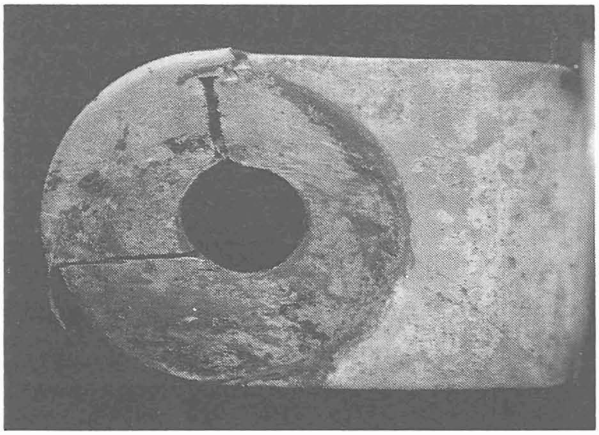

Figure 4. Fractured lug.

Metallographic examination of the aluminium alloy (2024) from which the lug was fabricated revealed extensive intergranular corrosion and exfoliation. Thus it was concluded that the fibrous fracture occurred first (as shown in Figure 5), and that this crack had not been located by DPI. Following that fracture, additional loading was imposed in the plane of the fatigue crack which subsequently resulted in the opening out of the lug.

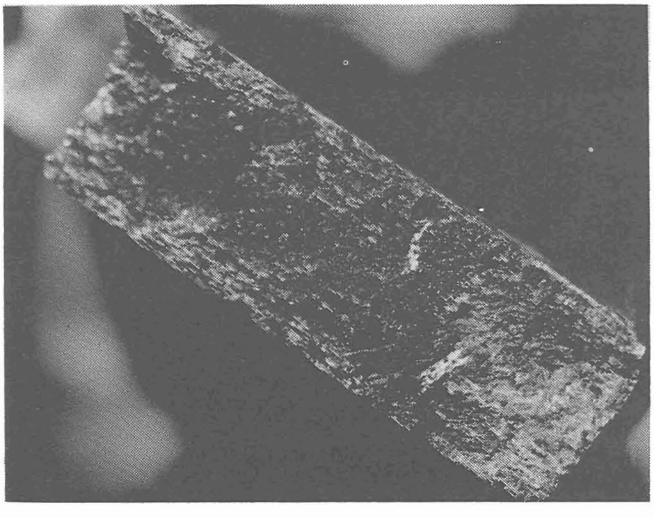

Figure 5. Red colour on stress corrosion fracture of lug.

This example illustrates again that NDT was not reliably performed though the method itself was clearly adequate since penetration of sufficient dye occurred. The competence of the operator (his training and certification) are in doubt; and the nature of the failed component indicates the possibility that inspection was performed with the lug in place in the yoke. A further reminder from this example is that fatigue cracking does not automatically indicate the original cause of a problem.

Helicopter Gearbox Output Shaft/Gear Carrier Figure 6 shows a section removed from a component similar to the one which failed in service in an accident. The sample shown exhibits a similar defect to the failure, and was identified on inspection deemed necessary after the original accident. Severe lack of fusion is present in the weld (probably an electron beam weld) used in the fabrication of the component. Fatigue cracking has then propagated around the component. In the sample from the accident, this cracking extended until the component failed, causing considerable secondary damage, and less recognisable debris for this example, although the fracture mechanism was able to be confirmed as comparable.

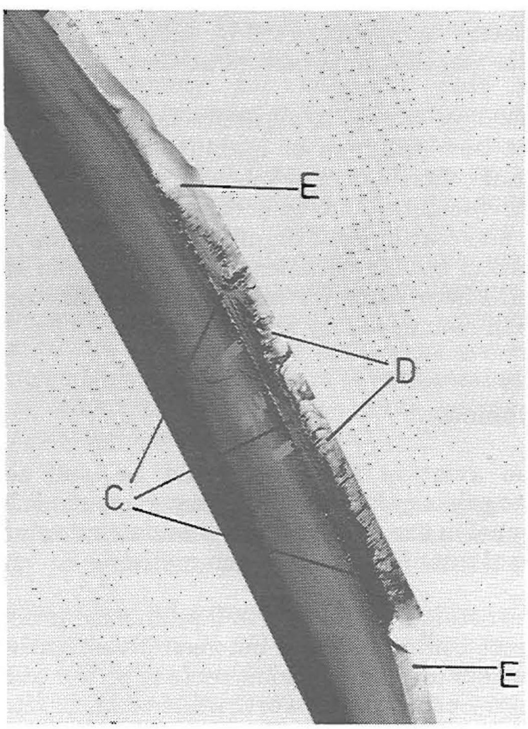

Figure 6. Fatigue propagation from lack of fusion in weld.

So here we see relatively modern technology being used in manufacture, but not being matched with common place NDT technology which is mandatory for ordinary pressure vessels, and in New Zealand, for critical welds in buildings and bridges. Once again, the offending defect is one which is entirely predictable as a possibility when welding is used for fabrication. Ultrasonic testing would have been a suitable inspection method.

Ball Joint Pins These failures concern a small threaded component with a ball joint on one end which forms an anchor-point for the control system of an aircraft. One such component failed in service by crack propagation across the threaded portion where in-service loading in bending is a maximum. After the first failure, other similar parts were subjects to NDT, whereupon 30 of 38 items in service were found cracked, and 24% of new unused items were also defective.

Metallurgical examination showed that the pins had been manufactured from a free-machining mild steel. They had been case carburised after machining, and then quenched and finally cadmium plated. There was no evidence of tempering, so the pins were presumably quenched to obtain wear resistance. Cracks, typical of intergranular quench cracks, were observed in the thread roots. A typical thread root and crack is shown in Figure 7, which also shows the banded martensitic transformation products. Using the energy dispersion analysis by X-ray (EDAX) facility of the SEM whilst studying the fracture surface, high concentrations of cadmium were found on the opened crack surface. This and the refractographic observations, confirmed that cracking was probably the result of quenching.

The inference from these result is again that either no quality assurance NDT such as MPI had been carried out, or that the inspection went wrong. Comparing the defect rates quoted above with, say, the automotive industry is revealing. Leaving aside the materials selection problem, an automotive manufacturer with a 24% defect rate in service would be in trouble, and even a manufacturing reject rate of 24% would be economically unacceptable, assuming all the defects were detected at that stage.

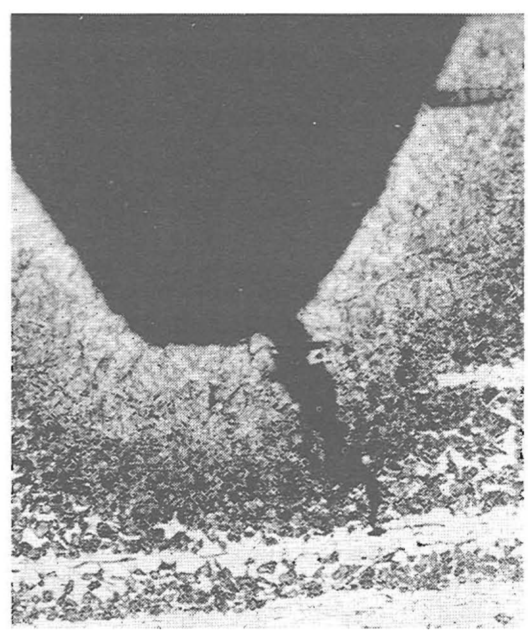

Figure 7. Microsection of typical crack in thread root.

Communication

In none of the above cases, and indeed, in none of the many similar cases of accident investigation so far undertaken, has there been any direct communication with a manufacturer or maintenance operation.

This is understandable in the first instance because the primary role of the metallurgist is to assist the officer of air accidents investigation to arrive at a satisfactory conclusion as to the causes of an accident. The objective is not specifically to provide any service or assistance to third parties.

However, during the course of a metallurgical investigation, it is often the case that detailed data and information is uncovered, as it was in the examples above, which would be of value to others. Of course, broad recommendations and suggestions can be given in an accident report in hope that remedial action will be taken to minimise future recurrences, but not all the available technical data is relevant to this purpose. Furthermore, the first-hand availability of the real defects in actual components is a great advantage when devising and assessing NDT methods which will serve to eliminate that particular problem.

From the investigators point of view also, there would be advantages if manufacturing data such as the intended material specifications and heat treatments were to be available through some established channel for direct communication. This would save considerable time and effort, and would help to minimise the unknowns amongst possible contributing factors.

A useful indicator of whether or not the overall process of communication is effective would be the rate of "carbon copies" of past accidents caused by materials testing and inspection problems. Some examples do come to mind. These concern the detection of small fatigue cracks in a notch-sensitive spring steel undercarriage component, heat treatment of turbine compressor blades, and the recent recurrence of a problem, 10 years later, in the area of the structural connection given as an example above. Thus it seems that there is room for improvement in existing forms of communication.

Discussion

If there is something amiss with NDT in aviation, it must be stressed that no evidence is available to show any shortcomings with the technology or techniques. Instead, it is believed that a change in attitudes to NDT would be worthwhile, particularly with respect to visual, MPI and DPI applications. This applies both to manufacture and to maintenance.

From discussion with NDT personnel both here and overseas, as well as the experience gained in accident investigations, it seems that the "simple" methods of NDT still need experience and training to be effective, but this is not widely recognised except by NDT people themselves. There is little or no official requirement for the personnel *doing these tests* to be trained or qualified, although an overseer may be. Furthermore, the degree of importance attached to a component's inspection is sometimes related to the difficulty of the test rather than the significance of the component's inservice role. Hence the simple methods could be taken lightly when it should not be.

The possibility of an attitude problem is also consistent with inadequate quality assurance systems. This view seems to be supported by failures which have predictable metallurgical factors at their root.

Perhaps, too, it is an attitude problem behind the current unwillingness or inability to make use of the potential contribution of metallurgists engaged in accident investigation. It is accepted that national boundaries and fear of legal liability may contribute to some reluctance, but nevertheless it is considered that there may still be a place for more contribution to improvements in overall safety and reliability.

Conclusions

1. The aviation industry would be well served by recognising the individual expertise of all NDT personnel in the adoption of a mandatory universal personal qualification for each method.

2. The establishment of a well publicised procedure for direct communication between investigating metallurgists and the various sectors of the aviation industry could prove worthwhile to all parties.

The Special Knowledge of Engine Manufacturers In Support of an International Accident Investigation

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Aircraft Engine Business Group
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Synopsis of Paper

Investigation of a large commercial air transport accident or incident in a multinational circumstance requires pooling of all the diverse skills and resources available from the technologically-advanced States. This is especially so if the event is situated in a State of Occurrence where the site is remote or inaccessible, without the usual support infrastructure. In managing such a circumstance, the Investigator-in-Charge for the Aviation Authority can always draw upon the engine manufacturer company for support. This paper describes the special knowledge and the extensive supporting resources which the Flight Safety Engineer of the Engine Manufacturing Company brings to the investigating team. Mr. Moehring describes the organizational relationships of an independent accident investigating section within General Electric and the resources, knowledge and expertise available to the team. Examples of current technology advances, a description of events in the aftermath of an accident is shown followed by an example of a multinational investigation where these resources were successfully pooled in isolating the causal factors.

Mr. Chairman, Distinguished Offices, my fellow investigators, ladies and gentlemen. Thank you for this opportunity to make this presentation to ISASI 86.

The powerplant of a modern large commercial air transport is the result of extensive development of a complex and sophisticated mix of many technologies. A high level of reliability has been achieved in these complex machines. However, where there is an air accident, a powerplant investigation is usually required as a normal part of the overall official investigation. Sometimes for various reasons one of these fine engines will fail internally or may be in a major ingestion event. The General Electric Company recognizes this as a reality and provides specialized expertise, experience and facilities to the official investigation team. I will describe the resources available from the engine manufacturer and the special knowledge contributed by the professional Flight Safety Engineers from General Electric. Not only

John T. Moehring

the major accidents, but important powerplant-related incidents also require the on-site participation by the engine manufacturer.

The equipment manufacturers must be involved. Even in the worst case—a large accident event in a remote location without supporting infrastructure, the engine manufacturer's expertise can be effectively pooled with the other skills to mobilize a multinational team effort. Maximum efficiency and effectiveness in isolating the cause factors is best achieved by utilizing the trained investigators and the factory facilities available from the engine manufacturer.

For the Investigator in Charge (IIC) to make maximum use of these resources it is helpful to understand the organization, background, skills, facilities, and equipment available from the Engine Manufacturer. We share the common objective to swiftly identify the origin and the cause factors, and if they are engine-related, quickly execute corrective action to protect the fleet.

In presenting what the engine manufacturing company has to offer as part of your accident investigating team, the following subjects will be discussed:

1. *Organization*—The General Electric Aircraft Engine Business Group and the Flight Safety Section.
2. *Knowledge and background* possessed by the engine company and the investigators from the GE Flight Safety Section.
3. *Resources Provided*—The expertise and services available to the GE Flight Safety Engineer assigned to the team.
4. *Typical sequence* of events—how the organization responds when a GE engine is involved in an air accident or incident.
5. *An Example*—The actual chronology of a well-managed international accident investigation where a GE engine was the primary cause factors.
6. *The future*—Current developments in large transport engine technology.

Organization

We are in the General Electric Company Aircraft Engine Business Group (GE-AEBG) with headquarters in Evendale, Ohio, just north of Cincinnati. AEBG headquarters and the large engine divisions are here; the smaller engines are made in Lynn, Massachusetts. Each location has an Operating Division and a Production Division. Each Division is headed by a Vice President. A central Division of Engineering and Technology covers both locations. There is the Chief Engineer's Office reporting to the Vice President, Engineering and Technology, and the Flight Safety Section reports to the Chief Engineers. Also reporting to him are the office of FAA Requirements and Airworthiness and seven Chief Consulting Engineers, each one an experienced resource person with an expertise in his own field such as compressors, turbines, structures, aerodynamics and performance, etc. In the Flight Safety Section there are eight people—including 4 fully-experienced air accident investigators. Every investigation of an accident or a flight safety incident involving a GE commercial engine comes under the direction of one of these Flight Safety Engineers.

You can see that up through the V.P. level, the Flight Safety Office is truly independent of the other functions responsible to Production or Operations, i.e. Manufacturing, Production Engineering, Marketing, Product Support and the Business Financial Interests. This is important because it gives Flight Safety the authority and freedom to operate in a professional climate to search for the truth without fear or favor. At the same time, being in the Chief Engineer's office, we have direct access to tremendous resources and whatever support we require during the conduct of an investigation, e.g. laboratories, analysis, quality records, design engineering, product support or the worldwide GE AEBG Technical Representative network with its communications and office support in each of the locations where there is a base of one of our customers.

Knowledge, Background and Mission

We are kept very busy with post-mishap work, i.e. conducting accident and incident investigations. This is our primary responsibility and we publish a very complete documentary of each case—the Factual Report of Investigation. However, a more important part of our job is the pre-mishap or preventive role. It is the policy of GE-AEBG, that before the first flight of an engine in a new airplane application, we conduct a Flight Readiness Review (FRR). This is the responsibility of the Flight Safety Office. This review is chaired by myself or someone from my office and is a concentrated team effort; usually there are from 6 to 14 of the most experienced engineers in each technical discipline including the Chief Consulting Engineers directly on the Chief Engineer's staff. Also included are experts from Manufacturing, Quality, Product Support and an Engineering Test pilot from our Mojave, California Flight Test Center. The FRR usually extends over several months and includes a series of in-house airworthiness review conferences which examine each component or system of the engine and review each problem the Design Engineer has experienced or worry which he may have. The Flight Readiness Review also includes installation review to go over every interface, both physical and functional, of the engine in the aircraft. Finally, there is a non-site conference and inspection with the aircraft manufacturing company for a final review of the installation of the engines in the aircraft before it is approved for a first flight. Each finding is designated either Critical (C), Important (I), or Routine (R). Any critical item puts the first flight on hold until the designated corrective action has been completed. This year we have conducted eight of these First Flight Readiness Reviews on new products.

A third responsibility of the members of the Flight Safety Office is to participate in Design Reviews and in definition of Engineering Design Practices wherever a safety-related issue has been defined.

Years before the engine is in production the Flight Safety Engineers have been keeping close touch with each new model, all through the development and certification testing. As it goes into production and begins airline service, they work closely with Product Support Engineering. They attend the weekly Airline Problem Review meetings and keep up to date with any problems which are developing in service. By this means the Flight Safety Engineer acquires excellent current knowledge of the engine and of the service experience of the components; all this knowledge is very important to the investigation when an accident or incident has occurred.

So, you can see that by the time that our Flight Safety Engineer eventually finds himself working on the engine wreckage on the scene of an accident or incident event, he has a high degree of familiarity with the hardware and behavior of the engine, and in addition to his own knowledge of the engine, he has a direct connection to the Design Engineer for any component or system. At GE, the Design Engineer has responsibility for his parts "from the cradle to grave"; not only is he the one who knows most about the design, he's charged with knowing all about its problems, its manufacture and production, and its history in service as well as how it functions under all manner of conditions, both normal and extreme. I'm going to emphasize my point about preparation and knowledge by showing you a short film presenting some scenes from the official CF6-80A certification tests.

(Movie)

You can well imagine that to get ready for these final demonstrations for our Certifying Authorities, these engineers conduct many development and substantiating tests on the Type design. And this detailed knowledge of the hardware and its history is available to your investigation through the GE Flight Safety Engineer assigned to your team in the event of an accident.

I believe it is very important, when your team is working at a crash site or making a runway search, that there is a GE investigator along who can look at each fragment on the ground and immediately recognize exactly what it is, where in the engine it came from, how it came to be where it is and what its condition means to the investigation. There is no way an overall generalist investigator, not familiar with the engine, can quickly sort this all out in a meaningful way.

Resources

GE makes sure that the Flight Safety Office has access to whatever resources may be needed to understand and isolate cause factors. This means we have access to not only the design, analysis and testing experience, but also to the production and field service experience data from the Airline Fleet operations. We are also supported by an extensive metallurgical and materials laboratory. This support organization has a dedicated Failure Analysis Group devoted to isolating the origin and failure process of the fractured, cracked, worn or otherwise failed parts which we bring to them. If necessary, the GE Flight Safety Engineer can call and quickly have a senior metallurgist or if necessary, a design engineer who really knows that part, come to the accident location. And beyond the AEBG Materials Laboratories in Evendale and Lynn, we can call upon the extensive resources of the General Electric Corporate Research Center. Occasionally, they have helped us isolate an understanding of a failure by using techniques developed for that unique circumstance. Some of these techniques that have been used in recent investigations required application of a state of technology beyond that available anywhere else.

Another of the unique resources available in support of your investigations is in the area of manufacturing records and special dimensional inspections. It is frequently necessary to exactly quantify the measurements of a distorted or distressed component recovered from wreckage. Years ago when engines were not so advanced, this was fairly easy but today special, computerized equipment is needed. This is especially so in the complex, precisely contoured geometry of turbomachinery hardware. Usually, the best way to do this is to repeat the original as-made dimensions using the very specialized one-of-a-kind tooling or automated 3-D measuring equipment which were specially made as a dedicated system for that part and are only available in the factory.

Besides these unique resources available in Design Engineering, Manufacturing, Quality Records and the Product Support Data Center, there are important analytical services and computer models dedicated to the engine. There are generally three such analytical disciplines we can call upon. Engine Performance Analysis maintains a history of the engine's thermodynamic and internal aerodynamic behavior and maintains an automated computer deck which is used to determine the altitude flight performance. A Structural Stress and Vibratory analysis section can respond to our requests for support in this field. For each engine, there is a Dynamic Analysis Computer Model which can be used to determine the transient response and stability behavior of the engine as an installed propulsion system.

Response to an Accident or Incident

Our notification of an event may come in any of a variety of ways. We may first hear about it as a telephone call or telex from one of our Tech Rep offices supporting the airline carrier in the State of Occurrence. It may come from the NTSB, the FAA or one of the foreign government accident investigation agencies. Whenever we learn of an accident or incident, depending upon the seriousness of the event, our Company internal action plan goes into effect. There is a central headquarters conference room for the in-house team, with telephone coverage around the clock. The Section-level Customer Support Manager for that Airline is the chairman of this team, charged with all aspects of response and crisis management. The Chief Engineer, Flight Safety Section, functions as the technical Investigator-in-Charge for the factory investigation team and is responsible to establish the causes of the event. He contacts the NTSB and the customer/user Safety Officer regarding GE support of the official investigation and participates in any hearing conducted by an agency or government.

In any event, whether an accident or an incident, domestic or foreign, we immediately get in touch with the duty officer at NTSB Washington Headquarters. One or more persons from the Flight Safety Office will prepare for immediate departure to the scene. Many times we'll also take with us a product support engineer who has responsibility for that model of engine and is involved in supporting that airline. If it is a domestic event, the NTSB Investigator-in-Charge (IIC) will usually assign our Flight Safety Engineer to the Propulsion Group and the Product Support Engineer to the Maintenance Records Group. If it is at a foreign location and the NTSB are sending an Accredited Representative, they use our services in a designated role as Technical Advisor to the Investigator-in-Charge.

Sometimes, an event involving a GE engine at a foreign location is not deemed serious enough for the NTSB Accredited US Representative to travel to the scene, yet our services are needed to assist in the investigation in the State of Occurrence. In this event we can still travel with official status as Technical Advisor to the NTSB Accredited US Representative and provide our services to the official government agency in charge at the site. The NTSB Accredited US Rep sends an authorization telegram to the foreign government agency involved. This is very helpful in establishing our credentials as support persons for the on-site investigation team.

Meanwhile, while the Flight Safety Engineer from my office is enroute, a whole series of actions takes place in the factory to provide him whatever data, records, or additional specialist expertise he may need at the site. The records for the engines are examined and the history is determined. Any prior problem symptoms, or maintenance and overhaul shop records are readied for transmission to the site. As soon as communications are established with the accident location, the factory team is assembled in the Support Center for a daily call from the Flight Safety Engineer on the scene, to respond to his needs and to give him whatever data he requires at the site to provide full support to the official investigation.

After the on-site investigation and documentation have been completed, engine disassembly is frequently necessary and more detailed component or fragment investigation, laboratory analysis and micro-photography are required. Arrangements are made with the Investigatory Authority and the engine is released to a suitable shop such as an airline overhaul center. If the distance is reasonable and circumstances warrant it, we may offer the use of a GE shop or the factory. In any event, it is important that the engine disassembly be controlled by people who are familiar with the engine model. It should be done in a shop where the specialized tooling, fixtures, workstands and support equipment for that model are available, along with the manuals and trained people experienced in disassembly of that engine model. Before anyone lays wrenches on the engine there must be a written, step by step sequence (we call it a workscope) prepared, reviewed and approved by the members of the official Powerplants Group.

Once the engine disassembly and documentation are complete, it is frequently necessary to take parts to a metallurgical laboratory for more detailed failure inspection using electron microscopy, spectroscopy or other specialized investigative techniques. Certainly this is required if any fracture of an engine component is suspect as a cause factor. We strongly prefer to bring the component to the factory for examination by senior GE metallurgists and chemists in our failure analysis laboratory.

In a country where we are unknown and they have never carried out an investigation with us before, they may become a sticky point. There are various reasons for this sensitivity. One is a natural mistrust of having the investigation done by the manufacturer since the Corporation may be perceived as self-serving, even in a professional, technical accident investigation. It may be that a government agency wishes to avoid internal criticism or media pressure about letting an article of evidence get outside the country. Sometimes the host country may have an embryo laboratory of their own and desire to show their expertise or to develop expertise with the manufacturer's technical assistance.

Where an engine failure of a flight safety nature has occurred, where a part of the engine is suspect, and where the origin and failure process are not completely understood, it is vital that the failure analysis be conducted as expertly and quickly as possible. If this should happen to be a new failure mode, the event could become the first of a series of events and sometimes the next one may not be long in coming. Speed is important so that the failure is quickly analyzed, understood and corrective action implemented to protect the traveling public and the rest of the fleet. In our view, the best way to provide this assurance is to transport the part to the factory for the laboratory analysis. It would indeed be indefensible if a second occurrence happened while the principal parties to an investigation were still debating about where the laboratory investigation should be done.

The benefits of bringing suspect hardware to the manufacturer's facilities for inspection, measurement, metallurgical analysis and identification of failure process and origin are:

1. The manufacturer's plant is the most efficient, the fastest and minimum-risk means to identify the

origin and failure process, to relate the failure to operations with this engine, and to swiftly identify the proper corrective action to protect the fleet.

2. The technology applied in a modern engine requires access to unique, one-of-a-kind facilities and specialized equipment to perform the necessary measurements and inspections accurately and in a reasonable time.

3. By bringing the parts in-house the full technical resources of the Company are immediately brought to bear in support of the investigation. With the failed parts or the engine wreckage in the factory shop, the expertise brought to focus on the study is expanded a hundredfold over that available at the site or in an overseas laboratory. The parts are brought under the direct scrutiny of those skilled engineers most knowledgeable and familiar with the design.

4. Application of the unique expertise and prior experience in analysis of that particular alloy or component is important. Note that some of these alloys and their heat treatment can be extremely difficult to analyze; the occurrence of material fatigue and the interpretation of morphology including scattered "striation" evidence pointing to a defect may be extremely elusive to an investigator not experienced in the alloy. This is so important, we only use our most skilled and experienced experts for this work.

The Investigator-in-Charge, either in the US or overseas, need not be concerned about maintaining control over the investigation. GE Flight Safety is committed to provide a full Factual Report of Investigation to other parties to the investigation for review and then publication. General Electric has built an excellent reputation for integrity and professionalism in their investigation and technical reporting. Emphasis should be placed upon inquiring about the past experience of those agencies which have worked with the GE Flight Safety-led factory teams in solving previous difficult failures.

It has been our experience that any problems of perception with regard to independence of investigation in the factory can be handled very adequately by having a Government Representative or the members of the Propulsion Group come to the factory and monitor the investigation there. In a number of cases this has been done expeditiously by the foreign government releasing the parts for sealed transport to GE and then requesting surveillance on the company premises by a US NTSB representative or metallurgist during the analysis.

A brief word with regard to documentation of the wreckage, both photographic and written. In those instances where there is a serious domestic accident and there is an NTSB team in charge, this is not a problem. The GE Flight Safety Engineer is part of the Propulsion Group and the factual notes of site investigation are usually written up and signed by the Propulsion Group members and group leader upon completion of this work. Occasionally we have problems in some foreign events which are only incidents, not accidents, and where we are on our own without an NTSB accredited representative with us. Sometimes it may turn out, after we arrive, that the nature of the failure has serious implications say, for example, an uncontained rotor failure. It is in such events that we can encounter frustrating delays or even loss of precious factual evidence which is urgently needed to isolate the failure origin. In some places, even getting permission to photograph the engine damage or take detailed notes can be an obstacle because of local restrictions.

In the investigation of such incidents, two things need to be emphasized. First, it is important to swiftly undertake actions to search and recover all liberated fragments and damaged hardware and second, it is very important to capture the data recorder even when an event is not classed as an accident. The fragments and the data are vital to understanding the failure. We must always keep in mind that, given a slightly different set of circumstances, many an incident could just as well have been a serious accident.

I cannot emphasize strongly enough the importance of finding and recovering the liberated fragments in the event of an uncontained rotor failure. If an uncontained engine rotor failure has occurred, it may be possible that we will never really know the exact cause if we can't obtain the primary fracture surface. Further, if it is an inflight failure, the flight recorder data is super-important to us; its needed in order to fix the location for a ground search for fragments. The cooperation of local people is tremendously helpful in conducting a successful ground search. We have found that advertising a generous reward and handing out these leaflets in the locale stimulates interest and participation. Backing and support from the local authorities are also vital to the success of a ground search. Our searches for fragments fallen into water are another long story; as you know, this is a job for professionals, with the necessary electronic locating gear and underwater skills.

Once found and recovered, the wreckage must be guarded and any fracture surfaces should be protected from further damage so that the laboratory analysis will not be compromised by smeared fracture surfaces.

Problems Sometimes Encountered

There are always some problems but usually they are solved if we can obtain the cooperation and support of the authorities. Here are some difficulties which we have occasionally experienced in conducting investigations at the event site:

1. Judicial systems in some countries have overriding laws and procedures governing determination of fault or responsibility which can delay or obstruct access to crash-damaged hardware by the manufacturer's investigators.

2. In some countries the visiting representatives of manufacturers sometimes are regarded with suspicion and are not trusted to fully and accurately report the findings. We may be prevented from having full access to available information which is urgently needed to analyze the failure.

3. Conflicts sometimes develop with the desire of a host country to use an event to develop their own investigatory expertise at the expense of timeliness in finding the real cause of the failure or accident. This can result in major delays in determining the cause and implementing corrective action in the fleet.

4. Adverse parties such as a hired representative or psuedo-expert for an insurance company are sometimes allowed to intrude themselves into the investigation process at the site in an obstructive way with the result that full, open exchange of needed information among the parties if inhibited.

Now let me describe a positive example of a multinational accident investigation where a GE engine was a primary cause. You will see how the procedures described earlier averted the problems and resulted in a successful, swift investigation.

On 3/17/82 at 5:00 AM local time an A300 aircraft of a large international carrier had an engine failure during takeoff at Sanaa, Yemen. The takeoff was aborted. The first and second stage wheels for the high pressure turbine exited the engine. They were subsequently recovered. The aircraft fire was quickly controlled by the airport fire department and there were no fatalities. However, the aircraft was damaged beyond economic repair. This occurred at an airport which was also used for military purposes and was under military control.

Management of the entire subsequent complex relationships was excellent. The Yemen CAA delegated the investigatory responsibility to the French Bureau Enquetes Accidents (BEA). The State of Manufacturer of the A300 aircraft was France and of the General Electric CF6-50 engine was the USA. Although the on-site investigation at Sanaa was conducted under military restrictions, a good site investigation was conducted and the damaged engine, the flight recorders, and other important components were released for shipment to France.

We immediately notified the NTSB and they designated Rudy Kapustin as the US Accredited Representative and one of our GE Flight Safety Engineers, Bill Thompson, as a Technical Advisor. An advance party from BEA, The Air Carrier, Airbus, and GE arrived in Sanaa on the same day as the accident to assist the Yemen CAA in the investigation. The remainder of the team arrived on-site by the 20th of March. The on-site investigation was quickly accomplished. All liberated components from the failed engine were recovered and on-site damage documentation, removal of recorders, witness statements, etc. were completed. The on-site investigation was concluded with the presentation of a preliminary on-site report from the Powerplants Group on the 23rd of March.

The Yemen authorities delegated responsibility for the on-going technical direction of the investigation to the BEA and the investigation team departed Sanaa on March 25th for Paris. The failed engine, major liberated fragments and aircraft recorders arrived March 28th in France.

A GE senior metallurgist and an additional Flight Safety Engineer from Evendale arrived the next day and coordination between the GE team and the French government authorities included the presentation by GE of the proposed investigation procedural workscope and initial examination of the failed hardware by French and GE experts.

The organizational meeting of the full investigatory team was held in Paris on March 30th led by the Chief, BEA and attended by all parties to the investigation, including the US NTSB, FAA, and French and Yemeni government authorities. The prior turbine disk history was reviewed, the proposed investigatory workscope was presented, and the various capabilities for accomplishing the analysis in the most expeditious manner were reviewed.

Although excellent metallurgical investigation capabilities were available in France, the decision was made to return the failed turbine disk to the GE facility in the USA where the full technical and physical resources of the manufacturer could be applied to the investigation. This investigation was to be done under the technical surveillance of the BEA and NTSB experts. The full engine teardown inspection and corollary metallurgical investigation work were agreed to be accomplished in France under the surveillance of the BEA with technical assistance from the on-site GE team.

The failed disk hardware along with the GE metallurgist and the BEA Investigator-in-Charge departed Paris on Concorde for New York. The Concorde flight was met in New York by the FAA with another plane waiting to fly the team and the hardware to the GE facilities in Cincinnati. All arrived in Cincinnati at the GE plant on March 31 in the afternoon.

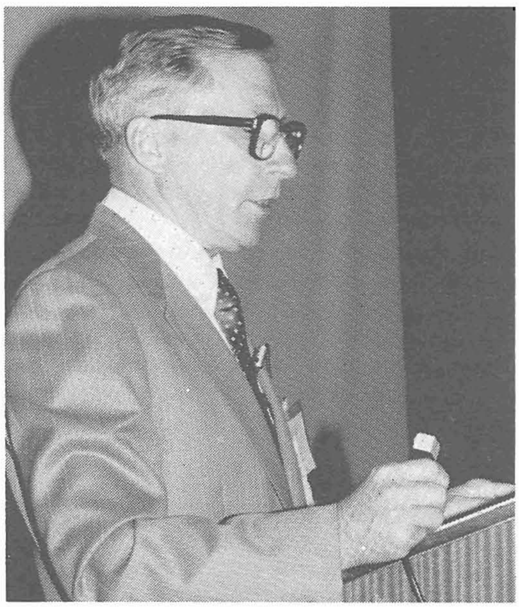
The predetermined procedural workscope was executed by the team—all the intricate contour and dimensional inspections were quickly made on the automated

Mauser 3-coordinate machine, the NDT procedures, both Zyglo and Eddy current, were done on the disk, the specimen cuts were made, and the laboratory analyses were conducted. By working around the clock at GE, the initial metallurgical investigation and dimensional inspections of the failed hardware were completed in less than one week. The results were presented to the US and French government authorities and an FAA telegraphic AD was sent to all CF 6-50 operators on 4/9/82 defining new inspection requirements and intervals to provide an adequate margin of safety for the fleet.

Meanwhile, the engine teardown and parallel investigations were completed in France on April 29th, 1982 and a presentation of the results was made to French and Yemeni authorities. At the conclusion the GE team was complimented for a responsive and professional investigation.

The findings of the Powerplants Group were presented by GE and approved by all the parties to the investigation at a team meeting in July. Subsequently GE provided a complete factual report of the powerplants investigation and the BEA published an overall report on this accident.

This was a success story which illustrates the benefits obtained when the investigatory agencies and manufacturers combine their resources in order to obtain a full and comprehensive investigation in the most expeditious manner. Only in such an atmosphere of professional trust and confidence can we do the best possible job of protecting the flying public when an accident or safety-related incident occurs.



Mr. Leo Sander, Beech Aircraft Corporation, USA, on "The Role of the Manufacturer"

Let me conclude by emphasizing the contributions the engine company's Flight Safety Representatives can make to the accident investigation team:

1. Unique maximum knowledge of the product, its design and its past service history including the problems.

2. Prior experience and technical expertise in engine failure investigations as well as accident investigations.

3. Ability to quickly assess damage and determine what on-site investigation aspects (workscopes) must be accomplished in order to maximize the potential for early determination of the cause of the failure or accident.

4. Availability of specialized inspection, measurement and laboratory equipment devoted to the engine model.

5. Support of the full technical resources of the Company to research manufacturing records, quality records, conduct analyses, perform design review, product support history, etc., to quickly answer questions as they arise during the course of the investigation.

I see that it is advertised here in the ISASI brochure that I will also speak about recent technology developments in large transport engines. This is an exciting story and there is much to be said, but I have already talked beyond my allowed time. Let me just give you one sample of it in the form of a brief movie about the first flight of the UDF™.

(Movie)

The engine company members can bring unique expertise and knolwedge to your team. As propulsion technology advances into the UDF™ era there will be new demands upon the multinational investigation. When these new engines enter service the GE Flight Safety Engineer will be well qualified, with the background acquired from development of the new technology, and can continue to provide unique expertise for your investigation.

Thank you.

Computer Graphics Within The Bureau of Air Safety Investigation

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1. INTRODUCTION

Animated computer graphics has the power to display complex and concurrent activities in a form understandable by experts and non-experts alike. The alternative is usually the interpretation of large amounts of data, in numerical tables and graphs, by experts who are invariably faced with having to explain the data in non-technical terms to non-experts. Experts themselves have difficulty when faced with data that represnts concurrent activities. The latter processes are long, complicated and significantly less descriptive than an accurate graphics display. These factors, combined with the high regard for aircraft safety within the Australian airline industry and government authorities, led the Bureau to purchase a powerful computer graphics system.

The Bureau's graphics system has been used in public hearings to demonstrate aircraft accidents. It is used by investigators as an aid to their understanding of the contributing factors of an accident/incident, and by researchers, who use the graphics system as a tool to examine or demonstrate human factors in accidents.

This paper is designed to inform the reader of the scope of computer graphics within the Bureau of Air Safety Investigation, as well as provide a brief description of the hardware details and software techniques used in the generation of the graphics applications.

While a general discussion on computer graphics is necessary to introduce the reader to some of the important issues, it should be understood that such a discussion is difficult for two reasons; firstly, the rate of development of computer graphics hardware and software is such as to make such a discussion irrelevant in a short period of time, and secondly, the feasibility and design of graphic applications is very much determined by the hardware that is available. As such, this paper concentrates on the graphic applications operating on the Bureau's, Evans and Sutherland PS 300 graphics system, including a brief discussion, gained from experiences with the PS 300, of the virtues and limitations of the hardware/software and provide some comment on future applications.

2. TYPES OF GRAPHIC APPLICATIONS

A more detailed description of individual graphics applications follows in a later section. But as an introduction to the use of graphics in accident/incident investigation, a brief description of the current types of applications will suffice.

Broadly, graphics applications are split into two areas:

1. Analysis of Flight Data Recorders: The objective here is to animate the information contained on the Flight Data Recorder (FDR). Typically this will be either a flight instrument panel or upto four aircraft flying along their precalcuated flight paths.

2. Research: One off tasks are undertaken for the purposes of determining human factors that may be involved in a particular aircraft incident/accident. For these applications the data is usually estimated or derived from experiments conducted in flight simulators.

All these applications can be run in real time, however the animation rate (frames/second) is usually controlled by an interactive device, called a dial, available to the user.

3. HARDWARE SELECTION

In 1984 the computing and engineering sections within the Bureau drew up a specification for a computer graphics system having in mind the following applications:

• Display a flight path in 2-D and 3-D views. Be able to manipulate the latter view in real time.

• Animate an aircraft on its flight path. If pitch and roll information is available then this should be displayed.

• Animate the basic instruments of a B747 instrument panel and run it in real time.

The real time nature of such applications limited the choice of the graphics system to a vector scanning type. At that time such systems where the only ones capable of real time performance. At the time of writing the performance gap between vector and raster systems has narrowed, but vector is still a magnitude better in performance, and will likely be for the next five years.

In January of 1984, an Evans & Sutherland PS 300 graphics system was chosen and in June of 1984 it was installed. At that time the complete graphics system consisted of the following:

- E&S PS300 Graphics System; consisting of
  - 19″ monochrome screen
  - One Data tablet
  - Interactive devices: dials and buttons.
  - 1Mbyte of Main Memory
  - 1 Single sided floppy drive (360kB)
  - Version A1.Vol the Operating system.

- Versatec Plotter, hosted to the E&S.

- PDP-11/73 Host computer Running under RSTS/E v7.0
- 1.75 Mb of memory

Several applications were developed using this hardware configuration but the need for longer animation times were recognised early on in the development, so in May of 1986 a further 2Mb of memory was installed in the PS 300. In March of 1986 Version A5.V05 of the E&S operating system was installed.

4. HARDWARE DETAILS

This section deals solely with the PS 300 hardware, as it constitutes the main graphics processing and display handling functions.

4.1 General Hardware Description: E&S PS300

The PS 300 graphics system is a high performance distributed interactive vector scanning system based on the MC68000 processor. Figure 4.1 shows the basic hardware components and interactive devices that comprise the PS 300 system. The features, that in combination, distinguish the PS 300 from other graphics systems are listed below:

- Vector Scanning Display—The PS 300 uses a vector-scan (also called random, stroke, or calligraphic) system to display objects on the screen. It has the capability to process and display about 45,000 average size vectors (about 50 cm in size) and up to 90,000 small vectors (not exceeding 2.5 mm) in each refresh cycle (30Hz). This compares with the best raster systems which claim about 100,000 vector transforms a second (about 2,000 per refresh) onto the screen.

- Hierarchically Structured Models—All displayed objects are created as vectors and stored in the systems own memory. Hierarchical structuring allows complex objects to be created from simpler parts. Individual components of a model can be used as parts of other models. Each part or grouping of parts of the model can be individually manipulated (i.e. translated, rotated, scaled) through software or hardware. See Section on PS 300 software.

- Local Manipulation of Models (Distributed Procession—The PS 300 controls the interactive manipulation of models locally. Values which are input from the various interactive devices (dials, keys, tablet and buttons) are sent through (see Appendix A) user-designed Function Networks to interaction points in the model's display structure. The host computer never has to participate in handling the interactive devices. Likewise, all transformation and display processing is performed within the PS 300.

- Real Time Interaction—Real time interaction allows an image on the screen to respond instantly to input from an interactive device. So complex 3D models can be manipulated in real

(a) E&S PS 300 processor cabinet
(b) Monitor
(c) Buttons
(d) Dials
(e) Keyboard
(f) Data tablet

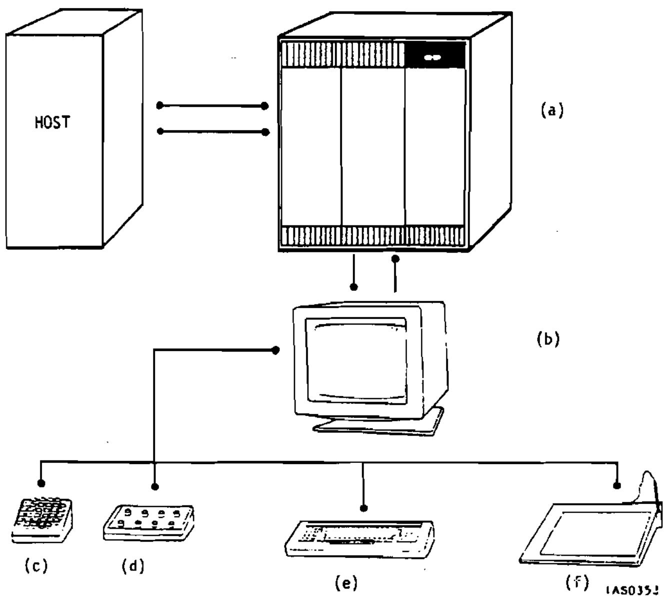

Figure 4.1 PS 300 hardware components.

time. This capability enables the user to change their observation point in a 3-D presentation without interrupting the animation.

- Perspective Views—The system is capable of displaying objects in perspective to enhance the illusion of three dimensions.

- Hardcopy of Screen Displays—The interface to a plotter and the software to plot screen displays are under the control of the PS300. The raster image of the display is generated within the Versatec plotter.

- Host-Independence—Any size or make of host computer can communicate with the PS 300 so long as it can accept RS-232-C and RS-449 asynchronous serial communication using START/STOP protocol. In most applications, the host is used for analysis programs and for file storage. Since the PS 300 does not store commands to save files which create objects and function networks, all of the applications create files on the host and transfer them to the PS 300.

- Optional Use of Colour—In complex three dimensional presentations, colour can be an important asset in interpreting information.

- Dec VT100 Terminal Emulation—One of the operating modes of the PS 300 can emulate the VT100 terminal. This allows for program entry from the keyboard.

- Raster Extension—The system has the capability to expand to include a raster screen and processor board. The raster screen has a 640x 640 pixel resolution. The software need only be slightly modified to incorporate raster processing.

4.2 Interactive Devices: Description and Uses.

Keyboard:
A standard QWERTY keyboard with 12 function keys, each with an 7 character LED display. These function keys can be programmed to perform numerous tasks. In a typical graphics application the function keys are used to:

- Switch from one viewport to another
- Display messages on the screen to aid the user
- Cycle through an object list to select an object for processing e.g. scaling, varying intensity
- Reset, stop and start animation
- Cycle through sets of dials

Buttons:
A unit containing 32 programmable function buttons which can be used to enable or disable branches in the Function Network. This can be used to toggle objects on the screen on and off, and toggle display attribute functions on and off, such as depth cueing.

Control Dials:
A set of eight programmable control dials is provided. However, any number of sets can be connected to various nodes in the display network. In several of our applications there are 20 dials assigned to various viewing nodes in the function network, each set chosen by a function key. The dials allow the user to send continuous data streams (as opposed to discrete data - used by Function keys and Buttons) to the viewing nodes which process and display the results in real time.

The effect is that objects can be rotated and scaled, or a complete display rotated, translated and scaled, all in real time. For example, this facility can be used by an investigator to position himself/herself at a location in the 3-D view that approximates the location of an eye witness of an aircraft incident. The investigator may run the flight simulation and confirm what the eye witness saw, or can if necessary, vary the flight path until it corresponds with the observed flight path.

Data Tablet:
The data tablet for the PS 300 consists of a 27.5cm by 27.5cm tablet (11-inch by 11-inch), a stylus, and an internal controller. The data tablet is normally used as an interactive pointing device to control the cursor that is displayed on the CRT. When the stylus touches the tablet, the x,y coordinate position on the tablet is converted to its digital equivalent for use by the system.

In our applications it is used to produce 2-D images that are routed to the host and stored in files created for the purpose. Typically they will contain the vector list of an airport map, or a coastline. Aircraft 3-D shapes can be generated from their 2-D cross-sections, input from the tablet.

5. SOFTWARE DISCUSSION

5.1 Graphic Standards

There are two graphics standards currently being developed. These are GKS-3D (Graphics Kernel System for 3-D) and PHIGS (Programmers Hierarchical Interactive Graphics System) both of which reside above the GKS-2D layer. While PHIGS is designed to cater for the more sophisticated end of the device market with the ability for rapid changes in a complex picture it is the least developed of the two standards, however a number of systems claim to follow the PHIGS standard. Evans & Sutherland make no claims to have implemented an exact version of PHIGS on the PS 300, but they have been instrumental in developing such a standard.

Particular features of the PHIGS structure facility that lend itself to complex graphics are:

1. Hierarchy—structures can call other substructures and the same substructure may be called more than once from a higher level. Thus a car may need only a single wheel substructure which is called four times.

2. Modelling Coordinates—structure elements contain positional information in modelling coordinates. Each structure has a global and local modelling transformation which are concatenated to produce the transformation to be applied to points to turn the modelling coordinates into the coordinates to be passed to the viewing pipeline.

3. Inheritance—substructures inherit attributes from the calling structure. Thus, the global modelling transformation is the one passed in by the calling structure. Similarly, attributes such as intensity and scale can be passed to the substructure.

   On completion of traversing a structure, control reverts to the higher structure that called it and the attributes are reset to those in force on entry to the substructure. Thus the substructure can have no effect on the calling structure.

4. Editing—labels can be placed in structures and there is a structure element pointer. Consequently, it is possible to move around a structure and edit it after initial creation. This is unlike GKS segment structure which cannot be changed once the segment is created.

5.2 Graphics Language

The actual graphics software developed by E&S is termed Function Net Programming (or more accurately as Function Graph Networks). It has a different semantic base than the conventional (or no Neumann) sequential programming languages, and is based on data driven semantics. The advantage of this is that the programmer may partition a program in a much more natural way than would be possible using a conventional language.

At a programing level, Data Driven methods allows for parallel processing and pipeling although it is not currently implemented in hardware. It will suffice to point out that parallel (or spatial concurrency) and pipelining (or temporal concurrency) in programs often leads to more natural expression of a solution to a problem and in complex animation processing is a very convenient way of programming.

For an example of a Function networks see Appendix A.

5.3 HOST Processing

While the PS 300 software sets up a hierarchical structure (also called a Display Tree) in its memory to be traversed within every refresh cycle, all the processing of the data contained in the Flight Data Recorders into appropriate data structures, is performed on the HOST. All the data is then transferred to appropriate nodes in the PS 300 display structure.

All FDR programs are written in DEC Fortran 77, and reside on the PDP11/73.

As DEC Fortran follows the standard, these programs should be transportable to any host with a Fortran 77 compiler.

Some of the essential programs for animation presentation are listed below, with a brief explanation of their function;

FDR_READ: This program reads an FDR file and enters the required parameters into a Direct Access Binary file leaving gaps between records for later smoothing. As each graphic application requires different parameters, depending on the level of sophistication, a modified version of FDR_READ presently exists for each application.

Not all digital FDRs are presently catered for, as each new type has slightly different formatting techniques. Each new type requires a modified READ program.

SMOOTH: Smoothing of the FDR parameters is required to produce data for each frame. A number of smoothing programs exist depending on the graphics application. Linear interpolation is currently used as a smoothing technique although a cubic spline is being developed to replace it.

FLIGHT-PATH: These programs calculate the flight path of an aircraft either from the integration of Velocity and Time or from ILS information. The output is a vector list (containing x,y,z coordinates) giving the aircraft position relative to the origin for each frame of the animation.

FLIGHT: Creates from the FDR data and flight path data, a file containing the aircraft position and pitch/roll/heading data for each frame in the animation.

For Analogue recorders only heading information is available. Pitch and roll can however be estimated and inserted into the file.

MEMORY: Creates an optimised binary tree. Each leaf contains a frames worth of data for all the moving objects (usually aircraft) in the animation. Initially the data is in the form of unit matrices until filled with actual data during process SEND. The structure is passed to the PS 300 where it is stored in its memory.

A binary tree is used as it allows for rapid access to frame data, where as sequential structure would slow the process of frame data retrieval.

SEND: Sends to each leaf (containing one or more unit matrices) of the binary tree in the PS 300 memory, the flight data of each aircraft. The data is sent as a 4x4 matrix.

The 4x4 matrix contains translation and rotation data about all 3 axes.

PSW: A program that passes files from the HOST to the PS 300.

6. GRAPHICS APPLICATIONS

The following section details the three major applications developed for the PS 300. Other applications have been developed but have been of a one off nature.

In all cases data is read from a FDR, processed and passed to the PS 300 where it is stored in the Binary Tree Memory structure, described earlier.

In applications two and three, all three-dimensional views (3-D) have the facility to be viewed from any direction. The viewer positions himself/herself using the dials provided:

Dials	Function
1 - 3	Translate the view along the x,y,z axes.
4 - 5	Rotate the view about each of the axes that pass through the origin.
7 - 9	Rotate the view about each of the axes passing through the observer position. This enables the viewer to rotate the view about his/her position.

In the case of the 2-D views, all views can be scaled by a dial. This enables the user to zoom the view in and out.

6.1 APPLICATION ONE: INSTRUMENT PANEL DISPLAY

This graphic application has the potential to animate the instrument panel of any aircraft equipped with a digital FDR, recording the basic flight instrument parameters. Currently however, only a B747 panel description file is available (which describes the type of dials in use) so other panels cannot be displayed to exact specifications.

The instruments that can be displayed simultaneously are listed below:

1. Airspeed
2. Altitude; Bar and Dial Display
3. Heading
4. Localiser
5. Glideslope Indicator
6. Vertical Speed Indicator
7. Engine RPM
8. Engine EPR
9. Engine Fuel flow
10. Leading Edge flap transit
11. Leading Edge flap extended

Figure 6.1 shows the type of display possible:

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Figure 6.1 shows the type of display possible:

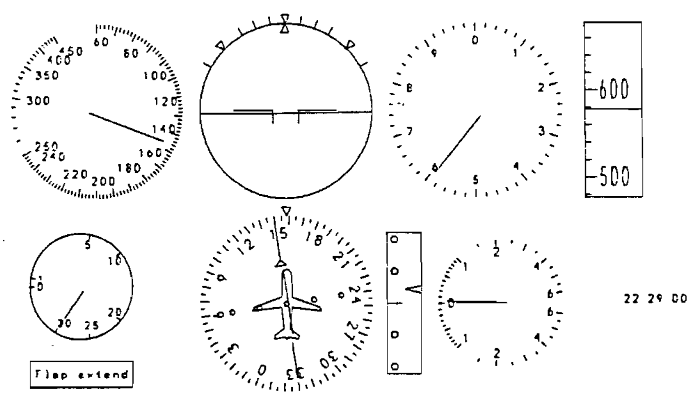


Figure 6.1 DIALS ANIMATION

6.2 APPLICATION TWO: FLIGHT PATH AND FLIGHT ANIMATION

This application displays the flight paths and animates up to four aircraft. Aircraft can be seen to pitch and roll, if the FDR records such information, otherwise, estimates may be used.

Four viewports can be displayed simultaneously or any one chosen for viewing in one large viewport. The four views available are:

1. Azimuth
2. Side evaluation
3. Front elevation
4. 3-D view

In addition a fifth view is possible if desired. This view can be either:

1. Formation View: view from behind any one of the four aircraft, flying the same flight path.
2. Pilots View: view from inside cockpit. Again, from any of the four aircraft.

A limitation of the memory capacity on the PS 300 will prevent all four aircraft having the fifth view. In the case of four aircraft involved in the animation, the optional fifth view maybe limited to one aircraft. However, with two or less aircraft all views are available in the one graphics session.

The animation time, is dependent upon the number of aircraft being displayed, and the number of frames displayed per second. More aircraft and faster framing (8 frames rather than 4 frames a second) will consume more memory and therefore reduce animation time.

For one aircraft animation times up to 2 minutes is possible, running at real time, and including the fifth view. Without the optional view animation times of 3 to 3.5 minutes may be possible.

Figures 6.2.1 to 6.2.3 show the type of displays discussed above.

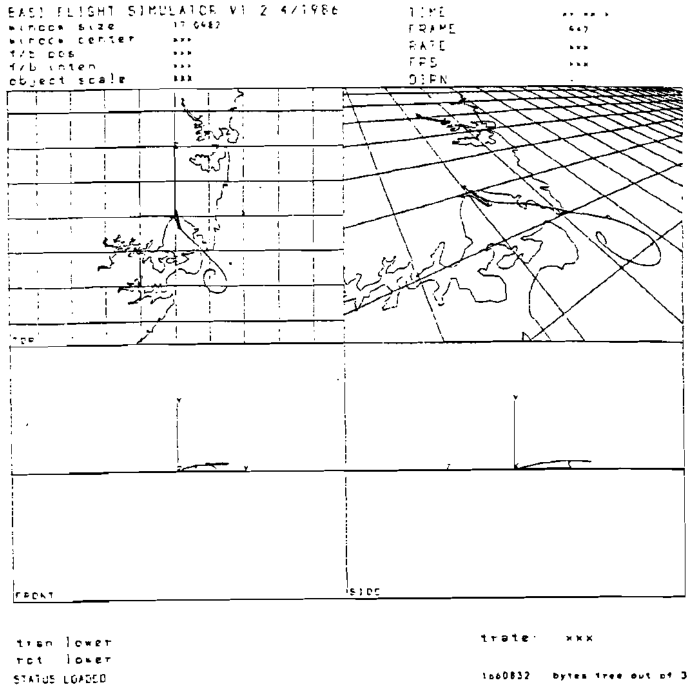


Figure 6.2.2 FLIGHT ANIMATION: Four views of flight path, showing;

(1) Flight Path - Originating from Sydney Airport, Australia, and spiralling into the sea outside Botany Bay heads.
(2) Coastline - Sydney
(3) Grid - square grid represents surface of earth.

N.B. This data originated from a flight simulator, and not from a FDR.

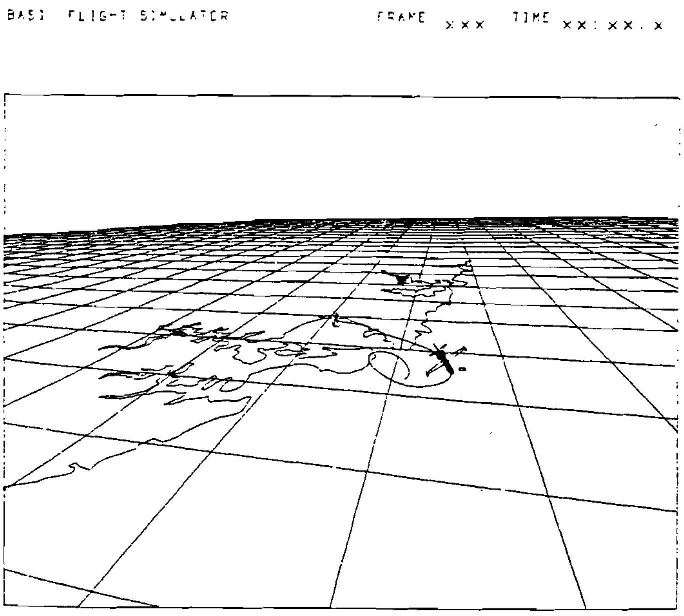


Figure 6.2.1 FLIGHT ANIMATION: Three dimensional view of flight path with aircraft. Aircraft is not to scale. Same flight path as in Figure 6.2.1

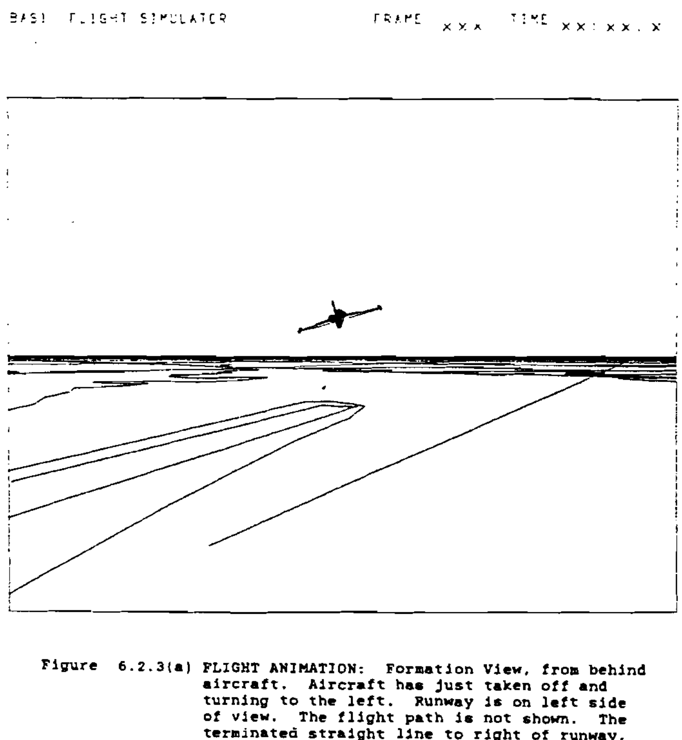


Figure 6.2.3(a) FLIGHT ANIMATION: Formation View, from behind aircraft. Aircraft has just taken off and turning to the left. Runway is on left side of view. The flight path is not shown. The terminated straight line to right of runway, is part of the grid network.

6.3 APPLICATION THREE: INSTRUMENT LANDING SYSTEM; FLIGHT PATH AND ANIMATION.

The third application calculates the flight path from the ILS information recorded by the FDR. The animation is displayed in two viewports; containing in the larger viewport either of the following:

1. Azimuth view of flight path and runway.
2. Three-dimensional view.
3. Pilots view of approach to runway.

The second viewport, is smaller and lies below the above views at all times. It contains a view of the flight path perpendicular to the runway centerline.

In all views, except the view from the cockpit, an aircraft can be seen to fly along the flight path.

Animation times of up to 2.5 to 3 minutes is possible, running at real time. Longer animation times are possible if less views are used.

Figures 6.3.1 to 6.3.3 show the type of displays discussed above.

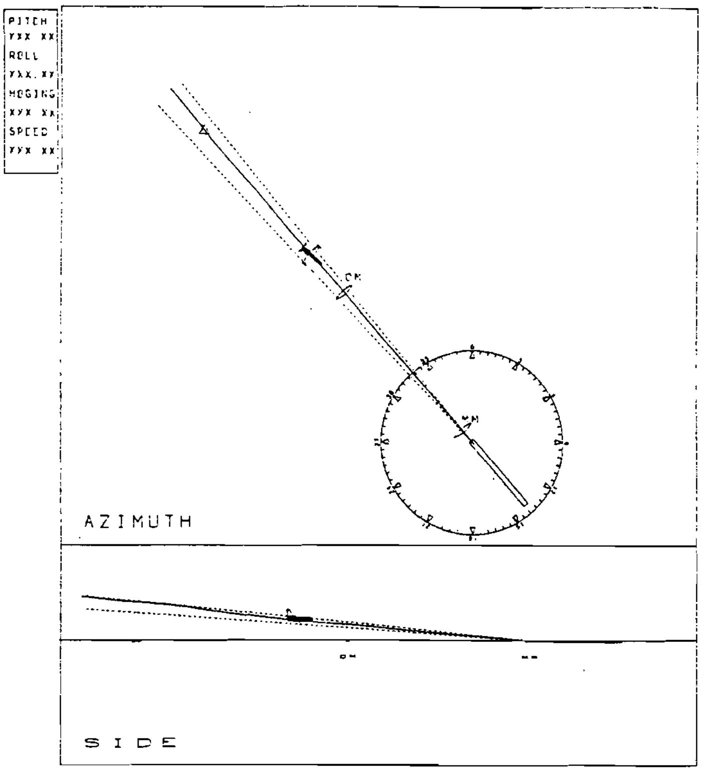


Figure 6.3.1 ILS ANIMATION: Aircraft flying towards Outside Marker. Aircraft not to scale. Dashed lines represent one dot deviation.

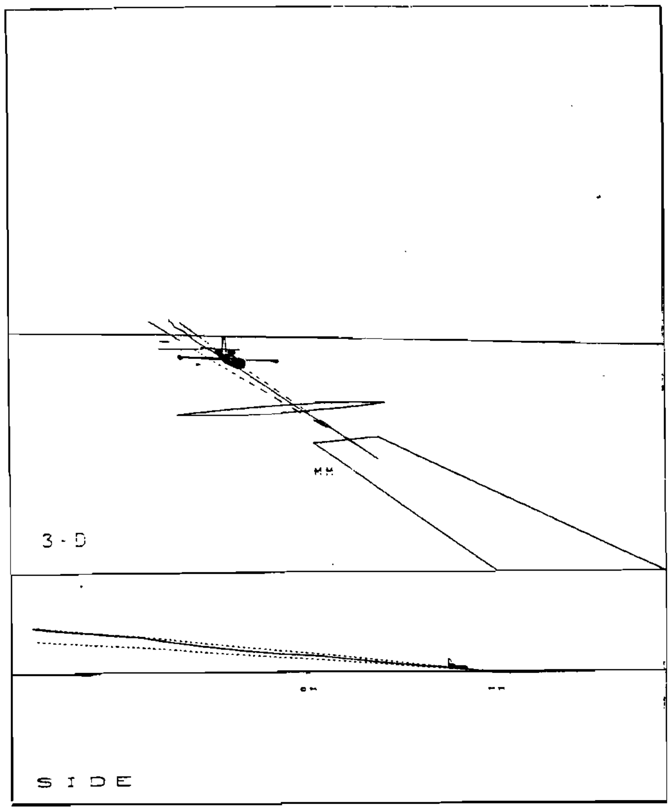


Figure 6.3.2 ILS ANIMATION: Aircraft positioned just before Middle Marker. Top viewport contains three dimensional view.

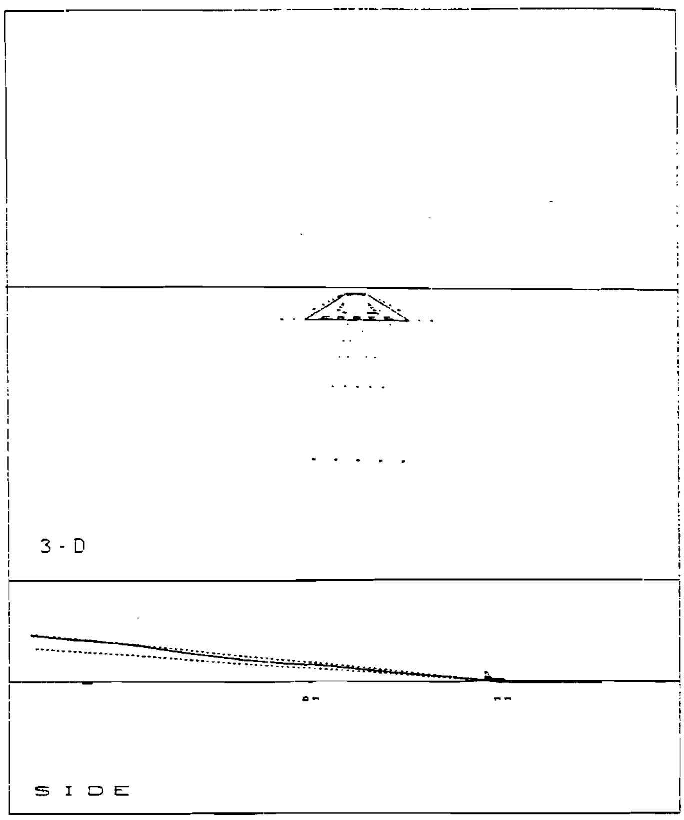


Figure 6.3.3 ILS ANIMATION: Aircraft positioned above Middle Marker. Top viewport contains view from cockpit.

6.4 FUTURE APPLICATIONS

The applications so far developed have the power and flexibility to satisfy most of the investigator's graphics requirements. Since the E&S advantage is rapid processing power, this guarantees that it will meet all of the foreseeable future requirements, with the minimum of compromises having to be made because of hardware limitations.

Future applications, however, may take advantage of hardware extensions to the current system. A colour monitor would improve the clarity, particularly on complex three dimensional views, involving several aircraft flight paths. A raster extension (consisting of monitor and processing board) would improve the dials presentation allowing for full colour solid modelling, further improving the realism.

An interesting hardware extension which has been developed for the PS 300 creates real three-dimensional views rather than the illusion of 3-D through the use of perspective. This is achieved by wearing spectacles, each lens having a shutter that opens and closes alternately. This coincides with alternate 3-D views on the screen for each eye. The effect of actual 3-D is created. This may be most useful on the views presented from the cockpit.

PROGRAMMING THE PS300

The software used by the PS 300 is properly described as a Function NET programs. It allows the user to specify a variety of interactive devices linked to nodes in the program.

Writing a program for the PS 300 is performed in two steps;

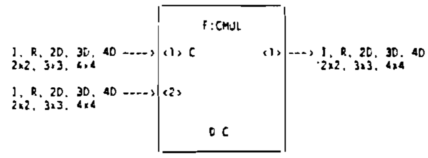
(1) Describing the Display Tree:

This defines the objects to be displayed and the transformations that will take place on it. This will typically be scaling, translating, and rotating the object. User interaction with the object by various interactive devices is achieved by linking the device to operation nodes or data nodes in the display tree. Operational nodes are shown as two concentric cirles in Figure A.1 .

The entire display tree is traversed from bottom to top (object vector lists to upper display node) during one refresh cycle, of which there are 30 in one second.

(2) Describing the Function Network:

The path between a device and an interaction node in a tree is a function network, created by the user to customise input from the interactive devices. A network is composed of individual functions, each function being thought of as a "black box", with inputs and outputs. See Multiply function below;



Accepts two input and outputs the product of the two inputs. Input <1> is constant. Inputs can be either an integer, real, 2D, 3D, 4D vectors, 2x2, 3x3, 4x4 matrices.

If new values are sent to a scale operation node, for example, the object will appear to grow smaller or larger on the screen. Interaction points in the display tree accept new values from function networks connected to interactive devices.

Function Networks differ from programs written in conventional programming languages to handle data from interactive devices. Function Networks are DATA DRIVEN. That is, networks are dormant until a function recieves data at its input queue(s). The function becomes active, processes the data, passes on the output, and becomes dormant again. In this way, the computer does not have to spend time polling the interactive devices to see if any activity has occurred.

Figure A.1 shows a simple example of a dial connected to an interaction node in a display trae.

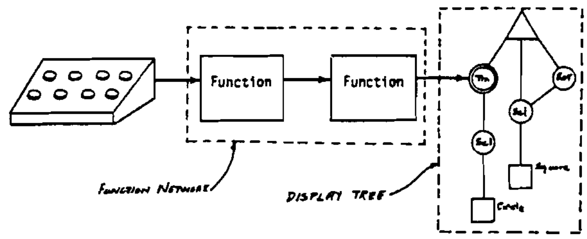
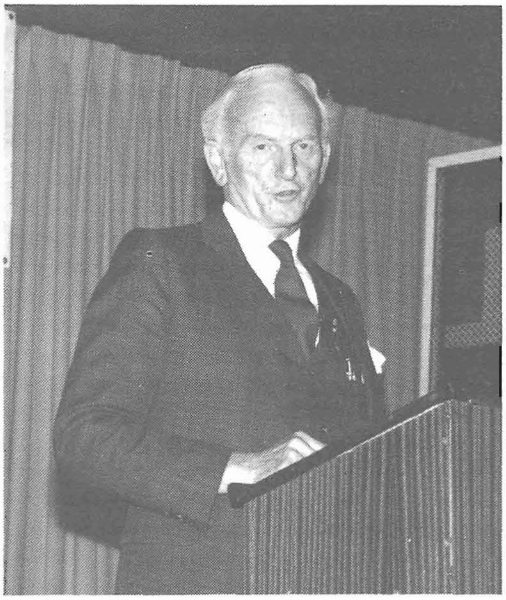


Figure A.1 The flow of Data though a Network.

Banquet Speaker

By Air Marshall Sir Richard Bolt,
KBE, CB, DFC, AFC former Chief of Defence Staff



Sir Richard Bolt

Noting your intensive programme these last three days—and the wide range of expert speakers you have been listening to on so many technical topics—I find it a daunting task to produce new thoughts with an air safety theme—especially before such a widely experienced international body of professionals.

Yet I am delighted and honoured to be here and allowed to try—and I make no apology for speaking as one whose own aviation career is well behind him, and who had most of it when flying was a little slower and less complicated than it often is today.

By contrast with the detailed special aspects you have been addressing I want to paint my thoughts on Air Safety with a rather broad brush—and you will not expect too many revelations from a non-expert in a small country such as New Zealand. Yet, having practised my own military aviation in many parts of the world, I've always felt that the NZ experience could well have more relevance than our small size would suggest.

- We have a very high density of total aviation per capita.
- While accidents become less and less affordable everywhere, this particularly applies in a small country of limited resources.
- We have a rugged mountainous terrain within our maritime environment—it's a lumpy country and we live at latitudes which ensure high winds and a wide variety of rapidly changing weather.
- And finally, regrettably, small as we are, we do have our own too extensive experience of accidents—both small and large—to draw upon.

But looking at the world aviation scene in total, we all recognize the immense changes and advances that have been made over the past two or three decades. It is called 'progress' but in my view it can only be called real progress when it is achieved without prejudice to safety. Certainly advancing technologies impose greater disciplines on designers, manufacturers and operators—and because the whole range of aviation activities is wider than ever before, it seems to me that your task as air safety people inevitably becomes more complex and demanding. Just keeping up to date technically must be quite a challenge in itself.

Yet just as we must accept that the processes of change and progress—and increasing aviation complexity, will go on a pace, I believe we must also accept that because of certain factors always present—notably weather factors and human fallibility, accidents will continue to occur. Murphy's law will see to that. Accidents will be increasingly costly and what I conclude from this is that we are faced with an ever sharper imperative to minimise the risk of accidents; that all those directly involved with air safety must assume a higher profile and perhaps work in a more coordinated way to achieve recognition of their best advice and an increasing influence on the whole aviation scene. This of course involves just about everyone in aviation—designers, manufacturers, operating authorities, management, aircrews and others—all these should be 'thinking air safety' in all they do—but I am especially referring to those in specific air safety appointments, those who make the rules and regulations within each national administration—and not least, you who are primarily involved in the accident investigative processes. You are at the very heart of the Air Safety business—the breadth of your expertise gives you a unique status—and after all, the accident record is inescapably the measure of success (or otherwise) in the whole effort towards accident prevention.

I have noted that within ICAO, 'accident investigation' is now formally linked with 'accident prevention' and this seemed to give me licence for what I would now suggest—that perhaps you might be playing an even greater role in accident prevention than you already are. I know that in your own parts of the world, you pursue your investigations as independent experts and that you make recommendations to your own national authorities on matters arising from specific accident experiences. But I am suggesting rather more than this—that your views could well be positively applied in the formulation of Air Safety provisions and policies in general—and that those views will be more compelling if they reflect the consensus of a majority of you as an international body of experts—if they are based on an international exchange of information and opinion, and not just the product of reaction to accidents as they occur.

Put another way, I am suggesting that this International Society which has brought you together here, might itself facilitate a greater contribution towards accident prevention—that when you again meet together, in addition to hearing very valuable inputs on special detailed aspects of Air Safety as you have here at Rotorua, you might also devote some time to an airing of views on some of the more basic ways of improving Air Safety in general—and perhaps the starting point for that would have to be a review of some statistics indicating the record of facts and trends for the recent past.

In preparing for this occasion, I must say I found difficulty in acquiring really meaningful statistics on the overall accident picture—or even a clear indication of what world-wide trends really are by Air Safety measures in the various categories of aviation activity. No doubt there are ample statistics buried within ICAO, the Flight Safety Foundation or elsewhere, but all I could find here was rather limited.

If one is to draw proper conclusions on Air Safety it seems to me quite basic that you should know precisely how your own national experience compares with others in types of accident and in different categories of activity. Perhaps here is a helpful area for a better exchange of information. But the records must be meaningful. For example, is "Scheduled air services" really an appropriate category? Can you really compare small propellor driven commuter carriers with modern wide-bodied jets to any good purpose?

I found the general aviation statistics depressing (albeit incomplete) in that from comparative figures from the US, UK, Australia and New Zealand, there is no indication of any real improvement over the past ten years—and still a high proportion of weather related accidents, often fatal. Clearly we are not sufficiently learning from past experience.

Then, in all the statistical data I could find, it was surprising to me that no account was taken of any military records. So let me make one or two observations about military aviation and why I think it does have some relevance and can make a contribution to air safety as a whole.

Military flying—especially in the major industrial countries—represents the leading edge of advancing aviation technologies, and I believe civil aviation derives a major part of its own modernisation and technical progress from military research and development.

Military aircrews fly their aircraft to more exacting limits and in much more varied flight experience patterns than anyone else.

Compared with their civil aviation counterparts, the military have very clear concepts of command responsibilities; there are no unions or adversarial situations with management, and because of freedom from the pressures of profit motives, more effort is devoted to training.

The military have much to offer in the field of aviation medicine where their more demanding requirements have led to more research.

And after all a considerable part of the military aviation activity is devoted to flying from A to B just like the airlines and others, using aircraft of similar sophistication, the same airspace and aids.

Now I know that the military generally investigate their own accidents and tend to keep their findings under wraps, but I do believe that a good case can be made for a very full and free exchange of information between military and civil aviation at accident investigation levels if national flight safety policies and standards are to benefit fully from the total experience. Any statistical data which totally excludes the military experience is, to me, incomplete and illogically so.

I'm sure some effective liaison is already in place in many cases but where it is not, it will not of course, just happen by itself and is only likely to come about if you seek it.

I am assuming of course that you will not totally disagree with my proposition that the accident investigation voice might come to play an even more active role in determining national air safety policies. What I am saying here is that the addition of the military experience and expertise to your own, could well make your voice and advice even more effective. And given the typical training and background of military aviation aircrews and engineers, the recruitment of more of them into your own staffs might well represent another worthwhile military contribution.

But may I turn now to one or two more philosphical thoughts on Air Safety—and some random questions which typify the kinds of issues on which you may well have views which could usefully be made more widely known.

- If we accept that because of human factors, absolute safety in all circumstances is unattainable, the objectives of Air Safety policies will essentially be to minimise the risks in all aspects of aviation—at an acceptable level of cost in resources. Certainly there will always be sensible limits to the provisions to be made; you can't just go on buying insurance with premiums unlimited.

But as progress and changes in aviation patterns occur, the limits of the resources available for Air Safety provisions will logically be reviewed—and perhaps more importantly, for there will never be enough resources to satisfy all, there will need to be constant reappraisal of priorities to determine how the available resources should best be applied. And in making such reappraisals, the lines must be carefully drawn to ensure that progress is made without true safety being diminished. Indeed, without enhanced safety standards overall, it is doubtful if real progress can be claimed.

I believe however that there could well be times when sensible reappraisals could lead to some safety provisions being reduced or even discarded, so that more attention can be afforded elsewhere. Let us look at two examples—call them hypothetical if you like, laugh them out of court, but I think they are real enough to deserve serious thought.

First, consider the relevance and effectiveness of crash-fire services at airports. Does the record really substantiate a case for continuing to pour resources into such services at the present rate? My research tells me very clearly it does not. In any case, if it is already acceptable to use some minor airfields without these services, are they really necessary at all in their present form?

Then again—if no high performance jet airlines have successfully ditched for some twenty years or more—and if because of their performance criteria, a ditching is probably unsurvivable anyway, is the carriage of all those life rafts and other passenger flotation gear really appropriate in all cases. Again, I think it is at least very doubtful.

I am well aware of course that public opinion enters these arguments—and that if such radical changes were to be made, they would have to be international in character. You will perhaps, see such issues as clearly someone else's concerns and so they are, but no one is better placed to have independent professional views on them than you at the very heart of the Air Safety scene; and your views on how best to re-apply the resources saved will also be as valuable as any. Such things as the universal application of flight recorders, for example, might become relatively easy to achieve with savings of that order.

But let me turn now to one or two other areas in which I think fair questions can also be raised.

Is there a conflict between the increasing reliance on computer technologies in air navigation, and traditional concepts of aircrew command responsibilities? Is there enough looking out the window in controlled airspace? What are the effects of automated systems on real aircrew experience levels? Certainly, in some types of operation, hours in the log book are not necessarily the same indicators of experience they once were. And is adequate effort being put into aircrew training to compensate for these changes, especially within airlines where profitability may be critical?

On the general aviation scene, what of those intrepid souls who press on too far underneath deteriorating weather and so often finish up in a pile of wreckage on the side of some hill. This goes on year after year and surely some improvement in this part of the accident record should be possible. In this country, and no doubt in others, single engined route flying is not permitted under IFR.

Would it not be better and less risky to allow such flights under IFR, either in or above the weather rather than have them boring on underneath until visibility is finally, and often fatally, lost? Or perhaps it is just that the rules and regulations need to be tighter with a great deal more emphasis on weather education and training.

On another topic (an old chestnut) what are the real merits of rearward-facing seats on certain types of passenger aircraft? RAF Transport Command, which has always adhered to such a policy, can point to at least one case in which a crash landing killed crew members while passengers walked out unscathed.

But these are just random sample questions and you could generate many more. I have my own views on most of them and they probably differ from the solutions which now exist but the real answers must come from current professionals. I touch on them here simply because they typify the kinds of areas in which, I believe, with raw evidence in your hands, you could, and even perhaps should, exercise a voice which reflects your collective professional views.

It is relatively easy when an accident occurs, to recommend some additional safety provision against repetition, and 'plugging holes' in that way undoubtedly can contribute to safety generally. But the preventative function goes well beyond that. It must, I believe, include those constant reappraisals of the safety measures which already exist in an every changing aviation scene, and perhaps seeking modifications or even reductions in some areas, to do better in others. I call this 'drawing the line' to ensure that all the available resources, experience and knowledge is being applied rationally to achieve optimum effectiveness towards Air Safety objectives. This, in my view, is the responsible approach to Air Safety by anyone involved, and surely you must be part of that.

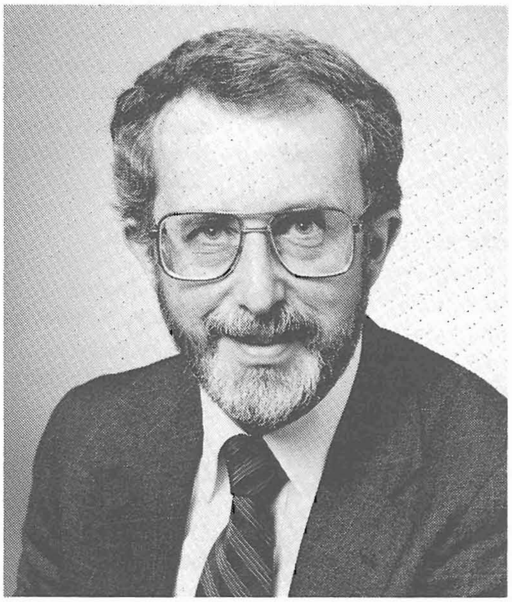
Gentlemen, I thank you for listening to my few 'broad frush' air safety thoughts. The simple message I leave with you is this—that by further developing your collective strengths and formulating consensus views on important safety issues, you have the potential to bring powerful influences to bear in the whole field of accident prevention—and on your own national Air Safety policies and practices. And should you see any validity in this thought, I ask you furhter to not ignore the military experience which is at hand, for I believe it too can make a significant air safety contribution.

I feel reasonably safe in promoting that last thought here, as your host, the NZ Chief Inspector of Accidents—and the Director of Civil Aviation—both have extensive military aviation backgrounds of their own.

And now I wish you all a safe return home and very light workloads in the years ahead.

1986 Seminar Activities

A **Big** Thanks to Official Seminar Photographer



John W. Purvis
Manager, Aircraft Accident Investigation
The Boeing Company

17th International Seminar
List of Attendees

Corporate Member Attendance List

Accidents Investigation Branch CP0058
Geoffrey C. Wilkinson (Virginia)
Richard C. McKinlay

Air Canada CP0052
Joseph Galliker

Air Line Pilots Association CP0002
Harold F. Marthinsen CM2507 (Kathleen)
Dale 'Bud' Leppard MO2034 (Carol)

Associated Aviation Underwriters CP0063
Bruce H. Mally AO2272

Beech Aircraft Corporation CP0028
Leo F. Sander CM0604

The Boeing Company CP0016
John W. Purvis (Carol)

Canadian Air Line Pilots Association CP0036
Gordon Anderson

Canadian Aviation Safety Board CP0060
David R. Owen
Bernard M. Deschenes
R. Hayman
Roger L. LaCroix

Canadian Pacific Airlines CP0054
P. M. Chan MO2499

Civil Air Operations Officers Association of Australia CP0062
Stuart Spinks
Peter McGuane

Civil Aviation Authority - UK CP0064
Peter M. Gray CM2886

The De Havilland Aircraft of Canada, Ltd. CP0048
Ian Gilchrist CM2787 (Joy)

Flight Engineers International Association CP0022
Nick Caulton

General Electric Company CP0065
John Moehring CM2887 (Jane)

International Federation of Air Line Pilots Association CP0051
Capt. R. H. J. Smith CM1334

The Japanese Aviation Insurance Pool CP0023
Toshiro Suzuki CM0662

Sundstrand Data Control, Inc. CP0005
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Speiser, Krause & Madole

Corrie, Stephan J. MO0702 (Kathy)
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Law Office of Floyd A. Demanes

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LS Dougherty & Associates

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Hawkins, Neil AO2667
Qantas Airways

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Wynyard, Wood, Barr & Solicitors - New Zealand

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John L. McWhorter & Associates

Mercer, Charles R. MO0331 (Margaret)
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C. J. Miles & Associates - Australia

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New Zealand Air Line Pilots Association

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Daniel C. Sayres Associates

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Shaw, Lawrence W. MO2163
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Sorrells, Ralph M. MO2750 (Nancy)
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Spencer Aviation Consulting

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Aeromarine Adjusters

Stripling, Wallace L. MO2601 (Iris)
National Transportation Safety Board

Strul, Isidor MO0968
Israel Aircraft Industries

Sweet, John W. AO202 (Gloria)
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Taylor, Frank T. MO2513 (Mattie)
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Thomas, Neal W. MO0665

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*Willetts, Gordon
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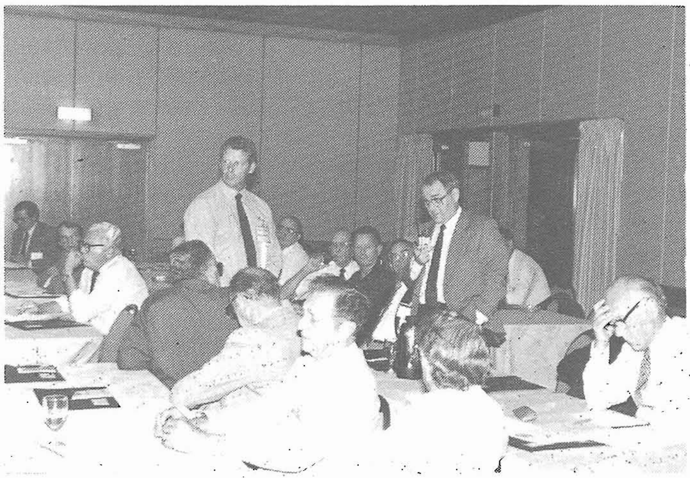
*Non-members

1986 Seminar Activities



INCORPORATED AIR SAFETY INVESTIGATORS AUGUST 31, 1964

ISASI No.________
(Office use only)
REV. 4-87

THE INTERNATIONAL SOCIETY FOR AIR SAFETY INVESTIGATORS

West Building, Room 259
Washington National Airport
Washington, D.C. 20001

APPLICATION FOR INDIVIDUAL MEMBERSHIP

(Inquiries concerning corporate membership should be sent to the above address.)

PLEASE PRINT OR TYPE

NAME OF APPLICANT ____ DATE OF BIRTH __________
Last First Middle Initial

HOME ADDRESS ____

CITY ______________________ STATE, DISTRICT or PROVINCE ______________________

COUNTRY ______________________ ZIP/ZONE ______________________

HOME TELEPHONE AC (_____) ________________ CITIZENSHIP __________ SPOUSE NAME OPT __________

THE INTERNATIONAL SOCIETY OF AIR SAFETY INVESTIGATORS HAS THREE CLASSIFICATIONS OF INDIVIDUAL MEMBERSHIP:

MEMBER: An Air Safety Investigator* who is, or has been actively engaged in the investigation of aircraft accidents including representatives from aircraft manufacturers, air carriers, the military, other government agencies, and members of aviation professional groups, for five (5) years shall be eligible for consideration for FULL Membership in The International Society of Air Safety Investigators. The five years may be reduced in the case of a graduate of a recognized school for aviation accident investigators and where justified by investigative experience but may not in any circumstance be reduced to less than three years. Aircraft accident litigation is not qualifying experience for this classification of membership. An applicant must have participated in at least TEN aircraft accident investigations; however, this requirement may be reduced where the applicant has equivalent experience and an endorsement by a ISASI member in good standing. An affidavit signed by a military applicant's commanding officer will be considered.

ASSOCIATE: An Air Safety Investigator* who is, or has been actively engaged in the investigation of aircraft accidents but who at this time fails to meet the requirements for FULL Membership outlined above shall be eligible for consideration for ASSOCIATE membership in The International Society of Air Safety Investigators. Aircraft accident litigation is not qualifying experience for this classification of membership.

AFFILIATE: Any person who is, or has been engaged in the promotion of air safety, including representatives from aircraft manufacturers, air carriers, military, other government agencies, members of aviation professional groups, and members of legal and law enforcement organizations shall be eligible for consideration for AFFILIATE Membership in The International Society of Air Safety Investigators.

**An "Air Safety Investigator" is a person who is or has been actively engaged in the investigation of aircraft accidents.*

EMPLOYMENT RECORD

List your present employer first. Use additional sheets as necessary. List at least five years employment.

Employers name and address: ______________________________

______________________________ Telephone (________) ______________

Your title or position: ______________ From: ______________ To: Present ______________

Aircraft Accident Investigation? ☐ Yes ☐ No

Employers name and address: ______________________________

______________________________ Telephone (________) ______________

Your title or position: ______________ From: ______________ To: ______________

Aircraft Accident Investigation? ☐ Yes ☐ No

INVESTIGATION EXPERIENCE

Your classification of membership in The International Society of Air Safety Investigators is dependent upon your investigation experience and related schooling. Therefore, please be most careful in submitting the requested details on your investigative experience as outlined below.

FIRST Investigation in which you participated: ______________________________

Date: ______________ Location: ______________ Make/Model of Acft: ______________

Whom represented ______________ Capacity/Specialty ______________

Most RECENT Investigation in which you participated: ______________________________

Date: ______________ Location ______________ Make/Model of Acft: ______________

Whom represented ______________ Capacity/Specialty ______________

On a separate sheet(s) of paper, identify by date, location, make and model of aircraft, etc. AT LEAST EIGHT INTERVENING ACCIDENTS IN WHICH YOU PARTICIPATED in addition to those listed above. Equivalent experience includes supervisory air safety responsibilities, safety committee assignments, participation in complex incident/mishap investigations, and/or in hearings/boards of inquiry, etc. Aircraft litigation experience is not qualifying for MEMBER and ASSOCIATE Membership classifications. Date and sign each sheet and attach to this form.

Specialty: Circle area(s) of primary interest/specialty and as many as apply.

1. Investigator in charge
2. Supervisory (Coordinator)
3. Operations
4. Air Traffic Control
5. Meteorology
6. Witness Interrogation
7. Helicopter
8. Maintenance
9. Powerplant
10. Structures
11. Systems
12. Instruments/Avionics
13. Voice Recorder
14. Flight Recorder
15. Aircraft Performance
16. Human Factors
17. Crash Survivability
18. Pathology
19. Human Performance
20. Other, specify

I, the undersigned, certify that the information contained in this application and any attached documents is correct. I agree that if elected to membership, I will comply with the Bylaws and Code of Ethics and Conduct of The International Society of Air Safety Investigators. Further, I also agree that, if for any cause my membership in The International Society of Air Safety Investigators shall terminate, my rights, title and interest in or to The International Society of Air Safety Investigators shall cease. I understand that the cost of my annual subscription to *forum,* the official publication of The International Society of Air Safety Investigators, is included in my annual dues.

I understand that the Membership Committee, authorized by the International Council, will determine the classification of membership for which I am eligible based on the information I submit. Information provided on this application is confidential and will not be released outside the Society without your permission.

Signature: ______________________________ **Date:** ______________

Do not write in the space below:

National Society

Date: ______________

Action: ______________

Signed: ______________

Membership Committee -International Council

Date: ______________

Action: ______________

Signed: ______________

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forum

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The Editorial objective is to report developments and advanced techniques of particular interest to the professional aircraft accident investigator. Opinions and conclusions expressed herein are those of the writers and are not official positions of The Society. The Editorial Staff reserves the right to reject any article that, in its opinion, is not in keeping with the ideas and/or objectives of the Society. It further reserves the right to delete, summarize or edit portions of any article when such action is indicated by printing space limitations.

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The Jerome F. Lederer Award

Nominations for the 1988 Award will close on March 31, 1988.

The award is given for outstanding contributions to technical excellence in accident investigation. Not more than one award will be made annually and presentation is at the ISASI Seminar. The recipient is selected by the ISASI Awards Committee.

Any ISASI member may submit a nomination for this award. It must be sent to the Chairman of the Awards Committee, and must include a statement describing why the nominee should be considered. This statement should be sufficiently descriptive to justify the selection but no more than one typewritten page in length.

This award is one of the most significant honors an accident investigator can receive, and so considerable care is given in determining the recipient. Each ISASI member should thoughtfully review his or her association with professional investigators, and submit a nomination when they can identify someone who has really been outstanding in increasing the technical quality of investigation.

Mail to: Dr. William J. McArthur
4900 Kingsway - Suite 310
Burnaby, BC
Canada V5H 2E3
(604) 432-1644

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Individual membership is available to persons who are, or have been actively engaged in the investigation of aircraft accidents, civilian or military, or in the promotion of air safety. The initiation fee is $35.00 and the first year's annual dues are $50.00 for a total of US $85.00.

Corporate membership is available to firms engaged in air transportation, in the manufacture of aviation products or providing services that are aeronautical in nature. Submit a letter to the President of ISASI and forward the sum of US $400.00 to provide an initiation fee of $100.00 and the first year's dues of $300.00.

Further information on membership may be obtained by writing:

John G. Young, Chairman
Membership Committee, ISASI
Technology Trading Park
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