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SUMMARY

A further study is being made, on a world-wide basis, of accident summaries and reports together with recent papers on the various aspects of fire safety. The aim is to compare the period since 1974 with the first twenty years of survivable accidents to turbine powered aircraft as presented to the 1975 AGARD Symposium in Rome.

While the study is still far from complete it does seem that, although some lessons have been learned and improvements have been made or are on the way, crashworthiness, fire and survival remain areas of major concern.

INTRODUCTION

This is not the paper I had intended to write since the above summary now reflects the continuing incompleteness both of our data base and our analysis of it. For this I apologise but it is hoped that this more general 'overview' will be of at least equal value to the more detailed analysis and comparison that had been envisaged. Please note also that the use of the first person in the paper is deliberate since this will now be a personal view rather than a totally dispassionate study.

My starting point was, and still is, my AGARD paper (reference 1) presented in Rome in 1975. This was to the best of my knowledge one of the first attempts made to use statistics to compare different groups of accidents. It was successful in so far that the first 20 years of turbine powered aircraft operations had by then produced just sufficient accidents for statistically significant differences to be detectable. At the time I felt not a little apprehensive in pointing out that the 20 year accident record confirmed what had been predicted from theory and experiment from the very outset of turbine operations. I was of course referring to the use of the less dangerous, low volatility fuels, namely kerosine rather than gasoline or wide cut fuels. Perhaps I also felt angry that lives had been lost in the time taken to 'prove' what was, to many, already self evident and described in reference 2. Further studies (references 3 and 4) and several excellent and comprehensive reports followed, which together laid the foundations for the use of past accident data to help in the evaluation of possible safety measures. Some of these will be discussed in the next section.

Perhaps the major success of the 1975 AGARD conference and the resulting discussion, however, has been the increased awareness of the importance of crashworthiness and survivability, not least when fire occurs, to aircraft safety and as reflected in aircraft accident investigation and the resulting reports. Without wishing to belittle in any way the efforts of other authorities I nevertheless believe that the AAIB report (reference 5) on the Manchester B737 accident in August 1985 does represent a milestone in the investigation and reporting of an aircraft accident involving fire.

With this in mind I should like to repeat an opening paragraph of a brief paper given at the Royal Aeronautical Society in 1986 (reference 6):

'The main purpose of any statistical review must be to establish where our limited 'safety money' is best spent. The traps we are otherwise liable to fall into are (i) overreaction following what may in fact be a one off, unlikely to be repeated accident or (ii) under reaction as a result of treating an accident with many similarities to previous accidents as if it were a one off'.

and also the conclusions:

'The Manchester B737 accident although apparently very severe was in fact fairly typical of a survivable, on the airport fire accident with no fuselage damage and no fatalities due to impact trauma. The findings and recommendations of the Accidents Investigation Branch will therefore be relevant not only to this one accident but to a large and important group of accidents. They should therefore be followed up by all concerned with even more than the usual urgency.

Where appropriate research should continue in areas that could make this type of accident less hazardous to the occupants.'

This brings us full circle with the original intention of the paper being to set out a complete list of relevant accidents to make the task of assessing priorities that much easier. In this I have failed due to circumstances not relevant to this meeting, however I trust that the list that is appended in conjunction with others presented or to be presented at this meeting and those from the past few years will prove useful. As always the original starting point for any list of accidents is the CAA's invaluable World Airline Accident Summary, WAAS, (reference 7) which usually makes plain which accidents need to be followed up regarding factors such as fire and cause of death. However by itself the WAAS may sometimes, through no fault of its compilers who rely on often inadequate information, be misleading. There have in fact been several accidents where a reading of the WAAS alone would not reveal the existence of fire let alone deaths due to fire and some comparatively recent papers have failed to capitalise on work already published which provided far more details than the WAAS, for example reference 6, probably the most comprehensive study yet completed and reference 9 which is more readily available. Others are referenced later and no doubt other valuable data will be presented at this symposium.

STATISTICS, COST BENEFITS, NET SAFETY BENEFITS, ETC.

When I first studied statistics, Moroney's 'Facts from Figures', reference 10, was only three years old; it continues to be in demand after 38 years! Apart from providing an excellent introduction to statistics the author headed each chapter with an apposite quotation (individual references for these quotations will not be given) and many of these have remained with me while much of the theory has been forgotten. Some are well known, most are worth repeating as containing in them a large measure of, if not always complete, truth.

For example, and perhaps as a reminder that we should always start with an open mind Francis Bacon once said:

'If a man will begin with certainties he shall end in doubts; but if he will be content to begin with doubts he shall end in certainties.'

To remind us today that we must be very careful to include <u>all</u> relevant information Lord Brougham, 150 years ago, stated an equivalent to the 'lies, damned lies and statistics' put down in that

'You have only to take in what you please and leave out what you please; to select your own conditions of time and place; to multiply and divide at discretion; and you can pay the National Debt in half an hour. Calculation is nothing but cookery.'

Even if you <u>have</u> been careful, in the truthful sense, both with your information and with your use of it, A.N.Whitehead made the statement, even more true now in our world of computers, that:

'There is no more common error than to assume that, because prolonged and accurate mathematical calculations have been made, the application of the result to some fact of nature is absolutely certain.'

It is perfectly natural and requires no ulterior motive whatsoever, to select for study just those accidents that one believes are relevant to the subject in hand. Thus if one is concerned with saving lives there is clear justification and logic in looking only at fatal accidents. With real care some useful conclusions may come out of such a study but it may be recalled (reference 1) that a comparison of fatal but survivable accidents alone could have lead one to deduce that the presence of fire made little or no difference to the proportion of those on board who were killed, about half, with or without fire. It was only when related non-fatal accidents were considered alongside the fatal that the significance of fire became apparent, with no fire only some 8% of the occupants died but with a fire present in a group of otherwise similar accidents this increased to 26% as a result of a larger proportion of accidents becoming fatal.

Similarly if one is principally concerned with <u>passenger</u> safety there is much sense in confining one's study to passenger carrying flights. In fact if our sample size were large enough there would probably be no argument against doing this. As it is such a sample is still mercifully small, often too small for any statistical analysis. Now while I believe it may be quite proper to exclude crew training flights and other non-passenger flights from any study related to accident causes, that is to preventing accidents, I suggest that such an exclusion need not and should not apply to any study of crashworthiness or survivability since the original cause is largely irrelevant to such a study. I therefore suggest that crew training, cargo, executive and other flights, both non-fatal and where one or more crew members died or escaped only by the skin of their teeth, are highly relevant and should also be considered. This is particularly so if one is involved in a 'what might have happened if' study.

On the other hand if one is looking for disbenefits it is natural also to include non-fatal accidents so as to consider whether some of the survivors in these might have actually died had some proposed 'safety' device been present. There is nothing at all wrong with such an approach, indeed it is absolutely vital that the disadvantages <u>are</u> always considered alongside the advantages, I merely wish to express my fear that no selection of accidents can be totally free of a bias that could affect the results; hence my own attempts to reduce selection to a minimum and include as many accidents as possible in any comparative study. For this study an attempt has been made to include all potentially survivable accidents involving fire and/or spilled fuel.

A problem at present is that the results of many studies are likely to be strongly affected by a handful of 'major' accidents. Unfortunately few, if any, of these appear to have been investigated with the thoroughness that the AAIB applied after the Manchester accident, and it is only with the benefit of all the information now available concerning this accident that one can venture to suggest 'what would have happened if ...' with any confidence at all. Even in this case there are surely no certain answers, only probabilities albeit sometimes very strong.

At this point I should like to try to set out my position concerning the use of accident data for assessing safety measures. Having started in the early sixties by arguing that one could and should draw valuable conclusions from a handful of accidents, backed by theory and experiment, and played down the counter argument that all accidents were different and one couldn't possibly say 'what would have happened if ...' (and this was the principal argument of the pro-JP4/wide cut lobby) I moved in the seventies to a pro-statistical approach (it could cynically be suggested because this confirmed my earlier prejudices) and now in the late eighties find myself doubting the value of some safety benefit analyses which should combine the best of both worlds (again it might cynically be said because I don't always agree with the results).

In fact this change of approach has come about as a reflection of the increasing amount of data that has gradually become available, my only concern is that this should be used and be seen to be used with an open mind in a disinterested manner. This is not easy and I venture to urge extreme caution to those concerned. The aviation fuel issue may have been unique in providing sufficient data to confirm a considerable difference in post crash fire properties at a statistically significant level and at a time when there were no other competing solutions. I still feel strongly that we should not again have to wait 20 years for such differences to be 'proved' by the accident record. To this end I support the concept of net safety benefit analyses providing the results are couched in terms that reflect their unavoidable lack of precision.

To say that in accident A safety measure Brand X would have saved say 20 lives may be a reasonable view. However it is more likely that a more balanced consideration of the circumstances would lead to the conclusion that taking a 'worst case' only 10 lives would be saved and taking a 'best case' 35 would have been saved. In accident B the circumstances might be different and better documented such that the spread would be smaller, say between 50 and 60. In another poorly documented accident C the only valid conclusion might be anywhere between 0 and 100 lives saved. The relative danger of assigning any precise figure to accident C is obvious.

Consideration of safety measure Brand Y might give better or worse results with more or less scatter and at a different cost. Such a comparison might be useful if one could be sure that one was looking at a range of accidents likely to remain typical and that the analyses had been completely fair to each safety measure. But what if there were 3 or 4 competing safety measures? Do you start from the previous 10 or 20 year baseline or do you try to take into account changes recently or about to be made? That is do you guesstimate the lives that might have been saved by Brand X, which is just being introduced, before guesstimating how many more might be saved by Brand Y or Brand Z?

I suggest that there is nothing wrong with making such an attempt but sight should never be lost of the often poor quality of the initial data nor of the progressive and further loss of quality, i.e.accuracy, every time one makes such a guesstimate, much as one must beware of taking too much notice of the small difference between two very large quantities.

This is of course not an academic question, for the first time within my experience there are indeed several safety measures being discussed that could improve cabin safety. We therefore have to ask ourselves questions that may never have arisen before, though the central one of 'where our limited safety money is best spent' remains. The first subsidiary question to this should perhaps be 'is it reasonable to search for one Best Buy or should we hedge our bets?' Coupled with this is the question 'do we seek perfection in one Brand or is our money more effectively spent by developing several Brands, perhaps bearing in mind the law of diminishing returns, to a slightly lower standard?'

So long as such a choice exists there also exists the possibility (in the long run the certainty) that an accident will occur after which it can be argued and maybe proved that we made the wrong choice, therefore we are liable. Since this applies whichever choice we make we can ignore this aspect altogether, so long that is as a reasonable amount of safety money is spent and that the decisions we make are based on reasonable and defensible premises.

My own view as expressed at an Air Safety Symposium in Brussels (reference 11) is that there is no single solution, no Brand however perfect could possibly save all lives under all accident conditions. At the same symposium the passenger in seat 9C (reference 12) expressed a similar view and provided a list of 11 topics deserving attention but not all directly relevant to aircraft fires.

Reference 11, written around the Manchester B737 accident referred to a similar list of topics all in some way to do with fire protection. It was suggested that these should not compete for our attention, nor in particular for the attention of the airworthiness authorities, rather they should all be considered and if possible introduced at some reasonable, necessarily non-perfect, standard. The principal topics discussed were the provision of

(i) external camera(s) and cockpit monitor

(ii) a cabin water mist system

(iii) less flammable fuels,ie JP5/AVCAT or AMK rather than JP8/JetA/AVTUR

(iv) improved cabin wall/ceiling materials

(v) passenger smokehoods

Others mentioned concerned:-

(vi) fuel tank and fuselage integrity following undercarriage collapse etc.

(vii) greater protection of fuel/hydraulic lines passing through the fuselage.

(viii) compartmentation of the fuselage

(ix) onboard extinguishing system in equipment bays

(x) passenger smoking.

One should add to these improvements in:

(xi) access to cabin exits

(xii) safety instructions to passengers

(xiii) cabin staff training

(xiv) certification evacuation procedures

(xv) strength/stiffness requirements for all overhead panels, bins etc (and perhaps dynamic testing thereof)

The list can be added to with consideration of limiting

(xvi) carry on baggage and duty free goods

and so on.

I hope it can be agreed that while an order of priority might be useful, these should not be in competition with one another and there should for example surely be no question of adopting <u>either</u> smokehoods <u>or</u> a cabin water mist system, nor of accepting without question that we don't need either now we have fire blocked seats. It would be equally wrong to state that we must have the whole list without full and proper evaluation and discussion. However the AAIB in the Manchester B737 report (reference 5) does strongly support this broad based approach and in the 31 safety recommendations does refer specifically to about half of these topics and give considerable emphasis to (i), (ii), (v) and (xiv).

The use of past accidents that I see as most beneficial is therefore not only to support or shed doubt on the need for a particular safety feature but also, and more importantly, to establish the conditions under which the various safety features are most likely to have to work. Only with this information can they be designed properly to give maximum benefit to the passengers.

Considering just a few of the topics listed I would like to look at some of the questions that we should try to answer (and which I had originally hoped to answer in this paper).

<u>External camera(s) and cockpit monitor</u>

This system is of great value in flight as well as on the ground so the questions are more varied than with some other systems.

Do we need to view the whole of the aircraft or are some areas so trouble free that we can ignore them? Will a top of fin camera looking forward and an undernose camera looking backwards cover enough with sufficient detail to be of value? In other words what failures etc are we hoping to show the crew? Do we need to keep recording after landing/engine shut down? If so we need a much longer tape than the 30 minutes currently in use in cockpit voice recorders, and even without this requirement should we cover the whole flight, maybe well over 12 hours in some cases?

Cabin water mist systems

What degree of damage to the fuselage should we expect the system to tolerate and still provide protection? An answer to this may be found in reference 6 (taken from reference 13), this was that up to 1978 roughly half the fire deaths had occurred in accidents where there was little or no damage to the fuselage (the Manchester B737 was of course like this), the rest principally in those where there were one or two breaks in the fuselage. The recent accident to a B737 at Kegworth (reference 14) perhaps typifies this kind of accident, the fuselage ended up in three pieces one of which was upside down, and there was a considerable quantity of spilled fuel (but on this occasion no fire). Of the 126 on board 47 died and only 5 escaped serious injury. Had the fuel ignited it would have threatened all 3 pieces of fuselage and those trapped and injured inside. The record needs to be examined to see if this represents a realistic worst case, initially it is suggested that excellent reports such as references 15 and 16 should be reexamined with this question in mind, including whether systems should work upside down!

It was also noted at Kegworth that not only the overhead bins but also most of the ceiling panels had failed; that is they had fallen, probably with some considerable force, onto the passengers. While the design of any protection system must tolerate some degree of trim failure the regular and frequent occurrence of overhead bins coming open or failing altogether, even sometimes with a heavy landing, is surely not acceptable. We must consider the degree of improvement necessary.

The Civil Aviation Authority, CAA, in its discussion document, reference 17, poses many other relevant questions regarding this system including reference to use in flight. Aircraft electrical systems already have to cope with spills, condensation and pressure changes that can force water into any nook or cranny, would a water mist be much worse? I personally doubt it but tests are needed.

Passenger smokehoods

Although early proposals following the Manchester B737 accident concentrated on use when threatened by a ground fire discussion quickly moved on to use following the start of an in-flight fire within the cabin or underfloor volume. Current proposals and the CAA's specification relating to passenger smokehoods call for protection against both ground and inflight fires. However one should continually reassess the comparative risks to ensure that the best compromise is reached, for example concerning the duration of protection required.

One crucial question that a detailed study of past accidents might answer is:- In what proportion of accidents has flash over actually occurred?

Flash over would seem unlikely to occur if, as with a Kegworth type accident, the fuselage is broken open during the initial impact and is thus fully vented. It did not occur in the initially intact fuselage of the B737 at Manchester, probably because of the rapid tail collapse and burn through of the roof near the point of collapse which also allowed smoke and hot gases to escape. Thus flash over might not in practice be the threat sometimes assumed in the past. Reference 5 argues this case convincingly.

The accident record does help with this, see reference 8 for evidence compiled by an aviation pathologist, but I believe that further experimental work with a normal, non-fire hardened fuselage, at for example Atlantic City, is needed to provide additional information concerning conditions in a cabin with roof burn through or intentional roof venting. This would of course be of relevance to many other possible safety measures as well.

Other questions relate to access and donning of smokehoods, the answers to which might help us assess whether any delay caused by the action of getting a smokehood out is likely to be of significance to the survival rate. So how rapidly have fires invaded the cabin?, how many people have evacuated before smoke has reached them, how many have been brought to a virtual standstill by a blockage in front of them? Note that while a blockage might be aggravated by people reaching for smokehoods that they in fact didn't need the people at the back of the queue are the ones who may die without a smokehood but who may survive almost indefinitely with a smokehood providing flash over does not occur.

Again while the accident record may provide some answers further evacuation testing in realistic conditions would also be invaluable.

In more severe accidents what proportion of the trapped and/or injured passengers would have been able to reach and don their smokehoods? This question may well be asked during the Kegworth investigation and some evidence from past accidents may also be available. It is likely that a considerable number of people in such an accident involving post impact fire would, though trapped or incapacitated, be able to don a smokehood which might keep them alive until the fire service arrived. It is also likely that some would be unconscious or otherwise incapable of doing anything for themselves and for them a water mist system, if it still worked to at least some extent, might be the only answer. Perhaps accidents of this nature make the case better than any other for a belt and braces approach.

THE PHILOSOPHY OF CRASHWORTHINESS

Justification for dealing with crashworthiness and survival rather than with preventing accidents is not needed at a meeting such as this, however I should like to include a few thoughts on the subject.

Crashworthiness, in one sense, is still a second line of defence but because of the diverse nature of causal factors it should be and usually is now treated as being of equal importance to conventional airworthiness, i.e. as a first line of defence. Certainly accident investigators are now heeding the ICAO Manual's instruction (reference 18) to give equal weight to crashworthiness and survival as opposed to cause.

It may be argued that as the chances of having an accident are small the level of passenger protection required need not be of a particularly high standard to still give a valuable safety improvement. A result of this approach is that it can lead to playing the numbers game. For in the current climate of safety assessment and acceptable accident rates one could find the absurd situation where the provision of say smokehoods to only half the passengers, or 16g seats for those in the rear cabin, could be just enough theoretically to move a particular and crucial failure condition from 'catastrophic', involving multiple deaths, down to 'hazardous', involving the death of a small number of occupants. Providing we do avoid the absurd there may nevertheless be merit in such a combined approach if it prevents us from seeking an unrealistically high level of protection.

An equivalent approach has I believe been used in protecting fuel tanks from engine debris. It may be argued that dangerous engine failures are rare but not rare enough to ignore. At the same time total, guaranteed shielding of all vulnerable parts is impracticable but ensuring that high velocity debris is likely to penetrate the fuel tanks (or other vital parts) only once in ten failures, or once in fifty, might be enough to meet the required and agreed standards.

A conclusion of this approach is that quite small improvements in cabin safety may indeed be worthwhile, even cost effective, to the manufacturer as well as to the passenger.

The submission that in the present remarkably safe climate of civil aviation the spending of a larger proportion of our safety money on crashworthiness and survivability is cost effective stems from the fact that there may be hundreds of different and largely unrelated reasons why an aircraft ends up in a smoking heap in the undershoot, on the runway, or in the overrun area. To prevent even a small proportion of these would cost a great deal: to concentrate on the smoking heap benefits all of them.

Only a month before the Manchester accident a NASA CV-990 rejected its take off at March Air Force Base California (reference 19); debris punctured the fuel tank; the spilled fuel caught fire before the aircraft came to rest; the fire burned through the fuselage skin; the rear fuselage collapsed onto the runway; the fire service couldn't deal with the interior fire; etc.etc. Very similar statements could be made for accidents all round the world, only the initial causes have differed. With the CV-990 it was wheel debris that punctured the fuel tank and not an engine combustion can as at Manchester; also, perhaps because there were only 19 on board, all escaped without injury.

It is worth noting that this accident does not appear in the usual lists because it was not a normal civil operation. This may partially detract from its relevance but not entirely.

One of the key factors used in the early and mid seventies to justify more effort being put into survival was the lack of any improvement in the survival rate in survivable accidents (e.g. in reference 1). Since then, despite an apparent improvement between 1977 and 1982, the situation does not appear to have changed. Reference 20 states that 'When the statistics for survivable accidents and fatal survivable accidents (90% of all accidents are survivable by some or all of the crew) are examined, it can be observed that although there is greater variability (from year to year) the percentage of fatalities for the last few years was similar to the percentage in the early sixties.'

It is of course hoped that the improvements that have been introduced over the past few years will before long be reflected by improvements in the survival record and that we have not just been running hard in order to stand still. The record to date however suggests that we must keep on running hard!

ANALYSIS

The format first presented in reference 4 and showing, for any chosen group of accidents, the overall percentage killed and the percentages due to impact and to fire has continued to be most useful and is used again here. The principal advantage of the chosen tabular presentation of the data is that it allows many different cross checks to be made, initially for spotting errors and then for unexpected trends, correlations (in a loose sense) and often to generate new ideas.

For this paper the Tables illustrate typical data output from the Cranfield program but since the number of accidents in recent years where as yet we do not know the breakdown of deaths due to impact and fire is large, I am limiting the figures to some simple comparisons. These show the total fatality rate and the proportions due to impact and to fire. In order to compare the rate due to fire more readily this is repeated alone in the form of those killed as a result of the fire as a proportion of those who have survived the impact. In each case the number above each column is the number of accidents in that group, adjusted where necessary to compensate for lack of detailed information.

The means of adjustment is similar to that used in reference 4 from which I quote 'In order to evaluate and present figures for the proportions killed by impact or by fire it has been necessary to make allowance for those accidents where the cause of death is not known. If for example there were 10 fatal and 10 non fatal accidents in a particular group and the cause of death was known in 8 of the 10 fatal accidents then it is considered acceptable to combine, in effect, 8 of the 10 non fatal accidents with these to provide 16 relevant accidents in all, not 18. If the same technique is used on all the numbers involved it is believed that the resulting 'adjusted totals' may be used for statistical purposes with a high degree of confidence.' A small change has been made to this technique which I leave the interested reader to fathom out.

Another useful factor that was incorporated into our tables around 1978 is the use of two 'percentages' for each set of figures. When these are similar one need look no further, and I have in the past normally used the lower of the two which is obtained directly from the 'sums'. The upper percentage is the average of the individual percentages, if the two differ by more than say 5 or 6% then it is worth finding out why. The most likely reasons are that in a small sample one accident involving a large number of people, whether fatalities or survivors, may dominate the lower percentage but not necessarily the upper. Conversely a single high fatality rate accident involving only a handful of people may dominate the upper but not the lower. For this report I have continued to use the lower value as being the more straightforward but this is under review.

A recent addition has been the presentation of the 'mean accident' under each heading, for example for jet aircraft with more than 60 seats and an overall load factor greater than 20% the 'mean fatal accident' involving no impact deaths was as follows:

> 44 killed from 132 aboard in an aircraft capable of carrying 197 people including crew.

This, one can see at a glance, is in no way unusual or unlikely.

Figure 1 considers the complete list of accidents over the period 1955 to 1989 from which it can be seen that there has been no consistent improvement in the survival record. A five year moving average has been used in an attempt to smooth out the effects of particularly good and bad years, however it can be seen that the good period around 1982 and the bad period around 1985 still stand out. To see what is happening since 1985 a further period of only just over three years has been included which encouragingly suggests a return to 'normal' for total fatalities and, on evidence from only a small proportion of the fatal accidents, a continued and welcome reduction in the proportion of deaths due to fire. In fact due to the large number of 'unknowns' the relative importance of impact and fire cannot yet be reliably assessed for any period after that centred on 1981, though the similarities for different groups discussed below suggest that the accidents for which figures are available are reasonably representative of the whole.

A cruder but probably better comparison is shown in Figure 2. This compares all the listed accidents for the two periods 1955 to 1975 and 1976 to 1989 (obviously incomplete'). The number of accidents in each period is virtually the same and so is the break down between impact and fire.

In reference 4 a significant difference was noted between jets and turboprops with respect to the proportion killed by impact. The higher proportion for turboprops has continued as can be seen in Figure 2, the proportion killed by fire remaining unchanged.

Earlier in the paper it was argued that when looking at survival aspects one need not eliminate crew training and cargo flights from a study primarily looking at passenger safety. The principal reason for keeping them in is perhaps that if a high proportion of the crew die or suffer severe injury it is often fairly certain that had there been passengers then they too would have suffered and hence there should be a great deal to be learned from these accidents of relevance to passenger safety.

To see whether limiting the jet sample to passenger carrying flights and excluding small jets made any significant difference to the proportions killed, figure 3 was plotted. The comparison of all jets with those with more than 60 seats and with these restricted further to an overall load factor of over 20% shows remarkably little variation. Also, since turboprops, particularly the larger ones, have increasingly been used for cargo flights these have been looked at with a load factor of over 20%. Although not shown on the figure the average overall seating capacity of the turboprop aircraft involved fell, both with the more recent time period and with the limitation to only passenger flights, however the proportions killed remain remarkably similar.

Figure 4 looks at the widebody jets, defined here by having a seating capacity of over 300. In the pre 1976 period there were only two relevant fatal accidents (Nairobi B747 and Everglades Tristar) and in the latter period there have been some particularly bad ones (the Tenerife B747 collision and the marginally survivable JAL B747) thus the two periods are markedly different with a relatively small sample in each. However the combination of the two periods puts the widebody record almost exactly the same as the overall jet record! Restricting the accidents to those with a load factor of over 20% merely eliminates three non fatal accidents and only slightly changes the proportions.

For jets with fewer than 20 seats, the overall picture is very like the other, larger, jets. This again is perhaps rather surprising.

CONCLUSIONS

The accompanying list of accidents involving fire and/or spilled fuel represents Cranfield's first step towards bringing the survival record up to date and no doubt some interesting differences will emerge when analysis has been completed. However there is no doubt that many accidents have occurred during the last 10 to 15 years that are replicas of those occurring during the first 20 to 25 years of turbine operations and these have been studied and reported on in considerable detail by a number of authors.

It is unlikely that recent and future trends will differ greatly from the past and there is no guarantee that any new trend will continue unless there is a clearly defined underlining cause. We should therefore make the best possible use of the data and analyses already available to us and thus ensure that by putting the more detailed or single subject contributions made at this symposium into the context of real accidents we get maximum benefit from them.

ACKNOWLEDGEMENT

I am deeply indebted to my colleague Ralph Anker for his perseverance in bringing our basic list of survivable accidents up to date and for getting our analysis program working again with some significant improvements of his own. We can now concentrate on keeping up to date, reducing the number of unknowns and correcting the errors that no doubt still exist.

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19.	Batthauer,B.E. et al	'Aircraft accident report: NASA 712, Convair 990,N712NA, March Air Force Base, California, July 17,1985',1986, NASA TM-87356.
20.	Muir H.C. and Marrison,C	'Human Factors in Cabin Safety',1989, Royal Aeronautical Society 'Aerospace Vol.16 No.4'.

TABLE 1

All Aircraft Types - 1955-1975

	Dead / Aboard	Aboard / Seats	Impact / Aboard	Fire / Surv Imp
Impact only				
< 43 >	1194 / 2073	2073 / 4507	1194 / 2073	0 / 879
	28 / 48	48 / 105	28 / 48	0 / 20
	51%	52%	51%	0%
	58%	46%	58%	0%
Fire and Impact				
< 34 >	1711 / 2334	2334 / 4328	785 / 2334	926 / 1549
	50 / 69	69 / 127	23 / 69	27 / 46
	76%	55%	35%	64%
	73%	54%	34%	60%
Fire Only				
< 27 >	879 / 1824	1824 / 3210	0 / 1824	879 / 1824
	33 / 68	68 / 119	0 / 68	33 / 68
	59%	55%	0%	59%
	48%	57%	0%	48%
Unknown				
< 8 >	170 / 348	348 / 827	? / 348	? / ?
	21 / 43	43 / 103	? / 43	? / ?
	54%	43%		
	49%	42%		
Non-Fatal				
< 166 >	0 / 9430	9430 /22681	0 / 9430	0 / 9430
	0 / 57	/ 137	0 / 57	0 / 57
	0%	41%	0%	0%
	0%	42%	0%	0%
Total				
< 278 >	3954 /16009	16009 /35553	? /16009	? / ?
	14 / 58	58 / 128	? / 58	? / ?
	25%	46%		
	25%	45%		
Adjusted Figures				
< 266 >	3784 /15320	15320 /34024	1979 /15320	1805 / 13341
	14 / 58	58 / 128	7 / 58	7 / 51
	25%	46%		
	25%	45%	13%	14%

TABLE 2

All Aircraft Types - 1976-1989

	Dead / Aboard	Aboard / Seats	Impact / Aboard	Fire / Surv Imp
Impact only				
< 24 >	938 / 2017	2017 / 2668	938 / 2017	0 / 1079
	39 / 84	84 / 111	39 / 84	0 / 45
	44%	67%	44%	0%
	44%	67%	44%	0%
Fire and Impact				
< 13 >	1139 / 1408	1408 / 2832	527 / 1408	612 / 881
	88 / 108	108 / 218	41 / 108	47 / 67
	78%	51%	40%	61%
	81%	50%	37%	70%
Fire Only				
< 15 >	527 / 2090	2090 / 2925	0 / 2090	527 / 2090
	35 / 139	139 / 195	0 / 139	35 / 139
	30%	68%	0%	30%
	25%	72%	0%	25%
Unknown				
< 76 >	1570 / 2998	2998 / 5799	? / 2998	? / ?
	21 / 39	39 / 76	? / 39	? / ?
	50%	53%		
	52%	52%		
Non-Fatal				
< 134 >	0 / 7001	7001 /15038	0 / 7001	0 / 7001
	0 / 52	52 / 112	0 / 52	0 / 52
	0%	46%	0%	0%
	0%	47%	0%	0%
Total				
< 262 >	4174 /15514	15514 /29762	? /15514	? / ?
	16 / 59	59 / 112	? / 59	? / ?
	24%	52%		
	27%	53%		
Adjusted Figures				
< 163 >	2604 / 9678	9678 /18255	1465 / 9678	1139 / 8213
	16 / 59	59 / 112	9 / 59	7 / 50
	24%	52%		
	27%	53%	15%	14%

TABLE 3

Jet Aircraft with more than 60 seats - Load Factor > 20% - 1955-1975

	Dead / Aboard	Aboard / Seats	Impact / Aboard	Fire / Surv Imp
Impact only				
< 13 >	699 / 1222	1222 / 2216	699 / 1222	0 / 523
	54 / 94	94 / 170	54 / 94	0 / 40
	53%	57%	53%	0%
	57%	55%	57%	0%
Fire and Impact				
< 20 >	1230 / 1716	1716 / 3201	444 / 1716	786 / 1272
	61 / 86	86 / 160	22 / 86	39 / 64
	74%	59%	26%	66%
	72%	54%	26%	62%
Fire Only				
< 15 >	677 / 1500	1500 / 2465	0 / 1500	677 / 1500
	45 / 100	100 / 164	0 / 100	45 / 100
	45%	64%	0%	45%
	45%	64%	0%	45%
Unknown				
< 4 >	147 / 303	303 / 482	? / 303	? / ?
	37 / 76	76 / 120	? / 76	? / ?
	51%	67%		
	49%	63%		
Non-Fatal				
< 71 >	0 / 7899	7899 /14034	0 / 7899	0 / 7899
	0 / 111	111 / 198	0 / 111	0 / 111
	0%	59%	0%	0%
	0%	56%	0%	0%
Total				
< 123 >	2753 /12640	12640 /22398	? /12640	? / ?
	22 / 103	103 / 182	? / 103	? / ?
	25%	60%		
	22%	56%		
Adjusted Figures				
< 116 >	2606 /11965	11965 /21202	1143 /11965	1463 /10822
	22 / 103	103 / 182	10 / 103	13 / 93
	25%	60%		
	22%	56%	10%	14%

TABLE 4

Jet Aircraft with more than 60 seats Load Factor > 20% - 1976-1989

	Dead / Aboard	Aboard / Seats	Impact / Aboard	Fire / Surv Imp
Impact only				
< 11 >	864 / 1844	1844 / 2333	864 / 1844	0 / 980
	79 / 168	168 / 212	79 / 168	0 / 89
	40%	77%	40%	0%
	47%	79%	47%	0%
Fire and Impact				
< 9 >	1000 / 1260	1260 / 2456	457 / 1260	543 / 803
	111 / 140	140 / 273	51 / 140	60 / 89
	73%	53%	37%	55%
	79%	51%	36%	68%
Fire Only				
< 12 >	513 / 2064	2064 / 2866	0 / 2064	513 / 2064
	43 / 172	172 / 739	0 / 172	43 / 172
	23%	75%	0%	23%
	25%	72%	0%	25%
Unknown				
< 25 >	1220 / 2329	2329 / 3614	? / 2329	? / ?
	49 / 93	93 / 145	? / 93	? / ?
	50%	68%		
	52%	64%		
Non-Fatal				
< 49 >	0 / 6048	6048 / 9026	0 / 6048	0 / 6048
	0 / 123	123 / 184	0 / 123	0 / 123
	0%	69%	0%	0%
	0%	67%	0%	0%
Total				
< 106 >	3597 /13545	13545 /20295	? /13545	? / ?
	34 / 128	128 / 191	? / 128	? / ?
	25%	69%		
	27%	67%		
Adjusted Figures				
< 70 >	2377 / 8950	8950 /13411	1321 / 8950	1056 / 7629
	34 / 128	128 / 191	19 / 128	15 / 109
	75%	69%		
	77%	67%	15%	14%

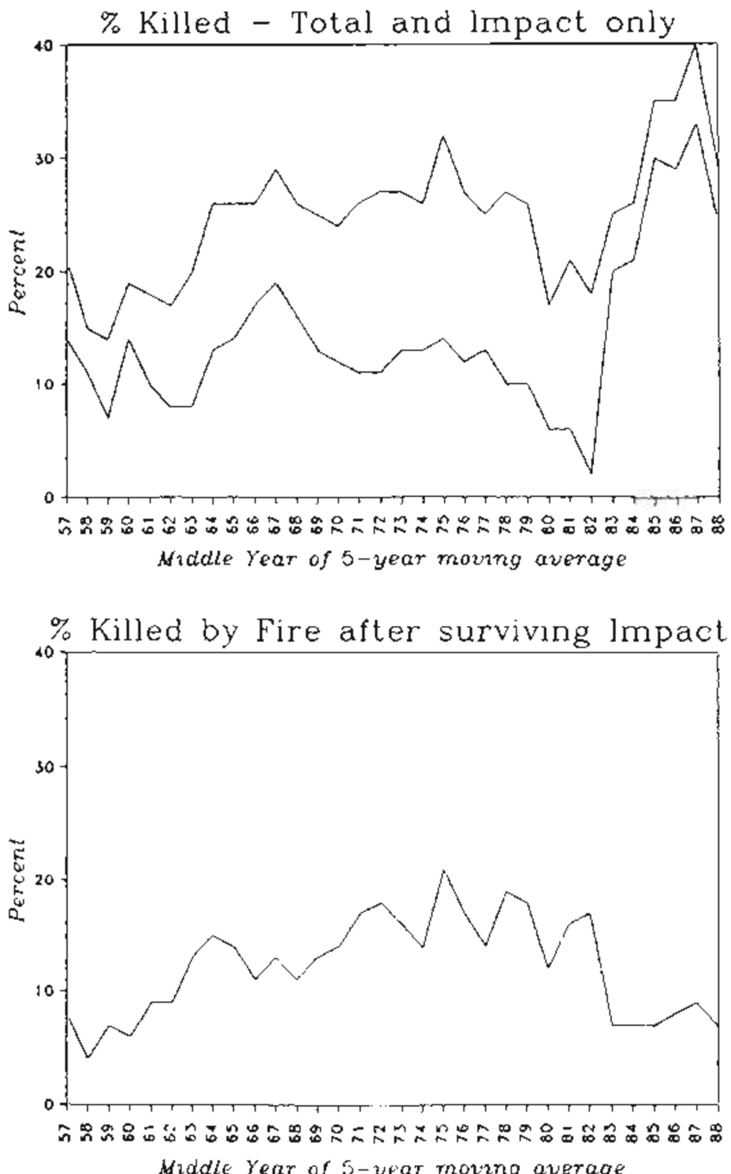

Figure 1

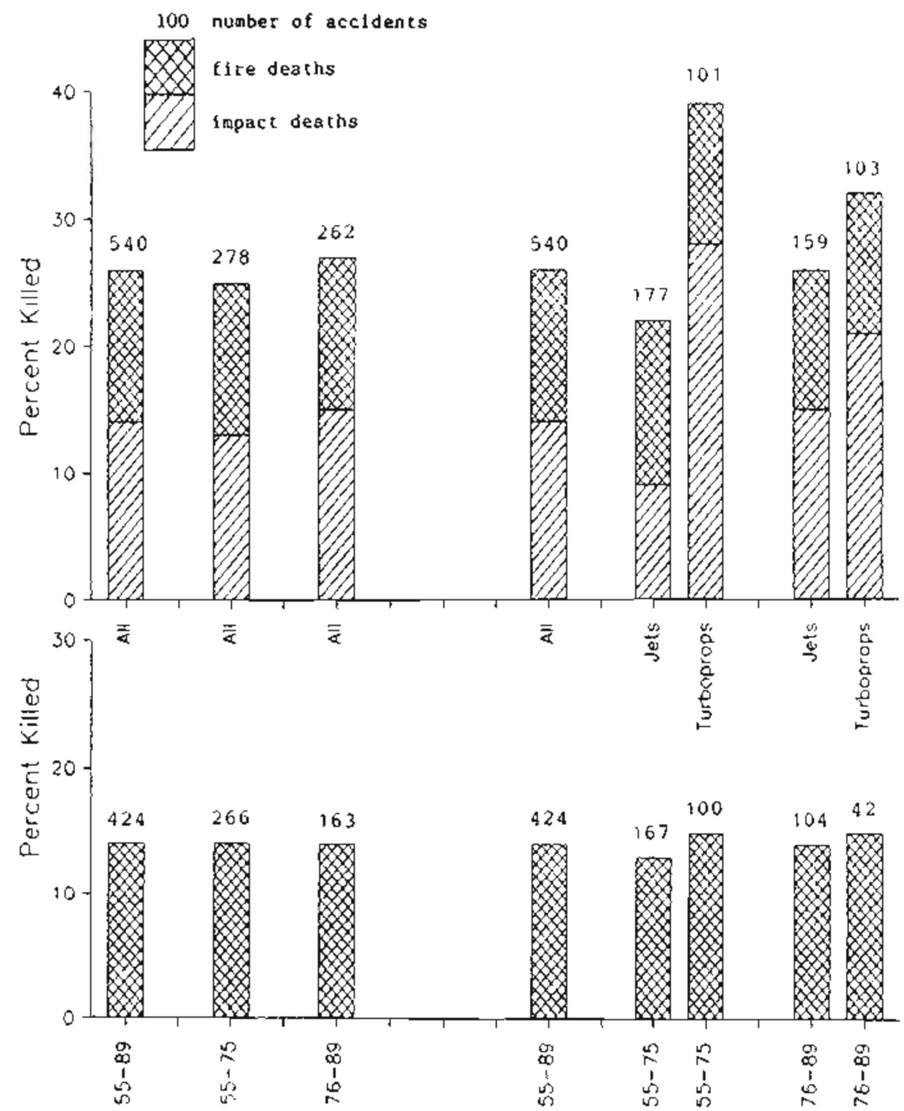

Figure 2

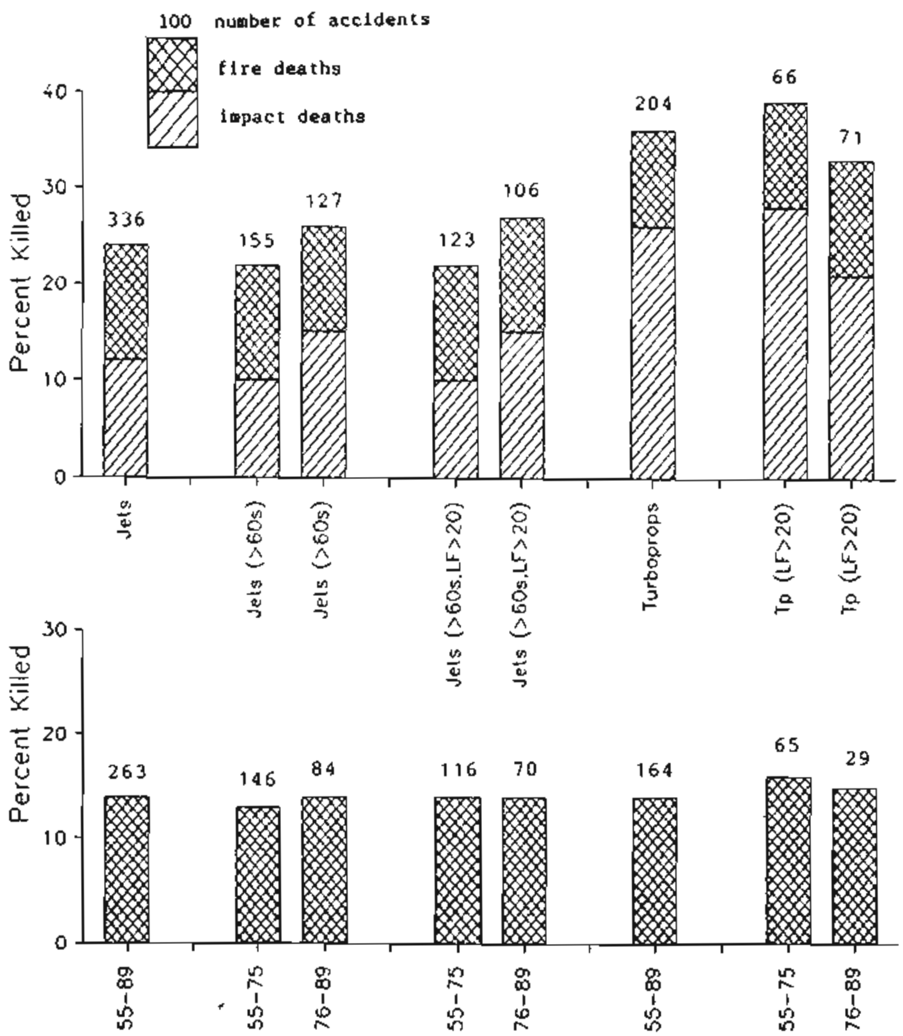

Figure 3

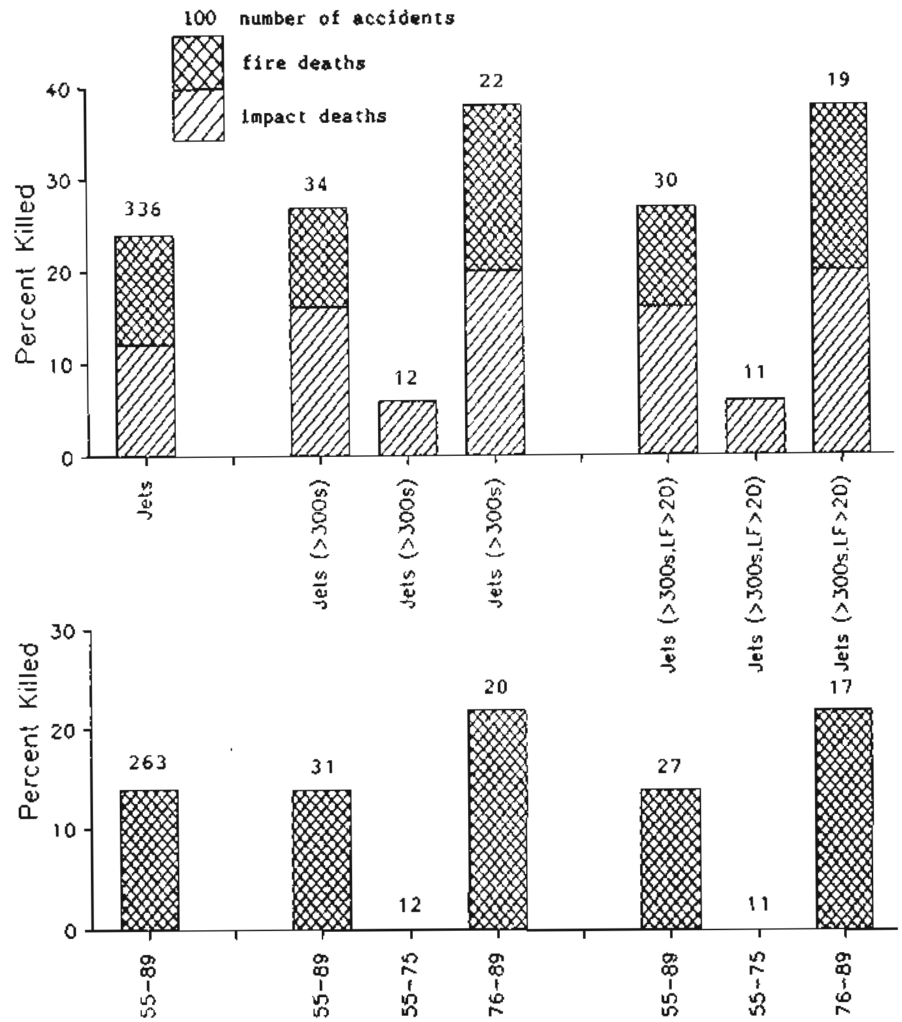

Figure 4

The following lists cover the accidents currently thought to be relevant to any study of aircraft cabin fire protection. It therefore includes all accidents where

a) there was a post impact fire.

b) there was fuel spilled on impact, whether or not it caught fire.

c) some but not all on board died as a result of the impact

d) there was an inflight fire but the aircraft landed (or crash landed) with at least some on board still alive.

This is essentially a list of impact survivable accidents (i.e. accidents where at least one person has survived the impact or is still alive after the aircraft has stopped) but excluding the more trivial non fatal accidents where no fuel was spilled and there was no fire.

The vast majority of accidents are relatively easy to assess for inclusion but inevitably some have been wrongly included or excluded, we would appreciate comments, with appropriate evidence, to help us to improve our data base.

The first three sub-lists are of fatal accidents where the cause of death is either known with a reasonable degree of certainty or has been estimated from reliable information. These are accidents with deaths believed to be:-

a) only by impact trauma

b) some by impact and some by the effects of fire

c) only by fire.

Such differences as there are between different sources are principally in list b), however these differences are mainly small and would not significantly alter the overall picture. Nevertheless firm evidence of errors in the figures presented would be appreciated.

List d) contains the fatal but survivable accidents where cause of death has not yet been learned. Evidence will exist somewhere for perhaps the majority of these so we would very much appreciate any relevant information.

The last list is of non fatal accidents, since the number of these included is all important to any study, comments concerning these are equally welcome.

LIST a) Deaths by impact

DATE	ACTYPE	PFAT	PTOT
31/10/54	Viscount	3 /	8
24/12/58	Brittania	9 /	12
14/08/59	Viscount	2 /	3
27/08/59	Comet 4	2 /	50
26/09/60	Viscount	31 /	37
03/06/62	B707	130 /	132
20/08/62	DC8	15 /	105
12/12/65	Learjet	1 /	9
04/07/66	DC8	2 /	5
28/02/67	F27	12 /	19
19/04/67	Brittania	126 /	130
05/09/67	IL-18	37 /	69
03/11/67	Herald	21 /	25
06/11/67	B707	1 /	36
20/11/67	CV880	70 /	82
07/02/68	B707	1 /	57
20/04/68	B707	123 /	128
01/07/68	Jet Commander	1 /	8
10/08/68	FH227	35 /	37
25/10/68	FH227	32 /	42
24/12/68	Hercules	2 /	4
24/12/68	CV580	20 /	47
27/12/68	CV580	27 /	45
06/01/69	CV580	11 /	28
20/03/69	Viscount	3 /	4
12/09/69	B1-11	45 /	47
21/09/69	B727	27 /	118
05/01/70	CV880	5 /	10
05/01/70	CV880	5 /	10
25/01/70	F27	1 /	23
09/05/70	F27	1 /	33
20/07/70	HS125	1 /	2
26/09/70	F27	8 /	34
30/12/70	Caravelle	1 /	38
06/09/71	B1-11	22 /	121
03/03/72	FH227	15 /	48
14/06/72	DC8	86 /	89
29/12/72	L1011	99 /	176
22/07/73	B707	78 /	79
23/07/73	FH227	39 /	45
07/09/74	F27	28 /	36
30/08/75	F27	10 /	32
27/09/75	CL44	6 /	10
05/04/76	B727	1 /	50
12/12/76	DHC-6	4 /	10
21/11/77	B1-11	46 /	79
26/06/78	DC9	2 /	107
04/12/78	Learjet	5 /	7
04/12/78	DHC-6	2 /	22
16/12/78	F27	1 /	2
28/12/78	DC8	10 /	189
28/01/79	F27	5 /	6
12/02/79	Nord 262	2 /	25
30/05/79	DHC-6	17 /	18
17/06/79	DHC-6	1 /	10
23/12/79	F28	39 /	43
12/06/80	Swearingen	13 /	15
15/09/81	B747	1 /	378
31/10/81	DHC-6	1 /	22
22/06/82	B707	17 /	111
12/08/85	B747	520 /	524
13/03/86	EMB 110	3 /	9
08/05/87	CASA 212	2 /	6
16/08/87	DC9	154 /	155
15/11/87	DC9	28 /	82
23/11/87	Beech 1900	18 /	21
08/01/89	B737	46 /	126

LIST b) Deaths by impact and fire

DATE	ACTYPE	PFAT	PTOT	PIMP	PFIRE
09/08/58	Viscount	36 /	54	(28 :	8)
12/06/61	L188	20 /	36	(5 :	15)
11/07/61	DC8	17 /	122	(1 :	16)
23/09/61	F27	28 /	29	(15 :	13)
21/12/61	Comet 4	27 /	34	(6 :	21)
22/07/62	Brittania	27 /	40	(13 :	14)
20/05/65	B707	121 /	127	(13 :	108)
08/11/65	B727	58 /	62	(44 :	14)
04/03/66	DC8	64 /	72	(35 :	29)
22/04/66	L188	83 /	98	(71 :	12)
31/08/66	Brittania	98 /	117	(73 :	25)
05/03/67	DC8	51 /	90	(23 :	28)
05/01/69	B727	48 /	62	(7 :	41)
26/08/69	HS748	3 /	4	(2 :	1)
17/09/69	CV580	4 /	15	(2 :	2)
20/11/69	VC10	87 /	87	(12 :	75)
10/10/70	Hercules	3 /	3	(2 :	1)
07/06/71	CV580	28 /	31	(1 :	27)
18/04/72	VC10	43 /	107	(1 :	42)
30/05/72	DC9	4 /	4	(3 :	1)
29/06/72	HFB 320	7 /	8	(4 :	3)
28/11/72	DC8	62 /	76	(8 :	54)
08/12/72	B737	43 /	61	(16 :	27)
20/12/72	DC9	10 /	45	(1 :	9)
23/12/72	F28	39 /	45	(19 :	20)
19/02/73	TU-154	66 /	100	(15 :	51)
10/04/73	Vanguard	108 /	145	(103 :	5)
31/07/73	DC9	88 /	89	(44 :	44)
26/01/74	F28	66 /	73	(16 :	50)
30/01/74	B707	97 /	101	(1 :	96)
11/09/74	DC9	71 /	82	(34 :	37)
30/10/74	L188	32 /	34	(19 :	13)
20/11/74	B747	59 /	157	(48 :	11)
24/06/75	B727	113 /	124	(100 :	13)
27/04/76	B727	37 /	88	(2 :	35)
04/06/76	L188	45 /	45	(17 :	28)
27/03/77	B747	327 /	396	(135 :	192)
27/03/77	B747	248 /	248	(52 :	196)
04/04/77	DC9	62 /	85	(37 :	25)
27/09/77	DC8	34 /	78	(17 :	17)
11/02/78	B737	42 /	49	(19 :	23)
13/03/79	B727	44 /	64	(14 :	30)
29/03/79	F27	17 /	24	(14 :	3)
31/10/79	DC10	72 /	89	(67 :	5)
16/02/80	Brittania	7 /	8	(4 :	3)
21/01/85	L188	70 /	71	(35 :	35)
02/08/85	L1011	134 /	163	(114 :	20)

LIST c) Deaths by fire

DATE	ACTYPE	PFAT	PTOT
17/02/59	Viscount	14 /	24
19/01/61	DC8	4 /	106
08/12/63	B707	81 /	81
23/11/64	B707	50 /	73
11/11/65	B727	43 /	91
15/02/66	Caravelle	2 /	80
05/06/66	HS125	2 /	2
26/08/66	CV880	5 /	5
22/09/66	Viscount	24 /	24
16/02/67	L188	22 /	92
27/04/67	F27	19 /	19
11/07/67	Gulfstream	2 /	2
16/02/68	B727	21 /	63
08/04/68	B707	5 /	127
13/06/68	B707	6 /	63
24/06/69	CV880	3 /	5
05/07/70	DC8	109 /	109
27/11/70	DC8	47 /	229
28/12/70	B727	2 /	55
31/12/70	F27	7 /	36
23/05/71	TU-134	78 /	83
24/12/71	L188	91 /	92
22/01/73	B707	176 /	202
26/02/73	Learjet	7 /	7
02/11/73	Herald	6 /	16
01/01/74	F28	38 /	42
15/03/74	Caravelle	15 /	96
25/03/76	Jetstar	4 /	4
01/03/78	DC10	2 /	197
17/12/78	B737	1 /	132
02/08/79	Citation	1 /	3
07/10/79	DC8	14 /	154
27/02/80	B707	2 /	135
19/08/80	L1011	301 /	301
19/11/80	B747	15 /	226
13/09/82	DC10	50 /	393
02/06/83	DC9	23 /	46
22/08/85	B737	55 /	135
04/03/87	CASA 212	9 /	19
26/06/88	A320	3 /	136
31/08/88	B727	13 /	105
15/09/88	B737	34 /	104

LIST d) Cause of death unknown

DATE	ACTYPE	PFAT	PTOT
13/08/66	DC8	6 /	6
02/08/68	DC8	13 /	95
01/04/70	Caravelle	61 /	82
12/08/70	YS-11	14 /	31
05/12/71	Nord 262	2 /	3
21/01/72	DC9	1 /	5
31/05/73	B737	48 /	65
24/09/75	F28	25 /	61
20/01/76	HS748	34 /	42
04/11/76	F27	29 /	38
22/11/76	Hercules	5 /	6
04/03/77	DC8	2 /	4
29/03/77	DHC-6	15 /	23
03/04/77	Falcon	4 /	5
18/10/77	HS748	2 /	5
19/11/77	B727	124 /	163
17/10/78	Learjet	1 /	2
15/11/78	DC8	183 /	262
23/12/78	DC9	108 /	129
24/01/79	Nord 262	14 /	23
06/07/79	Learjet	2 /	3
23/07/79	B707	6 /	6
30/09/79	DHC-6	2 /	16
19/10/79	Merlin	2 /	3
19/11/79	Citation	2 /	3
03/03/80	Learjet	3 /	4
12/04/80	B727	55 /	58
27/04/80	HS748	44 /	53
01/08/80	DC8	3 /	7
19/12/80	Jet Commander	3 /	4
27/02/81	DHC-6	2 /	3
31/05/81	Falcon	3 /	6
27/07/81	DC9	32 /	66
02/09/81	EMB 110	21 /	22
21/02/82	DHC-6	1 /	12
20/03/82	F28	27 /	27
24/05/82	B737	2 /	118
11/07/82	HS748	1 /	30
29/09/82	IL-62	7 /	77
16/01/83	B727	47 /	67
11/03/83	DC9	23 /	50
16/04/83	HS748	8 /	9
29/04/83	Caravelle	8 /	102
02/06/83	F28	3 /	61
14/09/83	Trident	11 /	106
07/10/83	EMB 110	7 /	15
08/10/83	DHC-6	9 /	14
23/11/83	DHC-6	4 /	7
27/11/83	B747	181 /	192
28/11/83	F28	53 /	72
07/12/83	B727	51 /	93
17/12/83	DHC-6	2 /	10
24/01/84	CASA 212	6 /	9
21/07/84	DHC-6	1 /	14
30/08/84	B737	2 /	118
24/12/84	Learjet	1 /	3
20/04/85	F27	2 /	5
27/05/85	CV580	2 /	13
12/08/85	DHC-6	2 /	19
22/09/85	Learjet	1 /	6
20/03/86	CASA 212	2 /	16
10/06/86	F27	23 /	26
12/06/86	DHC-6	1 /	16
23/10/86	F27	13 /	54
03/01/87	B707	50 /	51
04/04/87	DC9	23 /	45
13/04/87	Beech 200	3 /	5
19/05/87	DHC-6	14 /	16
31/05/87	Citation	2 /	4
31/07/87	Learjet	2 /	3
04/08/87	B737	1 /	33
11/10/87	DHC-6	2 /	9
05/12/87	HS125	2 /	4
18/01/88	HS125-600	1 /	8
19/01/88	MetroIII	8 /	17
06/07/88	CL44	3 /	8
26/07/88	Learjet	1 /	2
16/09/88	B737	31 /	114
17/10/88	B707	32 /	52
18/10/88	HS125	1 /	8
19/10/88	B737	130 /	135
25/10/88	F28	12 /	69
03/02/89	F27	26 /	29
10/03/89	F28	24 /	69

LIST e) Non-fatal accidents

DATE	ACTYPE	PTOT
16/01/55	Viscount	30
20/01/56	Viscount	5
17/04/58	B707	4
28/04/58	Viscount	5
10/11/58	Viscount	2
09/04/59	Comet 4	73
03/10/59	Viscount	38
47/01/60	Viscount	59
20/03/60	Comet 4	6
09/05/60	B707	109
14/09/60	L188	76
29/10/60	B707	91
15/06/61	B707	103
27/07/61	B707	41
29/07/61	B707	52
16/09/61	DC8	133
05/11/61	B707	42
25/11/61	Viscount	45
25/04/62	Caravelle	72
27/04/62	Viscount	27
27/04/62	B707	53
08/07/62	Viscount	16
06/08/62	L188	72
01/01/63	CV880	64
03/07/63	Caravelle	70
02/08/63	Comet 4	96
09/09/63	Viscount	34
06/11/63	DC8	97
22/03/64	Comet 4	68
07/04/64	B707	145
04/06/64	Learjet	2
13/06/64	Viscount	44
25/06/64	F27	31
01/07/64	B707	12
26/08/64	B707	138
11/12/64	HS125	2
27/02/65	CV880	6
17/03/65	B727	97
17/03/65	F27	23
26/03/65	B707	170
27/03/65	L188	6
16/04/65	F27	2
16/05/65	B707	93
28/06/65	B707	153
04/07/65	Argosy	2
11/07/65	HS748	52
13/09/65	CV880	4
14/10/65	Argosy	3
13/02/66	B707	127
02/03/66	DC8	79
21/03/66	CL44	6
30/06/66	Trident	84
25/07/66	Learjet	6
30/10/66	Comet 4	41
02/12/66	B727	3
05/01/67	B707	3
19/01/67	Viscount	50
23/01/67	CV580	28
25/01/67	HS125	2
31/03/67	B707	5
25/04/67	CV580	57
27/04/67	Jetstar	2
03/05/67	Viscount	3
01/06/67	Hercules	5
23/06/67	Comet 4	83
26/06/67	Viscount	33
09/07/67	IL-18	102
09/09/67	B707	174
21/11/67	B707	52
04/12/67	Argosy	3
08/12/67	Viscount	18
11/12/67	Viscount	18
09/01/68	B707	49
25/01/68	VC10	120
21/03/68	B727	3
11/04/68	Hercules	4
28/04/68	DC8	4
04/05/68	Viscount	83
16/05/68	Hercules	6
07/08/68	B727	83
06/09/68	B707	55
19/11/68	B707	38
27/12/68	DC9	68
12/04/69	B1-11	90
01/05/69	CL44	4
01/07/69	B727	46
09/07/69	Caravelle	75
07/10/69	TU-134	53
16/10/69	DC8	5
15/11/69	DC8	4
27/11/69	HS748	28
03/12/69	B747	11
04/12/69	HS748	9
09/02/70	Comet 4	23
11/02/70	B707	7
18/04/70	DC8	65
25/04/70	Saberliner	3
15/05/70	Hercules	3
22/05/70	Jet Commander	2
08/06/70	Saberliner	2
09/06/70	B707	166
22/06/70	B707	68
19/07/70	B737	61
18/08/70	TU-124	20
24/08/70	L188	3
15/09/70	DC8	156
18/09/70	B747	132
18/09/70	B747	132
09/11/70	DHC-6	6
30/11/70	B707	3
16/12/70	B727	91
23/12/70	CV580	33
13/01/71	Gulfstream	6
23/01/71	B707	5
18/03/71	Hercules	4
05/07/71	Falcon	2
21/07/71	B707	113
30/07/71	B747	218
23/11/71	F27	2
28/01/72	Viscount	2
16/02/72	CV580	3
18/02/72	B747	271
28/02/72	Falcon	2
19/03/72	L188	3
18/05/72	DC9	10
13/08/72	B707	186
13/08/72	Saberliner	7
01/09/72	B747	335
20/09/72	Viscount	45
24/09/72	DC8	122
26/09/72	L188	25
12/12/72	B707	3
12/12/72	HS125	7
20/01/73	B707	72
05/03/73	B707	3
24/04/73	DC8	3
01/05/73	HS748	20
16/06/73	B707	86
21/06/73	DC8	261
23/06/73	DC8	128
08/08/73	B727	81
28/10/73	B737	96
27/11/73	DC9	77
04/12/73	B1-11	74

LIST e) (concluded)

17/12/73	DC10	167
17/12/73	DC9	89
20/12/73	B707	109
23/12/73	Caravelle	48
16/01/74	B707	63
08/02/74	DC8	162
06/03/74	F27	27
19/05/74	Argosy	5
28/05/74	F27	40
23/11/74	DC9	50
11/12/74	L188	3
22/12/74	CL44	5
01/05/75	L188	3
12/06/75	B747	394
14/06/75	Saberliner	6
25/07/75	B707	5
15/09/75	Trident	117
27/09/75	Falcon	3
08/11/75	B747	315
12/11/75	DC10	139
20/11/75	HS125	8
28/12/75	DC9	34
18/02/76	B727	120
23/02/76	Hercules	6
12/03/76	L188	3
18/03/76	DC8	29
22/04/76	B707	4
07/06/76	DC10	139
12/11/76	Saberliner	3
16/11/76	DC9	86
16/12/76	CV880	2
27/12/76	B727	141
04/01/77	B1-11	42
24/01/77	DC8	5
02/03/77	B707	60
17/03/77	B707	5
26/05/77	Learjet	2
03/06/77	B727	92
30/09/77	Brittania	6
03/10/77	DC8	259
26/10/77	DC10	244
01/12/77	DHC-6	16
15/02/78	B707	196
16/02/78	B707	196
03/03/78	DC8	222
30/03/78	Learjet	5
02/04/78	B737	44
04/04/78	B737	3
04/04/78	CV880	148
25/07/78	CV580	43
03/08/78	B707	63
24/08/78	B737	105
24/10/78	Learjet	2
05/11/78	Learjet	10
28/12/78	B747	309
05/01/79	L188	15
09/02/79	DC9	5
12/03/79	Caravelle	41
26/04/79	B737	67
14/06/79	Concorde	90
30/06/79	TU-154	70
15/07/79	HS748	2
20/07/79	Caravelle	57
26/08/79	F28	10
18/11/79	F27	2
02/12/79	Learjet	6
27/12/79	B747	3
23/01/80	F27	18
26/03/80	Learjet	3
29/03/80	Jetstar	9
02/05/80	DC9	6
13/05/80	Swearingen	11
09/06/80	Caravelle	4
17/07/80	Viscount	62
23/07/80	Jetstar	3
28/07/80	DHC-6	5
16/09/80	DC10	237
13/10/80	B707	10
04/11/80	B737	134
21/11/80	B727	73
20/12/80	B707	4
29/12/80	DC8	238
31/01/81	B727	121
17/02/81	B737	111
29/03/81	Jetstar	9
05/06/81	F27	3
16/06/81	HS748	28
10/12/81	HS125	10
29/12/81	HS748	18
17/03/82	A300	128
16/05/82	DHC-6	8
24/05/82	EMB 110	4
26/08/82	B737	138
17/09/82	DC8	124
17/10/82	B707	182
12/11/82	Metro	15
06/12/82	Learjet	4
06/02/83	Citation	3
07/02/83	Caravelle	89
15/02/83	DHC-6	8
11/03/83	YS-11	53
27/03/83	B737	110
20/04/83	DHC-6	12
29/06/83	HS125	2
02/07/83	Caravelle	89
16/07/83	Gulfstream	2
18/12/83	A300	247
23/12/83	DC10	3
09/02/84	B737	142
22/02/84	Merlin	2
10/03/84	DC8	23
22/03/84	B737	119
11/06/84	DC9	5
20/07/84	Saberliner	6
04/09/84	DHC-5	3
30/12/84	DC9	75
31/01/85	Metro	3
04/02/85	DC9	50
07/02/85	Challenger	12
03/05/85	Merlin	2
17/07/85	CV880	19
04/08/85	EMB 110	16
12/08/85	Beech 200	2
30/11/85	L188	45
02/12/85	B747	273
28/01/86	B737	72
31/01/86	Shorts 360	36
21/02/86	DC9	23
10/03/86	F27	45
08/06/86	Hercules	5
22/06/86	DHC-6	20
06/08/86	Learjet	3
29/09/86	A300	195
02/01/87	F28	70
06/01/87	Caravelle	27
10/01/87	DC10	9
18/01/87	F27	3
13/06/87	DHC-6	9
23/06/87	Beech 200	1
24/06/87	Beech 200	2
24/09/87	Merlin	3
28/10/87	CV580	2
27/12/87	DC9	100
15/01/88	Falcon	2
29/01/88	Vanguard	4
29/01/88	Vanguard	4
02/02/88	Beech 200	3
25/03/88	Jetstream	2
15/04/88	DHC-8	40
23/05/88	B727	28
24/05/88	EMB 110	8
16/06/88	Viscount	48
17/06/88	DHC-6	16
17/06/88	ATR 42	3
10/07/88	F27	43
26/09/88	B737	62