Safety Regulation Group

CAP 681

Global Fatal Accident Review 1980-1996

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Civil Aviation Authority

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March 1998

ISBN 0 86039 727 0

First published March 1998
Reprinted September 1998
Reprinted May 2002 (incorporating new house style cover)

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EXECUTIVE SUMMARY

This document summarises an analysis of 621 global fatal accidents to jet and turboprop aeroplanes above 5,700kg between 1980 and 1996 inclusive, which resulted in 16,849 fatalities. It is believed that the study has been successful in highlighting the most important causal and circumstantial factors, and should help to focus attention on necessary changes in operating and training practices and indicate areas for regulatory action. The main conclusions were:

- North American and European operators have achieved the lowest fatal accident rates over the period 1980 - 1996, with 0.37 and 0.52 fatal accidents per million flights respectively. JAA full member operators achieved a rate of 0.35 fatal accidents per million flights compared with 0.37 for US operators.
- JAA full member operators achieved a fatal accident rate for Western-built jets which was eight times lower than that for operators from the rest of Europe.
- Ignoring accidents to Eastern-built aircraft and operators from the Commonwealth of Independent States (CIS):-

  Over the period 1980 - 1996, the annual number of fatal accidents has increased by 32% (best fit line), mainly attributable to an increase in world traffic.

  If this growth in fatal accidents continued, by the year 2010 there would be an annual average of 44 fatal accidents.

  However, over the period 1990 - 1996 the trend has been decreasing.
- Half of the 621 fatal accidents occurred during the approach and landing phases of flight.
- The fatal accident rates for African and South/Central American operators were considerably higher than those for operators from other world regions.
- The most frequently identified causal factor was “Lack of positional awareness in air” which occurred in 41% of all fatal accidents.
- “Design shortcomings” and “Post crash fire” were each causal factors in 10% of all fatal accidents.
- Nearly 40% of all fatal accidents involved aircraft which had not been fitted with currently available safety equipment such as GPWS or enhanced GPWS.
- The most frequently identified consequences were “Collision with terrain/water/obstacle” and “Controlled Flight Into Terrain”, followed by “Loss of control in flight”.
- Of the 589 fatal accidents with sufficient information, 447 (76%) involved a *crew* primary causal factor and in 517 accidents (88%) *crew* was identified as a causal factor.
- Of the 589 fatal accidents with sufficient information, 63 (11%) involved an *aircraft* primary causal factor and in 233 accidents (40%) the *aircraft* was identified as a causal factor.
- The fatal accident rate for freight, ferry and positioning flights was estimated to be eight times higher than that for passenger flights.

The fatal accident database is to be updated annually and will be used for more detailed analysis work in the future.

CONTENTS

GLOBAL FATAL ACCIDENT REVIEW 1980 -1996

1 INTRODUCTION

The CAA regulates civil aviation activity in the UK with the aim of maintaining, or where possible, improving safety standards. It also has an interest in the risks posed worldwide. Important safety lessons can be learnt from this worldwide hazard experience so that safety improvement strategies can be developed.

A group of experts was set up by the CAA to systematically review global fatal accidents in order to identify the foremost worldwide aviation risks. This group was called the Accident Analysis Group (AAG).

2 OBJECTIVES OF THE ACCIDENT ANALYSIS STUDY

It is important that a regulator influences others and makes policy decisions from an informed position. The primary aim of the analysis was to systematically extract safety related information from past accidents so that strategies are developed to reduce the worldwide fatal accident rate in the future.

The results of the study will be promulgated widely and the database generated by the AAG, which is to be updated annually, will be a valuable information source for future analyses.

3 THE ACCIDENT ANALYSIS GROUP (AAG)

Early in 1996, the CAA established a group of seven experts each bringing to the group extensive aeronautical experience gained both in and outside the regulatory environment. The experts brought to the AAG first-hand knowledge in, for example, the following areas:

- Commercial airline operations
- Flight testing, handling and performance
- Systems and structural design
- Human factors and flight deck design
- Risk / safety analysis techniques
- Cabin safety and survivability
- Regulatory / legal procedures
- Maintenance

4 WORKING PROCEDURE

The AAG was established to study global fatal accidents to jet and turbo-prop aeroplanes above 5,700kg maximum take-off weight between the years 1980 and 1996 inclusive, in order to identify the foremost worldwide aviation risks. The study covered public transport operations and business flights, as well as commercial training and ferry/positioning flights. The following were excluded from the study:

- Piston engined aircraft.
- Accidents known to have resulted from acts of terrorism or sabotage.
- Fatalities to third parties not caused by the aircraft or its operation.
- Eastern built aircraft and operators from the Commonwealth of Independent States (CIS) prior to 1990 as information from these countries was unavailable or limited at that time.
- Military-type operations or test flights.

Summaries of the accidents were obtained from the World Aircraft Accident Summary [ref 1] and were circulated to the AAG two weeks before each meeting, in order that group members could prepare their own analysis of each accident prior to discussion. For the rest of this document, “accident summary” refers to the World Aircraft Accident Summary.

The accident summaries were usually brief and were supplemented with other information when required and available. At the meetings, causal and circumstantial factors were discussed for each accident and a consensus reached on the factors to be allocated. These factors and any consequences were then recorded for each accident and entered onto a Fatal Accident Database for future analysis.

The AAG decided to assess all global fatal accidents, unlike other studies where only accidents with sufficient information were reviewed. This was done to avoid any bias in the analysis towards accidents that have occurred in more advanced nations where detailed investigations are carried out and reports issued.

It is intended that the AAG continue to assess global fatal accidents annually in order to maintain an on-going review. The Fatal Accident Database will be updated to take account of any new information received and further assessments by the group and could be used for similar studies requested by organisations such as ICAO, other regulatory agencies or safety organisations.

5 ACCIDENT ASSESSMENT

5.1 Assessment method

The AAG's assessment consisted of three main parts - causal factors, circumstantial factors and consequences - accompanied by an assessment of the level of confidence in the information available. These assessment criteria are detailed below and the complete list of factors can be found in the appendix.

When allocating factors, it was not the intention of the group to apportion blame.

5.2 Causal factors

A causal factor was an event or item which was judged to be directly instrumental in the causal chain of events leading to the accident. An event may have been cited in the accident summary as having been a causal factor or it may have been implicit in the text. Whenever an official accident report was quoted in the accident summary, the AAG used any causal factors stated for consistency. Additionally, it was agreed that the AAG would select one primary causal factor for each accident. Occasionally it was difficult for the AAG to reach a decision on which of the causal factors involved was the primary causal factor. In such cases, the group agreed to take a particular approach as a matter of policy, and then applied this policy consistently for all other similar cases that arose.

The causal factors were listed in groups such as "Crew" and divided further into specific factors such as "Failure in Crew Resource Management (CRM)". An accident may have been allocated any number of causal factors from any one group, and any combination of groups. The highest number of causal factors recorded for a single accident was eleven.

5.3 Circumstantial factors

A circumstantial factor was an event or item which was judged not to be directly in the causal chain of events but could have contributed to the accident. These factors were present in the situation and were felt to be potentially relevant to the accident, although not directly causal. For example, it was useful to note when an aircraft had made a Controlled Flight Into Terrain (CFIT) and it was not fitted with a Ground Proximity Warning System (GPWS). Although GPWS was not mandatory for all aircraft considered in the study, the non-fitment of a GPWS could have been considered circumstantial, but not causal, in a CFIT type accident.

In other cases, "Failure in CRM" may have been allocated as a circumstantial factor. In such cases, the accident summary did not clearly cite CRM and the AAG did not judge it to be a causal factor, but the AAG felt that had the CRM been to a higher standard during the situation the accident might have been prevented. For example, a Controlled Flight Into Terrain during descent may have been avoided by good crew CRM (cross checking by crew members, co-ordination) but the accident summary may not have given sufficient evidence that CRM failure was a causal factor.

The circumstantial factors were listed in groups (such as “Infrastructure”) and divided further into specific factors (such as “Company management failure”). It should be noted that an accident may have been allocated any number of factors from any one group, and any combination of groups. The highest number of circumstantial factors for a single accident was seven.

5.4 Consequences

A list of consequences was used to record the outcomes of the fatal accidents in terms of collisions, structural failure, fire, fuel exhaustion and other events. It was important to keep a record of the consequences as all fatal accidents consist of a chain of events with a final outcome resulting in fatalities. In some cases, it can be just as important to know what happened rather than why or how it happened as a particular combination of causal factors on one day may lead to a fatal accident whilst on the following day it may only result in a minor incident. In many cases, the consequence is all that is remembered about a particular event. The highest number of consequences in a single accident was five.

5.5 Level of confidence

The AAG also recorded the level of confidence for each accident. This may have been “High”, “Medium” or “Low” and reflected the group's confidence in the completeness of the accident summary and therefore the consequent factors allocated. It was not a measure of confidence in the allocation of individual factors but of the group's analysis of the accident as a whole. Alternatively, if the group felt there was not enough substantive information in the accident summary (and there was no possibility of obtaining adequate further information) then there was a fourth level of confidence - “Insufficient information”. For these accidents, no attempt was made to allocate causal factors, although there may have been circumstantial factors such as “Poor visibility” which may have been relevant. Less than 5% of accidents in the study were allocated “Insufficient information”, as shown in paragraph 7.8.

5.6 Summary of assessments

There were 64 possible causal factors, 15 circumstantial factors and 15 consequences and each accident was allocated as many factors and consequences as were considered relevant. The group could allocate any combination of factors although some factors were mutually exclusive. For example, factors A2.3 (“Failure to provide separation in the air”) and A2.4 (“Failure to provide separation on the ground”) would not be allocated to the same accident as the aircraft involved were **either** in the air **or** on the ground.

6 LIMITATIONS OF AAG DATA

It should be noted that only fatal accidents have been included in this study and therefore some important events, such as insufficient separation between aircraft during flight (AIRPROX) and non-fatal hull losses, have not been represented. It is important to recognise these limitations when using the data. However, it may be possible to use the AAG assessment method for events other than fatal accidents.

The information in Airclaims' summaries is believed to be accurate but the summaries are, in many cases, quite brief. These summaries may not include sufficient information for all relevant factors to be identified. Therefore, care should be taken not to dismiss particular factors as being irrelevant to accident risk as there could be an element of incomplete data. This is particularly true of crew related factors such as CRM and fatigue, which may be subject to under-reporting by some agencies, not actually apparent to the investigators, or simply not thought to be worthy of inclusion in a summary report.

In this report, the analysis of the data has been performed on groups of accidents, rather than individual accidents; it is considered that aggregation of the data will help to mask any random errors introduced by inaccurate "coding".

Accident reporting criteria are not consistent throughout the world so the number of factors assigned to accidents can vary widely. As with all statistics, care must be taken when drawing conclusions from this report.

7 WORLDWIDE RESULTS

Due to the lack of information on the numbers of flights worldwide, accident rates have not been included in this section. However, utilisation data was available for Western-built jets and accidents rates are included in Chapter 13.

7.1 Fatal accidents by year

The group studied 621 worldwide fatal accidents to jets and turboprops above 5,700kg, between 1980 and 1996. The number of fatal accidents are shown by year as follows:

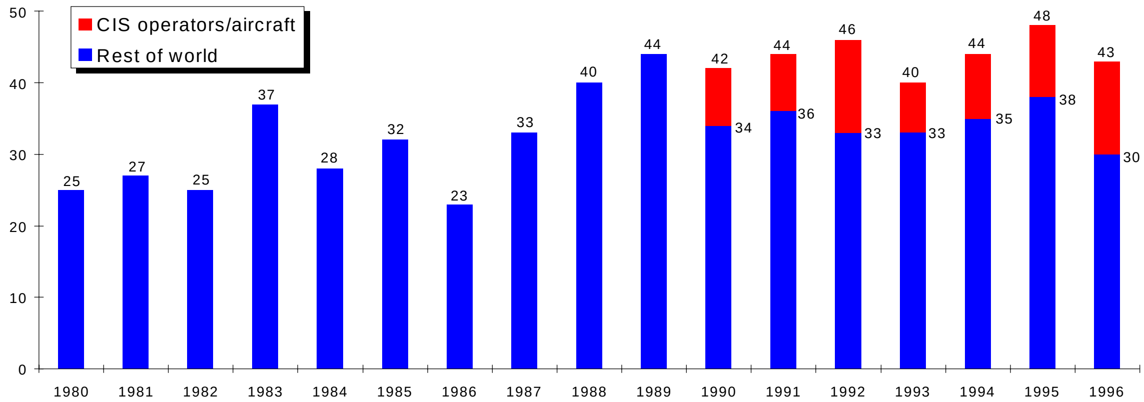

Figure 7.1 Fatal accidents by year

Note: Accidents to Eastern-built aircraft and operators from the CIS were not included prior to 1990 as information was unavailable or limited.

Ignoring accidents to Eastern-built aircraft and operators from the Commonwealth of Independent States (CIS):-

Over the period 1980 - 1996, the annual number of fatal accidents has increased by 32% (best fit line), mainly attributable to an increase in world traffic.

If this growth in fatal accidents continued, by the year 2010 there would be an annual average of 44 fatal accidents. However, over the period 1990 - 1996 the trend has been decreasing.

The most common months in which fatal accidents occurred were January and December which accounted for 11% and 10% of the 621 fatal accidents respectively, in inverse proportion to the number of daylight hours in the Northern hemisphere. The least common month for fatal accidents was May with 6.6%.

Of the 621 fatal accidents: 350 (56%) occurred during daylight, 199 (32%) occurred in darkness, 11 (2%) occurred during the twilight and the remaining 61 (10%) occurred at an unknown time. Of the 560 accidents of known light conditions, 37.5% occurred during darkness or twilight. A global figure for the proportion of landings made at night is not known but it is estimated that the figure is somewhere around 20%. If this is the correct magnitude then the fatal accident rate at night is more than twice that for day.

Of the 199 fatal accidents which occurred in darkness, 78 (39%) occurred during approach or final approach, 34 (17%) occurred during landing and a further 34 (17%) occurred during the take-off and climb phases of flight.

7.2 Fatalities by year

During the period 1980 to 1996, the 621 worldwide fatal accidents resulted in 16,849 fatalities, indicating an average of 27 fatalities per accident. The fatalities are shown by year in Figure 7.2:

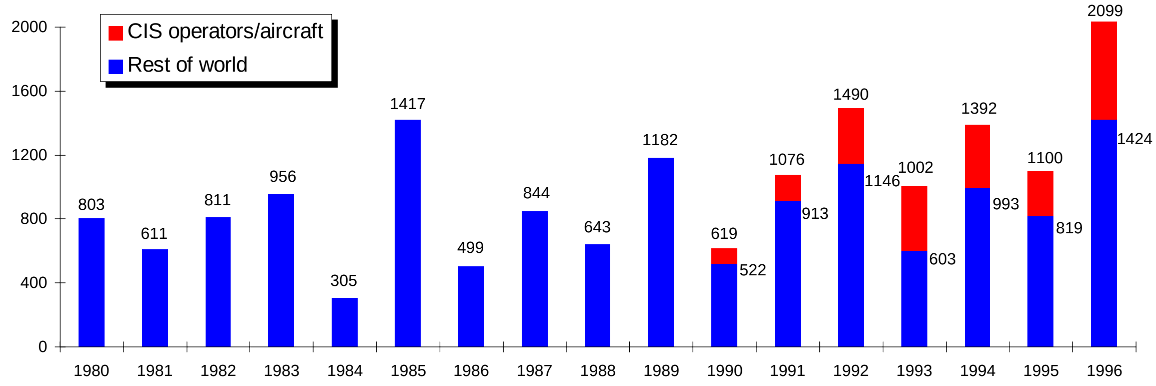

Figure 7.2 Fatalities by year

Note: Accidents to Eastern-built aircraft and operators from the CIS were not included prior to 1990 as information was unavailable or limited.

Excluding the accidents to Eastern-built aircraft and operators from the CIS, the annual number of fatalities has increased by 43% (best fit line) over the 1980-1996 period.

In 1996 there were 2,099 fatalities from worldwide accidents, which was the highest number in the 1990s by a considerable margin.

The total number of aircraft occupants in the 621 fatal accidents was 25,302. The number of fatalities divided by the number of aircraft occupants gives a fatality rate of 67%, indicating that on average 33% of aircraft occupants survived.

7.3 Phase of flight

Of the 621 accidents to all aircraft classes, 310 (50%) occurred during the approach and landing phases of flight including go-around [ref 2]. A further 23% occurred during take-off and climb:

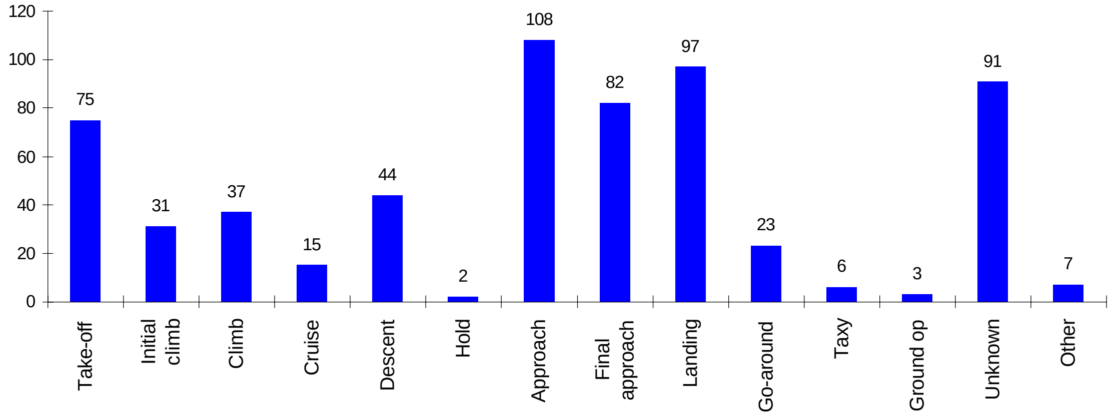

Figure 7.3 Fatal accidents by phase of flight

7.4 Accident locations

The world regions in which the 621 fatal accidents occurred are shown in Figure 7.4.1. The regions are those defined by Airclaims. "Europe" broadly covers all countries west of the Urals and therefore includes many from the CIS.

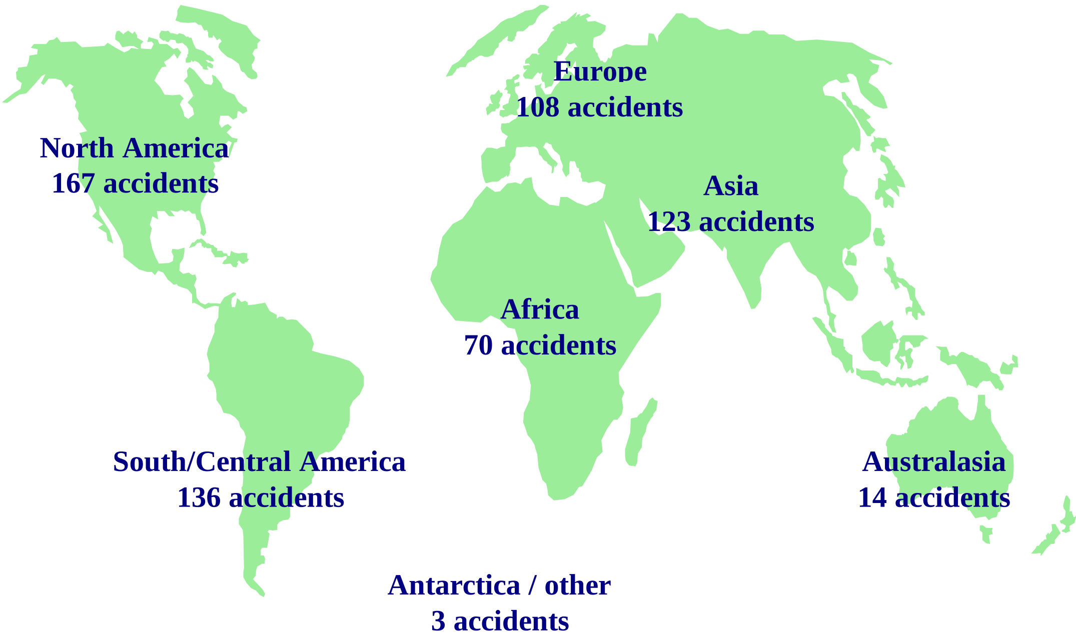

Figure 7.4.1 Accident locations - number of accidents

The corresponding fatal accident rates for the period 1991 to 1995 inclusive have been calculated using airport traffic statistics for 325 airports in ICAO states [ref 3]. The number of fatal accidents during passenger and freight/ferry/positioning flights per million commercial air transport movements (ATMs) are shown for each world region:

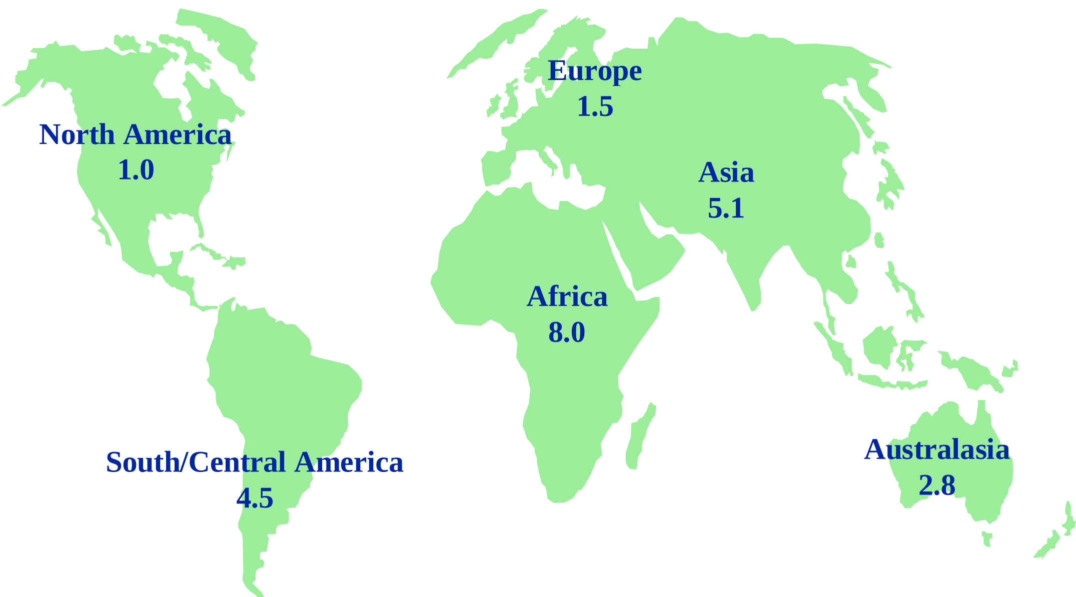

Figure 7.4.2 Accident locations - fatal accidents per million commercial ATMs

Note: Though there are small inconsistencies in the underlying data used in the production of the rates, it is believed that the figures give a reasonable indication of the regional rates.

7.5 Operator region

The 621 fatal accidents are shown below by region of operator. The fatal accident rates for each region of operator have been calculated using passenger-km performed during the period 1984 to 1996 inclusive as this was the information available at the time of publication [ref 4]. It is evident the African and South/Central American operators have fatal accident rates considerably higher than operators from other world regions:

Region of operator	All accidents 1980-1996	Accidents during passenger flights 1984-1996	Passenger-km performed (millions) (1984-1996)	Accidents per 100 billion passenger-km (1984-1996)
Africa	**62**	**27**	**376,893**	**7.16**
Asia	**117**	**79**	**4,241,966**	**1.86**
China	15	11	416,433	2.64
Rest of Asia	102	68	3,825,533	1.78
Australasia	**13**	**9**	**752,355**	**1.20**
Europe	**119**	**62**	**6,901,101**	**0.90**
JAA full members	63	35	4,512,836	0.78
Rest of Europe	56	27	2,388,265	1.13
South/Cent. America	**132**	**70**	**986,643**	**7.09**
North America	**177**	**63**	**16,855,158**	**0.37**
US	154	53	16,201,683	0.33
Canada/Caribbean	23	10	653,475	1.53

Table 7.5 Fatal accidents by operator region

Operators from JAA full member countries [see Definitions] achieved a lower fatal accident rate than that for operators from the rest of Europe. The fatal accident rate for operators from Canada/Caribbean was more than four times higher than that achieved by US operators.

7.6 Service type

The 621 fatal accidents occurred during the following types of service:

	Fatal accidents	
Passenger	380	(61.1%)
Freight / ferry / positioning	155	(25.0%)
of which ferry / positioning	*43*	*(6.9%)*
Business / other revenue	53	(8.5%)
Training / other non-revenue	33	(5.3%)

Though the actual number of flights for all types of service are not available, it is clear that there is a much higher accident rate for freight/ferry/positioning flights than for passenger flights. During the period 1990 - 1996 inclusive, 3.6% of the international and domestic flights performed during scheduled services of IATA members involved all-cargo flights [ref 5]. UK CAA's data on fixed wing air transport movements at UK airports [ref 6] from 1986 to 1996, for aircraft above 5,670kg (12,500lb) maximum take-off weight, showed an average of 5% were all-cargo flights; there was a steady increase over this period from 4.4% in 1986 to 5.6% in 1996. The average for the period covered in this study (1980 - 1996) is therefore estimated to be 4.6% for UK airports.

These indicate that, overall, the freight/cargo operations together with ferry and positioning flights represent about 5% of the number of flights carried out in commercial transport operations. This indicates that the fatal accident rate on freight, ferry and positioning flights (ie. when no passengers are on board the aircraft) is approximately 8 times higher than that for passenger flights. This is an important conclusion because the safety and operational standards are, in general, the same for freight and passenger operations.

7.7 Aircraft class

The classes of aircraft involved in the 621 fatal accidents were:

	Fatal accidents	
Western-built jets	180	(29.0%)
Eastern-built jets	31	(5.0%)
Western-built turboprops	247	(44.8%)
Eastern-built turboprops	35	(5.6%)
Business jets	128	(20.6%)

Note: Accidents to aircraft built in the CIS were not included prior to 1990 as information was unavailable or scarce.

For more detailed analysis of Western-built jets see Chapter 13.

7.8 Level of confidence

The level of confidence reflected the group's confidence in the completeness of the accident summary and therefore the consequent factors allocated for each accident, as detailed in paragraph 5.5. Of the 621 fatal accidents considered, 300 were allocated a “High” level of confidence and only 32 were allocated “Insufficient information” as shown below:

	Fatal accidents	
High	300	(48%)
Medium	222	(36%)
Low	67	(11%)
Insufficient information	32	(5%)

Those accidents with insufficient information were not included in the analysis of causal factors.

8 ANALYSIS OF PRIMARY CAUSAL FACTORS

8.1 Primary causal factors

In the study carried out by the AAG, any number of causal factors may have been allocated for each accident of which only one was identified as the primary causal factor. Of the 621 fatal accidents considered, 32 were judged to have insufficient information available leaving 589 fatal accidents for which causal factors, and therefore primary causal factors, were allocated.

The most frequently identified primary causal factors in the 589 fatal accidents were as follows:

	Fatal accidents	
1) Lack of positional awareness in air	123	(20.9%)
2) Omission of action / inappropriate action	116	(19.7%)
3) Flight handling	76	(12.9%)
4) Press-on-itis	46	(7.8%)
5) Poor professional judgement / airmanship	22	(3.7%)
6) Deliberate non-adherence to procedures	14	(2.7%)
7) Design shortcomings	13	(2.2%)
8) Windshear / upset / turbulence / gusts	12	(2.0%)
9) Maintenance or repair oversight / error / inadequate	10	(1.7%)
10) System failure - affecting controllability	10	(1.7%)

These most frequently identified primary causal factors account for 75% of the 589 fatal accidents. The first six primary causal factors were from the *crew* causal group, accounting for 67% of the 589 fatal accidents.

8.2 Primary causal factors by operator region

8.2.1 When the operators are divided by world region, there are obvious differences in the most frequently identified primary causal factors. The top five primary causal factors for each operator region are ranked in Table 8.2:

Primary causal factor	World	Africa	Asia	Australasia	Europe	South / Central America	North America
Lack of positional awareness in air	**1** (20.9%)	**1** (19.4%)	**1** (31.6%)	**1** (30.8%)	**3** (10.9%)	**1** (33.3%)	**4** (7.3%)
Omission of action / inappropriate action	**2** (19.7%)	**=3** (11.3%)	**2** (16.2%)	**2** (23.1%)	**1** (24.4%)	**2** (18.2%)	**1** (19.2%)
Flight handling	**3** (12.9%)	**2** (12.9%)	**3** (9.4%)	**3** (15.4%)	**2** (11.8%)	**3** (9.8%)	**2** (15.8%)
"Press-on-itis"	**4** (7.8%)	**=3** (11.3%)	**=4** (2.6%)		**4** (10.1%)	**4** (6.8%)	**3** (8.5%)
Poor professional judgement / airmanship	**5** (3.7%)	**=5** (4.8%)		**=4** (7.7%)		**5** (6.1%)	
Deliberate non-adherence to procedures	**6** (2.7%)			**=4** (7.7%)	**5** (3.4%)		
Design shortcomings	**7** (2.2%)						**5** (4.5%)
Windshear / upset / turbulence / gusts	**8** (2.0%)	**=5** (4.8%)	**=4** (2.6%)				

Table 8.2 Primary causal factors by operator region

Note: The figures in brackets are the percentages of accidents involving that primary causal factor and operator region. Accident reporting criteria are not consistent throughout the world so the number of factors assigned to accidents may vary widely. Care should be taken when drawing conclusions from this data.

"Lack of positional awareness in air" was found to be the most frequently identified primary causal factor for most operator regions. This generally involved a lack of appreciation of proximity to the ground, frequently when the aircraft was not equipped with a Ground Proximity Warning System (GPWS) and/or when precision approach aids were not available. These are generally Controlled Flight Into Terrain (CFIT) accidents.

"Omission of action / inappropriate action" was the most frequently identified primary causal factor for European and North American operators. This most commonly referred to the crew continuing their descent below the Decision Height or Minimum Descent Altitude without visual reference, or when visual cues were lost.

8.3 Primary causal factors by aircraft class

Table 8.3 shows the ranking of the most frequently identified primary causal factors by aircraft class:

Primary causal factor	All classes	Western-built Jets	Eastern-built Jets	Western-built Turboprops	Eastern-built Turboprops	Business Jets
Lack of positional awareness in air	**1** (20.9%)	**2** (11.1%)	**=2** (19.4%)	**1** (27.5%)	**=1** (17.1%)	**2** (18.0%)
Omission of action / inappropriate action	**2** (19.7%)	**1** (26.1%)	**1** (25.8%)	**3** (10.9%)	**4** (11.4%)	**1** (23.4%)
Flight handling	**3** (12.9%)	**3** (8.9%)	**5** (6.5%)	**2** (12.6%)	**3** (14.3%)	**3** (17.2%)
"Press-on-itis"	**4** (7.8%)	**4** (7.8%)	**=2** (19.4%)	**4** (5.3%)	**=1** (17.1%)	**4** (5.5%)
Poor professional judgement/airmanship	**5** (3.7%)	**5** (4.4%)		**5** (3.2%)	**=5** (2.9%)	**5** (3.1%)
Deliberate non-adherence to procedures	**6** (2.7%)				**=5** (2.9%)	
Design shortcomings	**7** (2.2%)					
Windshear/upset/turbulence/gusts	**8** (2.0%)		**4** (9.7%)		**=5** (2.9%)	

Note: The figures in brackets are the percentages of accidents involving that primary causal factor and operator region. Accident reporting criteria are not consistent throughout the world so the number of factors assigned to accidents may vary widely. Care should be taken when drawing conclusions from this data.

Table 8.3 Primary causal factors by aircraft class

"Windshear/upset/turbulence/gusts" seems to have been more frequently identified for Eastern-built aircraft, being the primary causal factor in nearly 10% of accidents to Eastern-built jets.

"Press-on-itis" was higher in the rankings for Eastern-built aircraft, mostly operated in the former CIS countries, with an average of 18% of accidents involving this as the primary causal factor, compared with an average of 6% for Western-built aircraft and business jets.

8.4 Primary causal factors (five year rolling average)

The five most frequently identified primary causal factors are shown in Figure 8.4 as a five year rolling average:

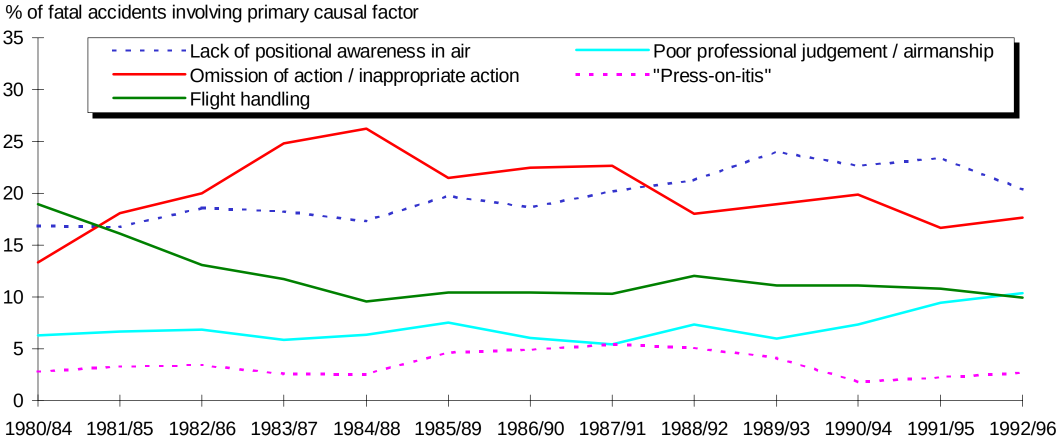

Figure 8.4 Primary causal factors (five year rolling average)

As the primary causal factor, “Lack of positional awareness in air” has shown an increasing trend over the 1980 - 1996 period considered. Conversely, “Omission of action / inappropriate action” has been allocated less frequently over the 1990’s and shows a decreasing trend.

9 ANALYSIS OF ALL CAUSAL FACTORS

9.1 All causal factors

Any number of causal factors could be allocated by the AAG to each accident. Frequently, an accident results from a combination of causal factors and it is important to see the whole picture rather than just the single primary causal factor. For the purposes of this analysis, primary causal factors have been included with the other causal factors. The average number of causal factors per fatal accident was 3.3. The largest number of causal factors allocated for one accident was 11.

The most frequently identified causal factors in the 589 fatal accidents (not including those with insufficient information) were as follows:

	Fatal accidents	
1) Lack of positional awareness in air	244	(41.4%)
2) Omission of action / inappropriate action	216	(36.7%)
3) Flight handling	177	(30.1%)
4) Poor professional judgement / airmanship	134	(22.8%)
5) Slow and/or low on approach	113	(19.2%)
6) Failure in Crew Resource Management (CRM)	101	(17.1%)
7) Press-on-itis	97	(16.5%)
8) Deliberate non-adherence to procedures	72	(12.2%)
9) Design shortcomings	67	(11.4%)
10) Post crash fire	63	(10.7%)

Note: The factors are not mutually exclusive as each accident generally involves more than one factor.

It is interesting to note that the 8 most frequently identified causal factors (including primary) belonged to the *Crew* group, and that "Design shortcomings" and "Post crash fire" were each involved in over 10% of accidents. In this case, "Post crash fire" was deemed to be instrumental in causing the fatalities whilst in other cases it would only be included as a consequence.

9.2 Causal factors by operator region

The top five causal factors for each operator region are ranked in Table 9.2:

Causal factor	World	Africa	Asia	Australasia	Europe	South / Central America	North America
Lack of positional awareness in air	**1** (41.4%)	**1** (37.1%)	**1** (47.0%)	**1** (69.2%)	**2** (31.1%)	**1** (54.5%)	**3** (27.1%)
Omission of action / inappropriate action	**2** (36.7%)	**3** (21.0%)	**2** (30.8%)	**2** (30.8%)	**1** (42.9%)	**2** (33.3%)	**2** (38.4%)
Flight handling	**3** (30.1%)	**2** (22.6%)	**3** (23.1%)	**=3** (15.4%)	**3** (28.6%)	**5** (21.2%)	**1** (39.0%)
Poor professional judgement / airmanship	**4** (22.8%)	**4** (19.4%)		**=3** (15.4%)	**4** (23.5%)	**3** (23.5%)	**4** (26.6%)
Slow and/or low on approach	**5** (19.2%)	**5** (17.7%)	**=4** (13.7%)	**=3** (15.4%)		**4** (22.7%)	
Failure in Crew Resource Management (CRM)	**6** (17.1%)		**=4** (13.7%)		**5** (21.0%)		**5** (21.5%)

Note: The figures in brackets are the percentages of accidents involving that primary causal factor and operator region. Accident reporting criteria are not consistent throughout the world so the number of factors assigned to accidents may vary widely. Care should be taken when drawing conclusions from this data.

Table 9.2 Causal factors by operator region

"Lack of positional awareness in air" was the most frequently identified causal factor for most regions with 69% of accidents to Australasian operators involving this factor.

"Flight handling" was the most frequently identified causal factor for North American operators, evident in 39% of the accidents.

The list of causal factors most frequently identified differs from the list of primary causal factors. "Slow and/or low on approach" and "Failure in CRM" were prevalent as causal factors but not often identified as being the primary causal factor.

9.3 Causal factors by aircraft class

The rankings of the most frequently identified causal factors are shown in Table 9.3 by aircraft class:

Causal factor	All classes	Western-built Jets	Eastern-built Jets	Western-built Turboprops	Eastern-built Turboprops	Business Jets
Lack of positional awareness in air	**1** (41.4%)	**3** (29.4%)	**2** (32.3%)	**1** (47.0%)	**1** (28.6%)	**1** (43.0%)
Omission of action / inappropriate action	**2** (36.7%)	**1** (44.4%)	**1** (38.7%)	**2** (27.5%)	**=3** (22.9%)	**2** (37.5%)
Flight handling	**3** (30.1%)	**2** (31.7%)		**3** (26.7%)	**=3** (22.9%)	**3** (30.5%)
Poor professional judgement / airmanship	**4** (22.8%)	**4** (25.0%)		**4** (19.4%)	**5** (20.0%)	**5** (22.7%)
Slow and/or low on approach	**5** (19.2%)		**=4** (19.4%)	**=5** (14.2%)		**4** (27.3%)
Failure in (CRM)	**6** (17.1%)	**5** (22.2%)	**=4** (19.4%)	**=5** (14.2%)		
"Press-on-itis"	**7** (16.5%)		**3** (25.8%)	**=5** (14.2%)	**2** (25.7%)	

Note: The figures in brackets are the percentages of accidents involving that primary causal factor and operator region. Accident reporting criteria are not consistent throughout the world so the number of factors assigned to accidents may vary widely. Care should be taken when drawing conclusions from this data.

Table 9.3 Causal factors by aircraft class

"Press-on-itis" was higher in the rankings for Eastern-built aircraft with an average of 26% of accidents involving this as a causal factor.

9.4 Causal factors (five year rolling average)

The five most frequently identified causal factors are shown in Figure 9.4 as a five year rolling average:

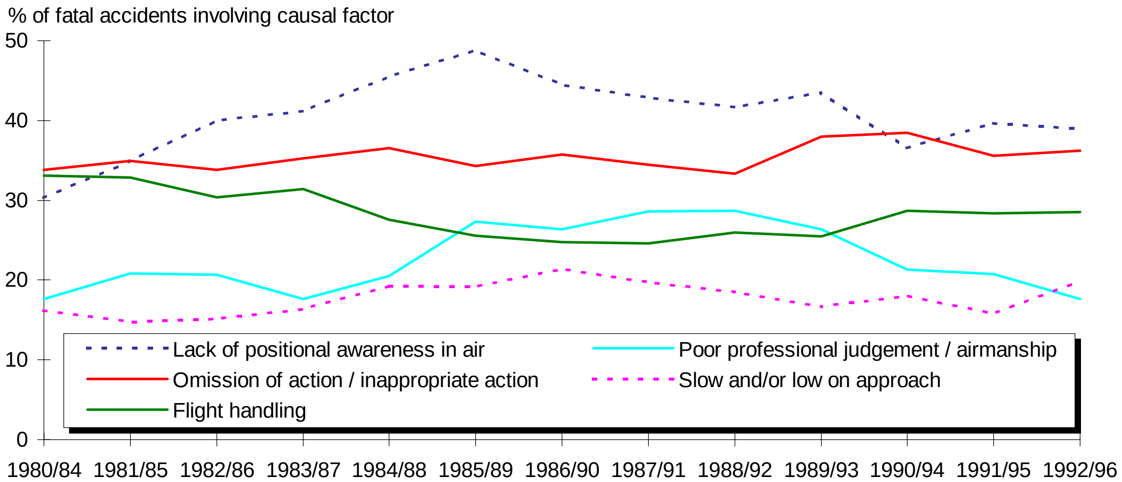

Figure 9.4 Causal factors (five year rolling average)

The five most frequently identified causal factors have varied little over the 1980 to 1996 period.

It appears that "Lack of positional awareness in air" and "Poor professional judgement/ airmanship" have shown a decreasing trend over the 1990's, indicating a lower percentage of accidents involving these causal factors. This may reflect the increased use of GPWS and the introduction of CRM training.

10 ANALYSIS OF CIRCUMSTANTIAL FACTORS

10.1 Circumstantial factors

As stated earlier, a circumstantial factor was an event or aspect which was not directly in the causal chain of events but could have contributed to the accident. An accident may have been allocated any number of circumstantial factors by the AAG in any combination. The average number of circumstantial factors allocated per accident was 2.2 whilst 9 accidents were allocated more than 5 circumstantial factors.

The most frequently identified circumstantial factors were ranked as follows:

	Fatal accidents	
1) Non-fitment of presently available safety equipment	247	(39.8%)
2) Failure in CRM	234	(37.7%)
3) Weather (other than poor visibility or runway condition)`	194	(31.2%)
4) Inadequate regulatory oversight	153	(24.6%)
5) Company management failure	135	(21.7%)
6) Poor visibility	124	(20.0%)
7) Lack of ground aids	92	(14.8%)
8) Inadequate regulation	53	(8.5%)
9) Incorrect / inadequate procedures	51	(8.2%)
10) Training inadequate	40	(6.4%)

Note: The factors are not mutually exclusive as each accident generally involves more than one factor.

10.2 Circumstantial factors by operator region

The top five circumstantial factors for each operator region are ranked in Table 10.2:

Circumstantial factor	World	Africa	Asia	Australasia	Europe	South / Central America	North America
Non-fitment of presently available equipment	**1** (39.8%)	**2** (37.1%)	**2** (46.2%)	**=1** (61.5%)	**3** (29.4%)	**1** (56.1%)	**3** (29.9%)
Failure in Crew Resource Management (CRM)	**2** (37.7%)	**1** (40.3%)	**1** (47.0%)	**3** (53.8%)	**2** (34.5%)	**2** (48.5%)	**5** (23.7%)
Other weather	**3** (31.2%)	**3** (27.4%)	**3** (34.2%)	**=1** (61.5%)	**1** (35.3%)	**3** (31.1%)	**4** (26.0%)
Inadequate regulatory oversight	**4** (24.6%)		**5** (17.9%)		**4** (25.2%)		**1** (37.9%)
Company management	**5** (21.7%)				**5** (22.7%)		**2** (35.6%)
Poor visibility	**6** (20.0%)	**5** (17.8%)	**4** (21.4%)	**4** (23.1%)		**4** (24.2%)	
Lack of ground aids	**7** (14.8%)	**4** (21.0%)		**=5** (7.7%)		**5** (20.5%)	
Inadequate regulation	**8** (8.5%)						
Incorrect / inadequate procedures	**9** (8.2%)						
Training inadequate	**10** (6.4%)			**=5** (7.7%)			

Note: The figures in brackets are the percentages of accidents involving that primary causal factor and operator region. Accident reporting criteria are not consistent throughout the world so the number of factors assigned to accidents may vary widely. Care should be taken when drawing conclusions from this data.

Table 10.2 Circumstantial factors by operator region

"Non-fitment of presently available safety equipment" was the most frequently identified circumstantial factor overall and referred, in most cases, to the lack of GPWS or enhanced GPWS (even if it was not available at the time of the accident).

"Failure in CRM" was the most frequently identified circumstantial factor for African and Asian operators. A judgement was made by the AAG as to whether the lack of good CRM was actually one of the causes that led to the accident (in which case it was allocated as a causal factor), or that had CRM been improved it may have helped prevent the accident (meaning the allocation of a circumstantial factor).

"Other weather" and "Failure in CRM" were found to be the most common circumstantial factors for European operators.

"Inadequate regulatory oversight" and "Company management failure" were the two most frequently identified circumstantial factors for North American operators.

"Training inadequate" was identified in 8% of accidents to Australasian operators.

"Lack of ground aids" was identified in over 20% of accidents involving African and South/Central American operators.

10.3 Circumstantial factors by aircraft class

The rankings of the most frequently identified circumstantial factors are shown in Table 10.3 by aircraft class:

Circumstantial factor	All classes	Western-built Jets	Eastern-built Jets	Western-built Turboprops	Eastern-built Turboprops	Business Jets
Non-fitment of presently available equipment	**1** (39.8%)	**=1** (31.7%)	**2** (35.5%)	**1** (46.6%)		**1** (45.3%)
Failure in Crew Resource Management (CRM)	**2** (37.7%)	**=1** (31.7%)	**1** (41.9%)	**2** (40.5%)	**2** (28.6%)	**2** (42.2%)
Other weather	**3** (31.2%)	**5** (24.4%)	**=3** (29.0%)	**3** (39.3%)	**1** (31.4%)	**3** (25.8%)
Inadequate regulatory oversight	**4** (24.6%)	**3** (31.1%)	**=3** (29.0%)	**4** (23.9%)	**3** (25.7%)	
Company management	**5** (21.7%)	**4** (25.6%)	**5** (22.6%)	**5** (21.5%)	**4** (22.9%)	
Poor visibility	**6** (20.0%)				**5** (20.0%)	**4** (23.4%)
Lack of ground aids	**7** (14.8%)					**5** (19.5%)

Note: The figures in brackets are the percentages of accidents involving that primary causal factor and operator region. Accident reporting criteria are not consistent throughout the world so the number of factors assigned to accidents may vary widely. Care should be taken when drawing conclusions from this data.

Table 10.3 Circumstantial factors by aircraft class

"Non-fitment of presently available safety equipment" was identified in 47% of accidents to Western-built turboprops and 45% of accidents to business jets and was equal first in the rankings for Western-built jets.

"Weather" was the most common circumstantial factor for Eastern-built turboprops and was identified in 31% of accidents.

"Lack of ground aids" was identified in one fifth (19.5%) of accidents to business jets.

10.4 Circumstantial factors (five year rolling average)

The most frequently identified circumstantial factors are shown in Figure 10.4 as a five year moving average:

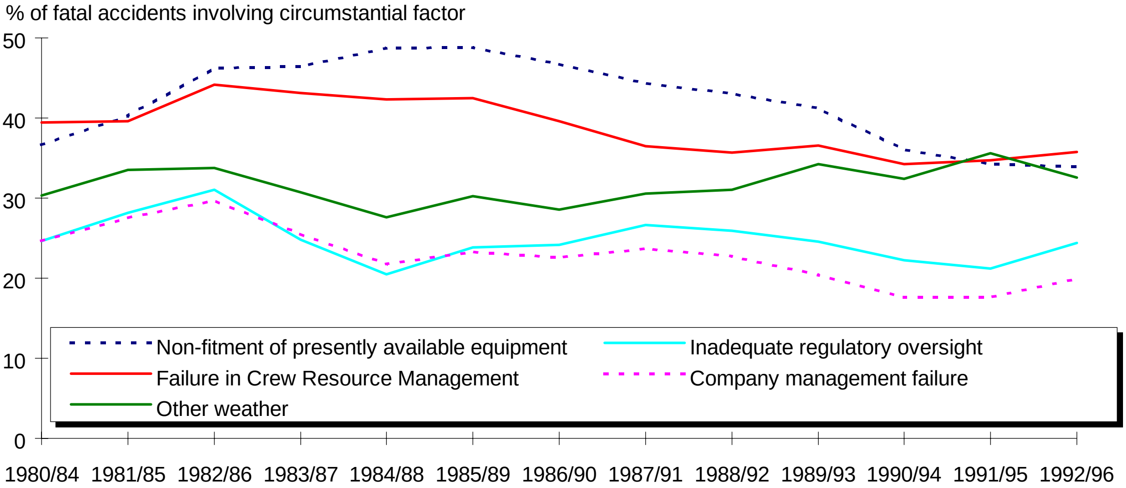

Figure 10.4 Circumstantial factors (five year rolling average)

It appears that "Non-fitment of presently available safety equipment" and "Failure in CRM" have shown a decreasing trend over the 1990's, indicating a lower percentage of fatal accidents involving these circumstantial factors.

11 ANALYSIS OF CONSEQUENCES

11.1 Consequences

A list of consequences was used to record the outcomes of the fatal accidents. Although the consequences are not part of the cause of the accident, they are relevant to a complete understanding of the accident history. The average number of consequences per accident was 1.8.

The most frequently identified consequences were ranked in the following order:

		Fatal accidents	
1)	Collision with terrain / water / obstacle	289	(46.5%)
2)	Controlled flight into terrain (CFIT)	219	(35.3%)
3)	Loss of control in flight	178	(28.7%)
4)	Post crash fire	134	(21.6%)
5)	Overrun	55	(8.9%)
6)	Undershoot	53	(8.5%)
7)	Ground collision with object / obstacle	39	(6.3%)
8)	Forced landing - land or water	30	(4.8%)
9)	Structural failure	27	(4.3%)
10)	Fire/smoke during operation	24	(3.9%)

Note: The consequences are not mutually exclusive as each accident generally involved more than one consequence.

"Collision with terrain/water/obstacle" was a consequence in 47% of accidents, whilst "Controlled Flight Into Terrain (CFIT)" was a consequence in 35% of accidents. When the impact with the terrain occurred in circumstances where it was not clear whether or not the aircraft was under full control, the former consequence has been applied - this almost certainly underestimates the number of CFIT accidents.

“Post crash fire” was involved in 21.6% of accidents.

11.2 Consequences by operator region

The top five consequences for each operator region are ranked in Table 11.2:

Consequence	World	Africa	Asia	Australasia	Europe	South / Central America	North America
Collision with terrain/water/obstacle	**1** (46.5%)	**1** (45.2%)	**2** (34.2%)	**2** (38.5%)	**1** (49.6%)	**2** (38.6%)	**1** (59.9%)
Controlled Flight Into Terrain (CFIT)	**2** (35.3%)	**3** (24.2%)	**1** (41.0%)	**1** (61.5%)	**2** (31.1.%)	**1** (50.8%)	**4** (24.9%)
Loss of control in flight	**3** (28.7%)	**4** (21.0%)	**3** (20.5%)	**=3** (7.7%)	**3** (30.3%)	**4** (16.7%)	**2** (46.3%)
Post crash fire	**4** (21.6%)	**2** (25.8%)	**5** (12.8%)	**=3** (7.7%)	**4** (19.3%)	**3** (22.0%)	**3** (28.2%)
Overrun	**5** (8.9%)	**5** (14.5%)	**4** (13.7%)		**5** (9.2%)		
Undershoot	**6** (8.5%)			**=3** (7.7%)		**5** (9.1%)	**5** (7.9%)
Ground collision with object	**7** (6.3%)						
Forced landing - land or water	**8** (4.8%)						
Structural failure	**9** (4.3%)						
Fire/smoke during operation	**10** (3.9%)			**=3** (7.7%)			

Note: The figures in brackets are the percentages of accidents involving that primary causal factor and operator region. Accident reporting criteria are not consistent throughout the world so the number of factors assigned to accidents may vary widely. Care should be taken when drawing conclusions from this data.

Table 11.2 Consequences by operator region

"Controlled Flight Into Terrain" was the most frequently allocated consequence in accidents to Asian, Australasian and South American operators, indicating that the aircraft was flown into the ground under full control. However, it was ranked fourth as a consequence of accidents to North American operators reflecting, among other factors, the long-term mandatory fitment of GPWS to larger aircraft.

"Loss of control in flight" was cited as a consequence in 30% of accidents to European operators and 46% of accidents to North American operators.

"Post crash fire" was the second most common consequence for African operators, occurring in 26% of accidents.

11.3 Consequences by aircraft class

The consequences are ranked in Table 11.3 by aircraft class:

Consequence	All classes	Western-built Jets	Eastern-built Jets	Western-built Turboprops	Eastern-built Turboprops	Business Jets
Collision with terrain/water/obstacle	**1** (46.5%)	1 (48.9%)	1 (38.7%)	1 (42.9%)	1 (51.4%)	1 (67.9%)
Controlled Flight Into Terrain (CFIT)	**2** (35.3%)	4 (24.4%)	2 (35.5%)	2 (42.5%)	=2 (28.6%)	2 (38.3%)
Loss of control in flight	**3** (28.7%)	2 (31.7%)	=3 (16.1%)	3 (28.3%)	=2 (28.6%)	3 (28.1%)
Post crash fire	**4** (21.6%)	3 (16.7%)		4 (18.6%)	=4 (17.1%)	4 (21.9%)
Overrun	**5** (8.9%)	5 (12.8%)	=3 (16.1%)		=4 (17.1%)	
Undershoot	**6** (8.5%)		=3 (16.1%)	5 (6.5%)		5 (9.4%)

Note: The figures in brackets are the percentages of accidents involving that primary causal factor and operator region. Accident reporting criteria are not consistent throughout the world so the number of factors assigned to accidents may vary widely. Care should be taken when drawing conclusions from this data.

Table 11.3 Consequences by aircraft class

"Collision with terrain/water/obstacle" was the most common consequence for all classes of aircraft, which implied that control of the aircraft had been lost or severe weather or some other factor had contributed to the impact. Where the extent of control at the time of the accident was unknown, this conclusion has been used rather than CFIT.

"Loss of control in flight" was ranked second as a consequence for Western-built jets and equal second for Eastern-built turboprops.

11.4 Consequences (five year rolling average)

The five most frequently allocated consequences are shown in Figure 11.4 as a five year rolling average.

It is evident that "Collision with terrain/water/obstacle" has shown an increasing trend over recent years, indicating an increasing percentage of annual accidents involving this consequence. "Post crash fire" and "Overrun" have been increasing over the 1990's.

"Controlled Flight Into Terrain" has shown a decreasing trend over recent years with 33% of accidents involving this consequence during the last 5 year period.

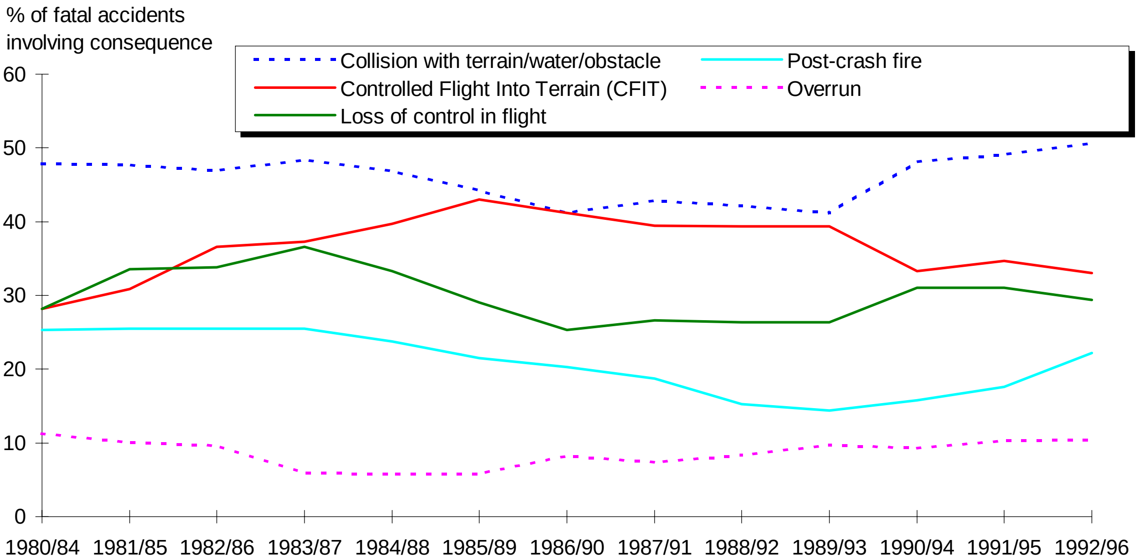

Figure 11.4 Consequences (five year rolling average)

11.5 Consequential analysis

It is recognised that accidents are generally the consequence of a chain of events, and not the product of just one causal factor. Four of the consequences most frequently identified in the study are shown in terms of the most frequently allocated causal and circumstantial factors for those accidents. No attempt has been made to sequence the events or prioritise the factors.

The numbers under each causal and circumstantial factor are the number of accidents with the consequence listed at the top of the chart which involved each causal or circumstantial factor. In Figure 11.6, there were 289 accidents (of the 621 total) which involved "Collision with terrain/water/obstacle" as a consequence. Of these 289 accidents, 137 involved "Flight handling" as a causal factor and 94 (33%) involved "Inadequate regulatory oversight" as a circumstantial factor.

In some of the charts, "Failure in CRM" has been shown both as a causal factor and a circumstantial factor. In these cases the factors are mutually exclusive as "Failure in CRM" was **either** allocated as a causal factor **or** a circumstantial factor. In Figure 11.6, 117 of the total 289 fatal accidents involved "Failure in CRM" to some extent.

In Figure 11.6, the allocation of "Post crash fire" implies that the fire was judged to have contributed to the fatalities (ie. was a causal factor) and was not just a consequence.

11.6 Collision with terrain/water/obstacle

Of the total 621 fatal accidents, 289 involved "Collision with terrain/water/obstacle" as a consequence. Of these 289 accidents, 137 (47%) involved "Flight handling":

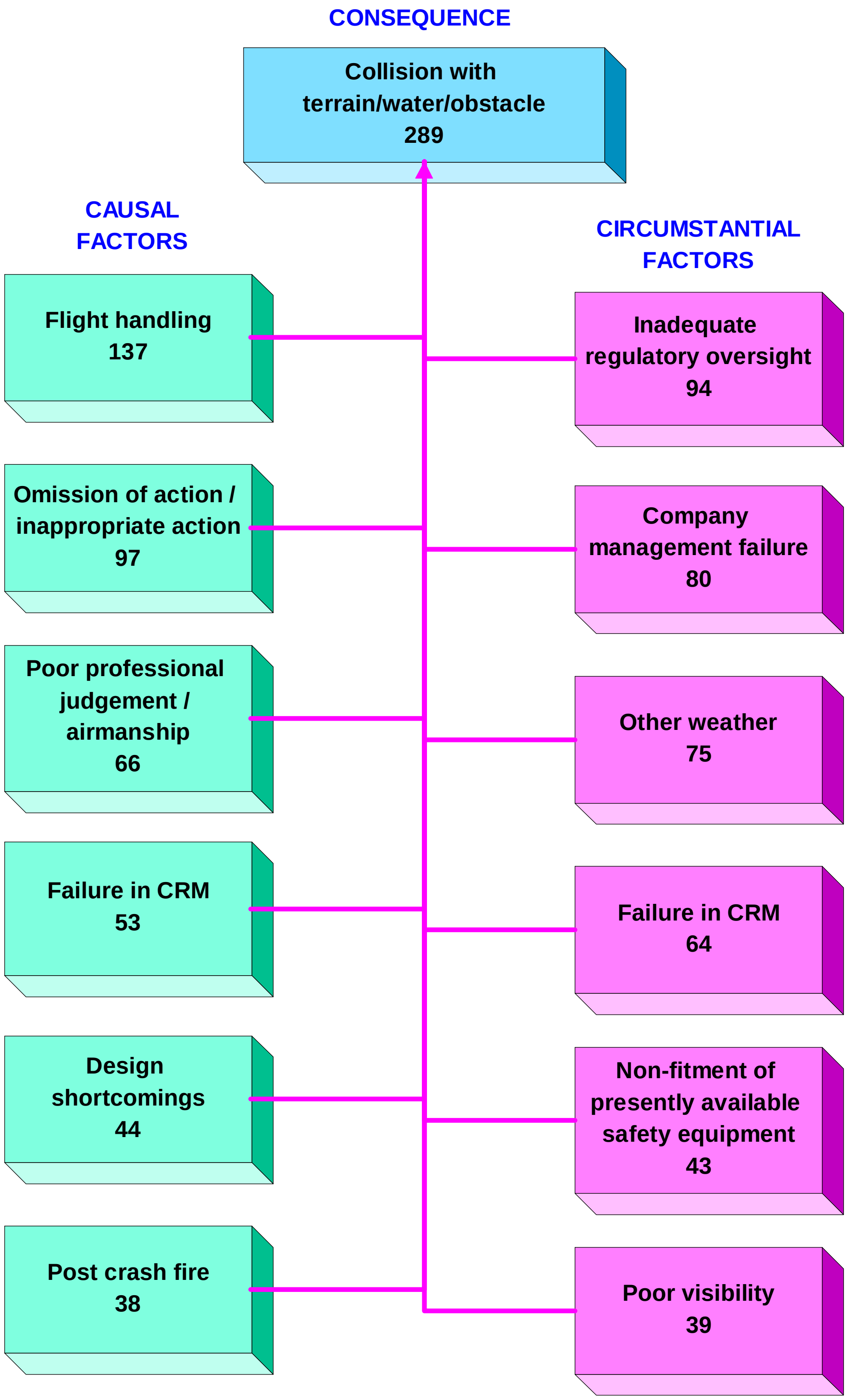

Figure 11.6 Collision with terrain / water / obstacle

Note: The factors are not mutually exclusive as each accident generally involves more than one factor.

11.7 Controlled Flight Into Terrain (CFIT)

Of the 621 fatal accidents, 219 (35%) involved CFIT. All of these fatal accidents were identified as involving "Lack of positional awareness in air" by the crew:

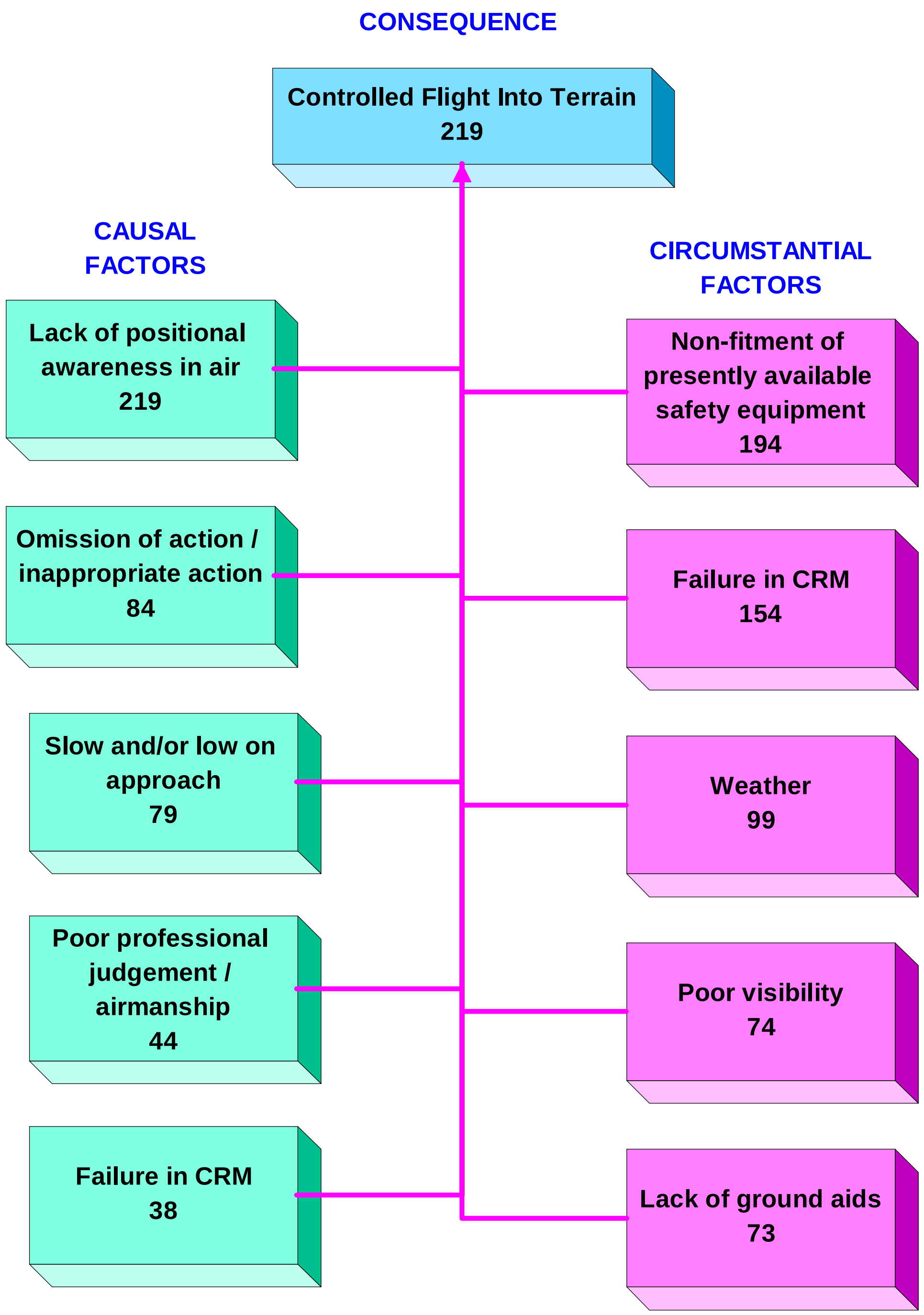

Figure 11.7 Controlled Flight Into Terrain (CFIT)

Note: The factors are not mutually exclusive as each accident generally involves more than one factor.

11.8 Loss of control in flight

Of the 621 fatal accidents, 178 involved "Loss of control in flight" of which 108 (61%) involved "Flight handling":

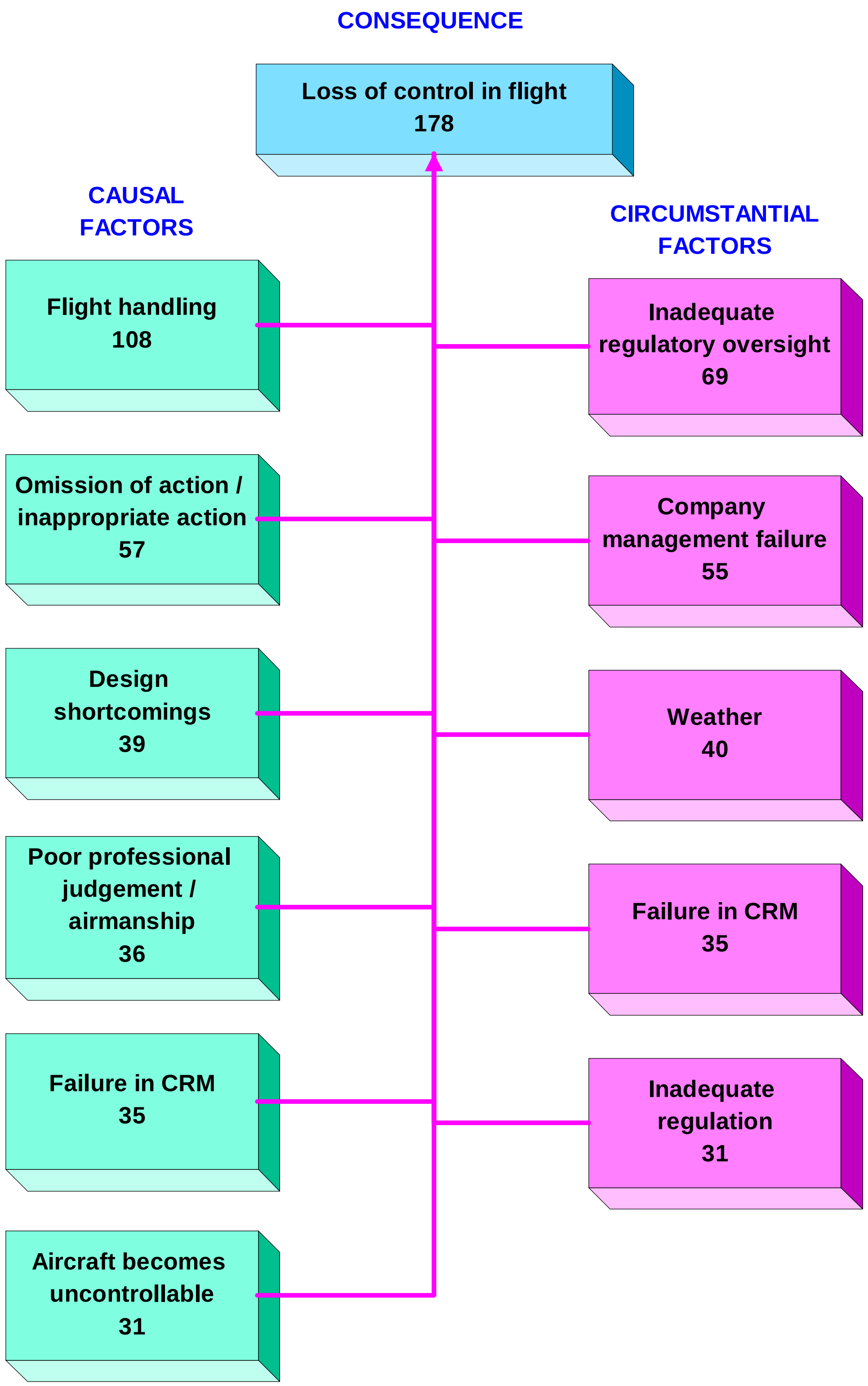

Figure 11.8 Loss of control in flight

Note: The factors are not mutually exclusive as each accident generally involves more than one factor.

11.9 Overrun

Of the 621 fatal accidents, 55 involved "Overrun" as a consequence of which 26 (47%) involved "Omission of action / inappropriate action":

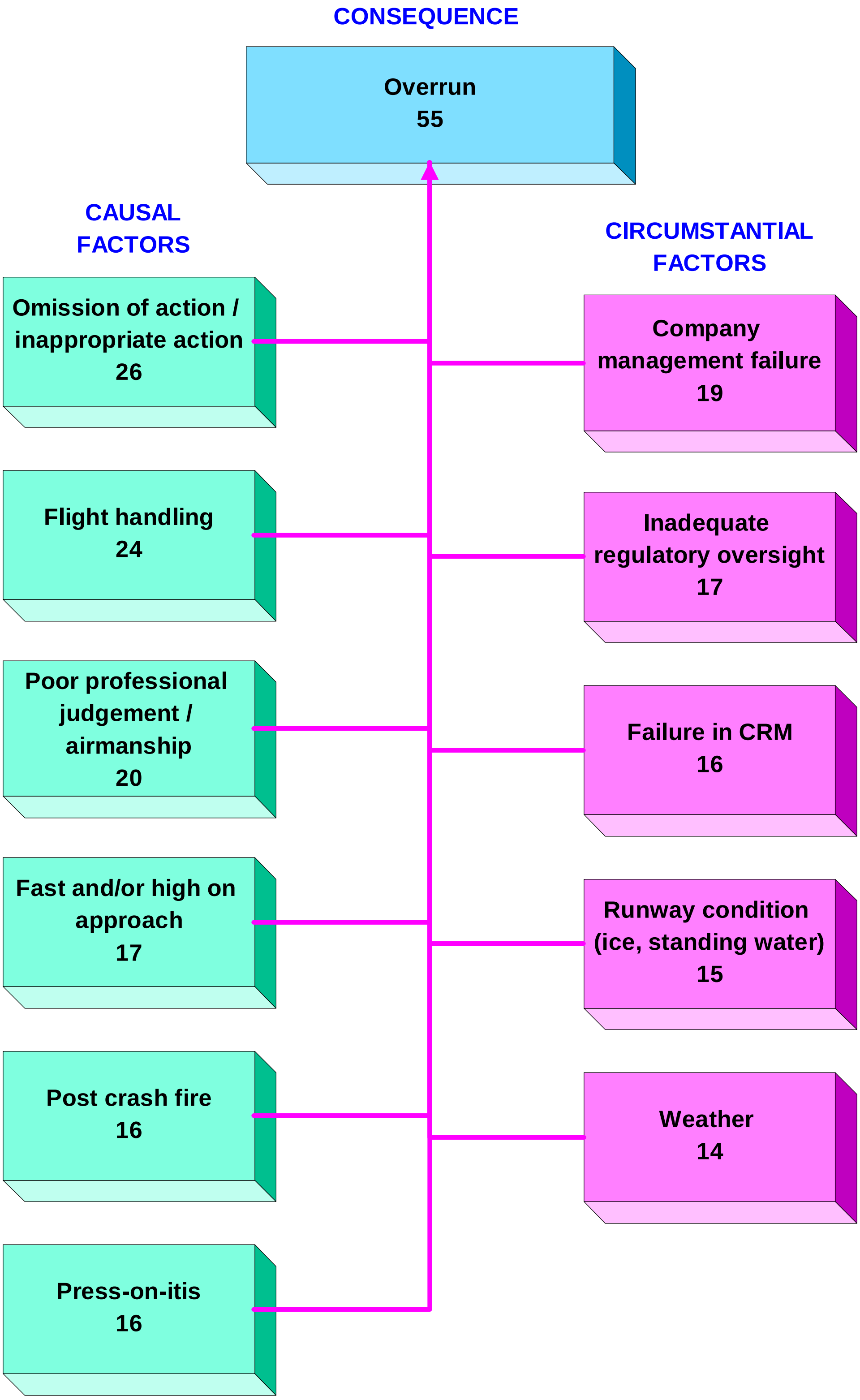

Figure 11.9 Overrun

Note: The factors are not mutually exclusive as each accident generally involves more than one factor.

12 CAUSAL GROUP ANALYSIS

Of the 589 accidents with sufficient information, the primary causal factors were identified to be in the following causal groups:

	Primary cause
Aircraft groups	
Aircraft systems	19
Design	14
Engine	18
Performance	5
Structure	7
Crew group	447
Other groups	
ATC/Ground aids	10
Environmental	27
Fire	15
Infrastructure	3
Maintenance/Ground handling	19
Other	5

Of the 589 fatal accidents with sufficient information, 447 (76%) involved a *crew* primary causal factor and in 517 accidents (88%) *crew* was identified as a causal factor.

Of the 589 fatal accidents with sufficient information, 63 (11%) involved an *aircraft* primary causal factor and in 233 accidents (40%) the *aircraft* was identified as a causal factor.

The full list of factors can be found in the Appendix.

13 ANALYSIS OF WESTERN-BUILT JETS

This chapter presents an analysis of Western-built jet airliner operations broken down into world regions. Airclaims has provided utilisation data such as flights and hours flown for Western-built jets, although the information for other classes of aircraft is scarce or not readily available. The fatal accident rates are shown in relation to the number of flights, as flights are considered to provide the most useful and valid criterion to indicate safety standards [ref 7].

13.1 Fatal accidents between 1980 and 1996 inclusive

During the study, the group analysed 180 fatal accidents to Western-built jets which represented 29% of the 621 fatal accidents:

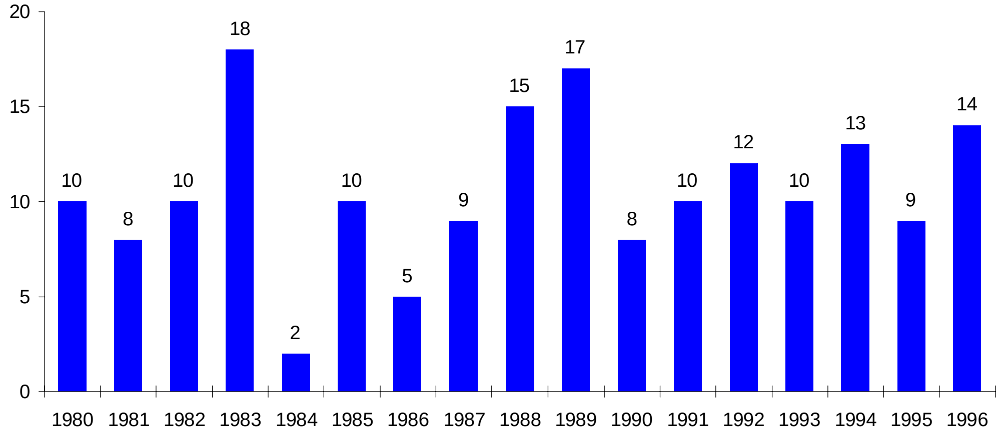

Figure 13.1 Fatal accidents between 1980 and 1996 inclusive

13.2 Fatalities between 1980 and 1996 inclusive

These 180 fatal accidents to Western-built jets resulted in 10,680 fatalities which represented 63% of the total 16,849 fatalities over the 1980 to 1996 period:

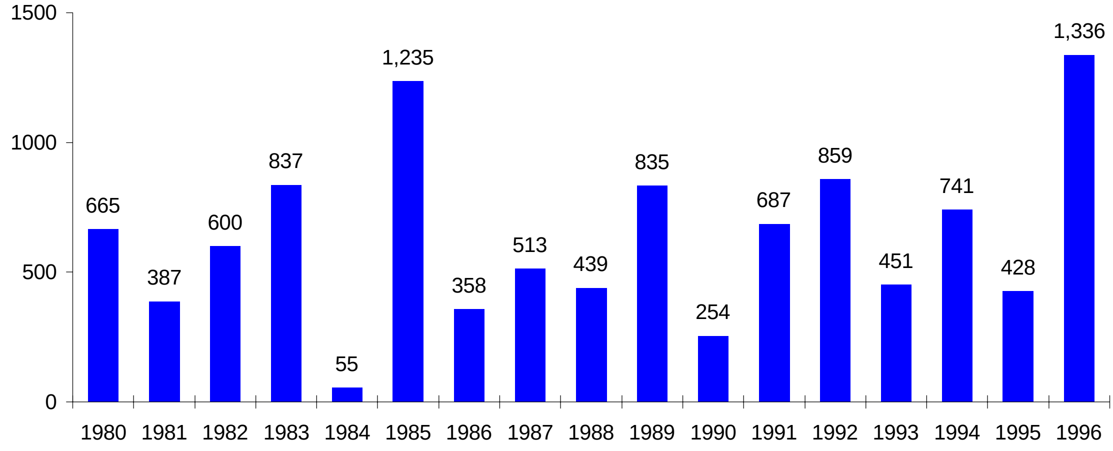

Figure 13.2 Fatalities between 1980 and 1996 inclusive

In 1996 there were 1,336 fatalities, which was over twice the average number of fatalities per year of 628. The average number of fatalities per accident was 59.

The total number of aircraft occupants in the 180 fatal accidents was 17,565. The number of fatalities divided by the total number of aircraft occupants in the 180 fatal accidents gives a fatality rate of 61%. Alternatively, on average 39% of aircraft occupants survived in the 180 fatal accidents to Western-built jets.

13.3 Fatal accidents by operator region

The 180 fatal accidents to Western-built jets are shown by operator region:

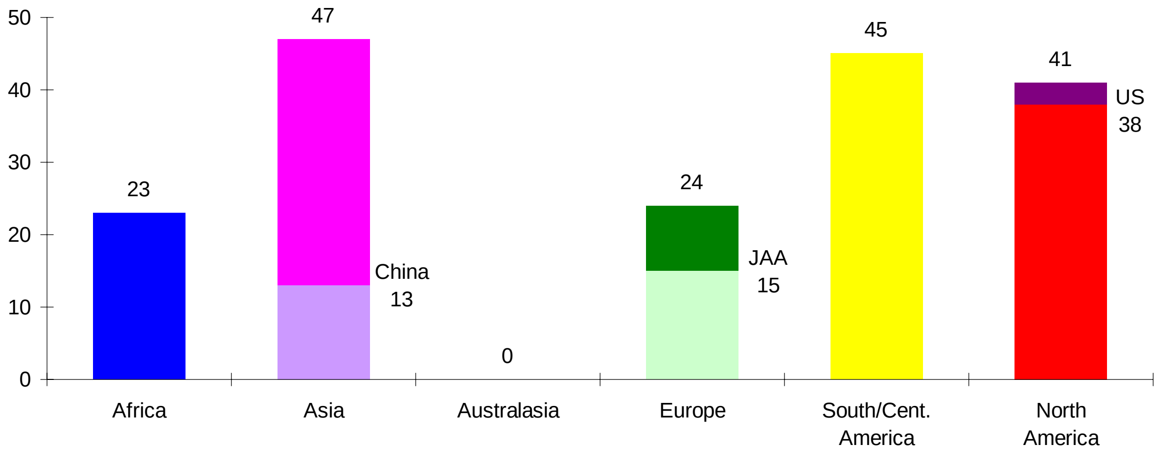

Figure 13.3 Fatal accidents by operator region

There have been no fatal accidents to Western-built jets flown by Australasian operators over the period 1980 - 1996 inclusive.

13.4 Fatal accidents rates by operator region

When utilisation data such as flights are applied to Western-built jets to give fatal accident rates, the comparisons are totally different as shown in Figure 13.4:

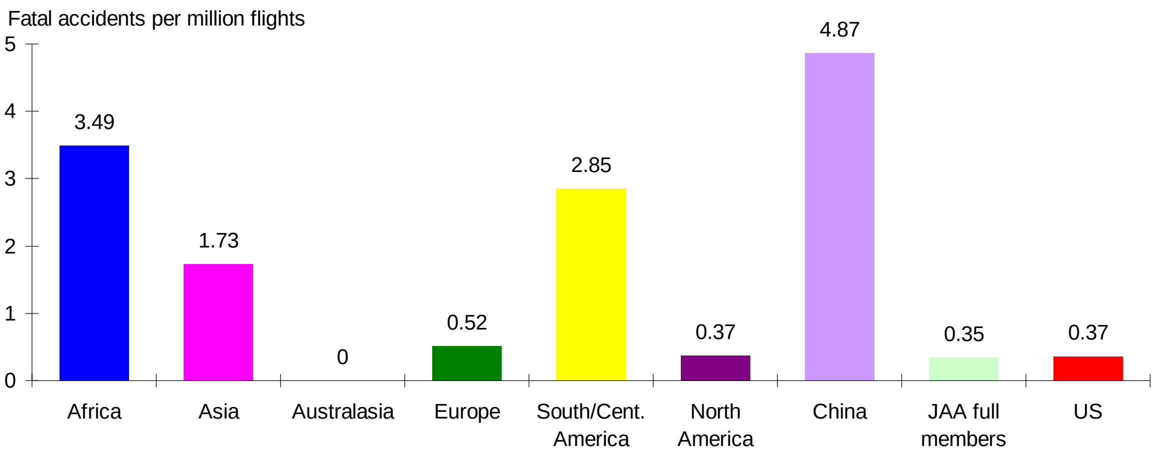

Figure 13.4 Fatal accidents rates by operator region

North American and European operators have achieved the lowest fatal accident rates over the period 1980 - 1996, with 0.37 and 0.52 fatal accidents per million flights respectively.

The fatal accident rate for African operators was 9 times higher than that for North American operators and nearly 7 times higher than that for European operators.

The fatal accident rate for Chinese operators was nearly 3 times higher than that for Asian operators as a whole; 9 times higher than that for European operators and 13 times higher than that for North American operators.

Operators from the rest of Europe (excluding JAA full members) achieved a fatal accident rate of 2.88 due to 9 fatal accidents in just over 3 million flights. This fatal accident rate was 8 times higher than that for JAA full member operators.

13.5 Fatal accident rates 'unlikely to be exceeded' by operator region

The evaluation of service experience through the determination of fatal accident rates presents one particular problem. Where the aircraft population is relatively small and the associated fatal accident rate is very low (e.g. zero), the fatal accident rate may be misleading because of the small sample size of the population used. Such a fatal accident rate would be considered to have a low level of statistical confidence.

To overcome this problem and establish a consistent level of confidence for fatal accidents rates of different populations, an accepted approach is to employ the Poisson distribution. This is used to determine the fatal accident rate which, to a given level of confidence, is unlikely to be exceeded. In practice, this rate is determined by:

- considering the number of fatal accidents for the population,
- determining, using Poisson distribution data, the number of fatal accidents which on average is unlikely to be exceeded to the defined level of confidence,
- dividing this latter figure by the number of flights to obtain a fatal accident rate figure which is unlikely to be exceeded at a defined level of confidence.

A level of confidence commonly employed in statistical comparisons is 95%, which has been used to derive Figure 13.5:

When a 95% level of confidence is applied to the fatal accident rate for the operator regions, Australasian operators have a notional fatal accident rate figure which is unlikely to exceed 0.61, rather than the actual rate of zero. This takes into account the relatively low number of flights accrued by Australasian operators.

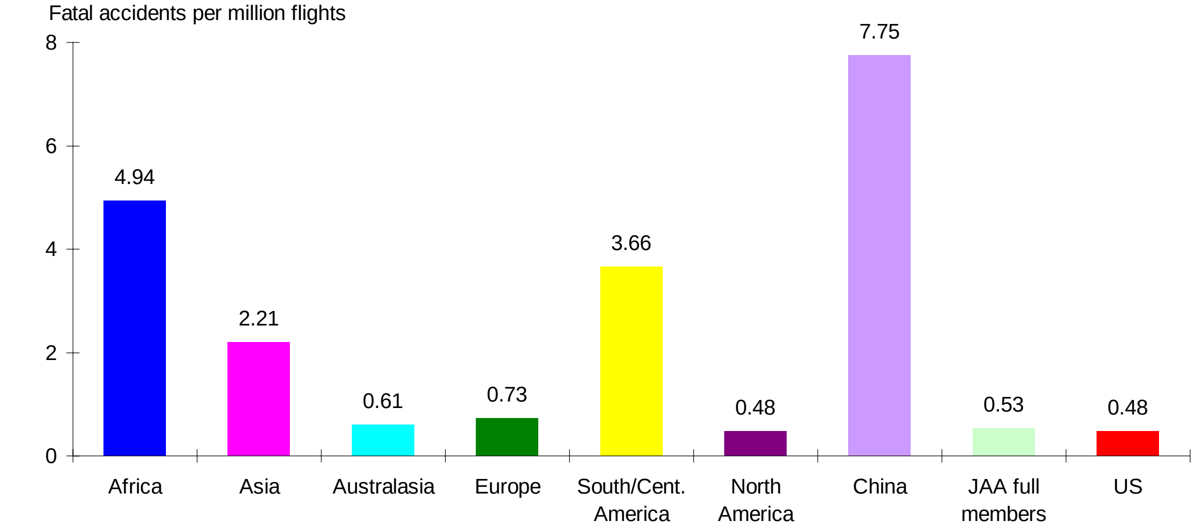

Figure 13.5 Fatal accident rates 'unlikely to be exceeded' by operator region

13.6 Fatalities by operator region

The fatalities from the 180 accidents to Western-built jets are shown by operator region:

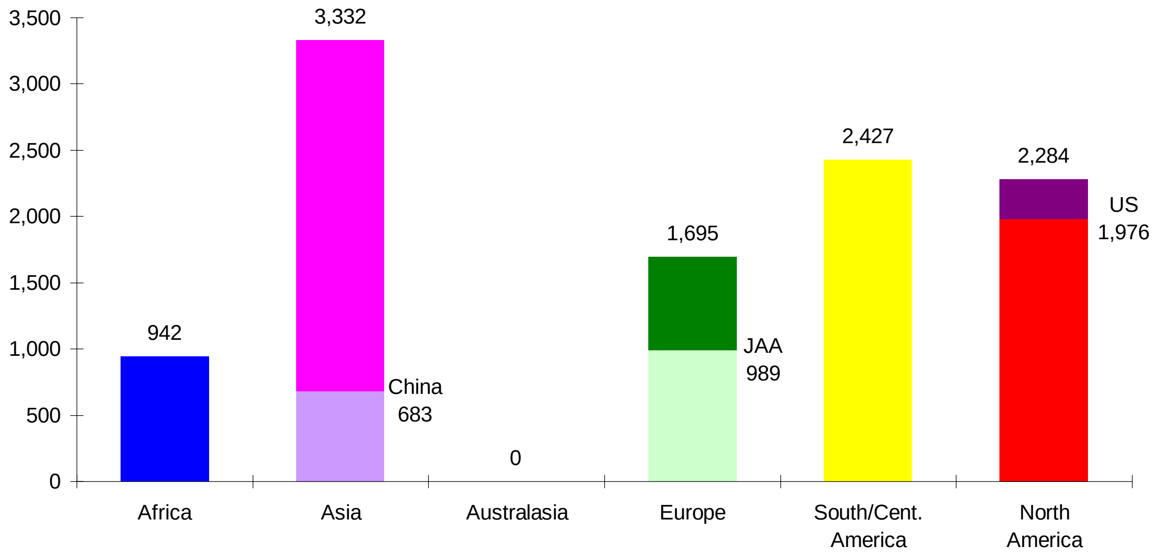

Figure 13.6 Fatalities by operator region

The highest number of fatalities (3,332) occurred in accidents involving Asian operators, accounting for 31% of fatalities in Western-built jet accidents.

13.7 Fatality rates by operator region

Utilisation data such as flights has been applied to give fatality rates, as shown in Figure 13.7:

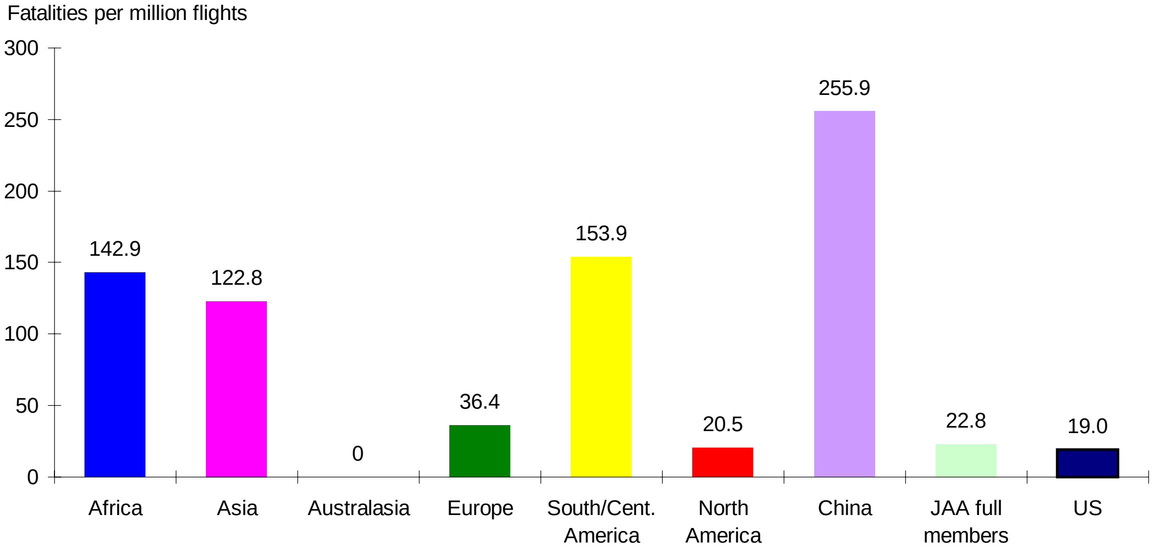

Figure 13.7 Fatality rates by operator region

The fatality rate for accidents involving Chinese operators was twice that for Asian operators as a whole; 11 times higher than that for European operators and 12 times higher than that for North American operators.

14 CONCLUSIONS

A study has been carried out to establish primary causal factors, causal factors, circumstantial factors and consequences for 621 fatal accidents between 1980 and 1996 inclusive. It is believed that the study has been successful in highlighting the most important causal and circumstantial factors, to help focus attention on necessary changes to further enhance aviation's safety record.

14.1 Worldwide accidents

14.1.1 Ignoring accidents to Eastern-built aircraft and CIS operators:-

Over the period 1980 - 1996, the annual number of fatal accidents has increased by 32% (best fit line), mainly attributable to an increase in air traffic growth.

If this growth of fatal accidents continued, by the year 2010 there would be an annual average of 44 fatal accidents. However, between 1990 and 1996 the trend in the number of fatal accidents has been decreasing.

14.1.2 Half of the 621 worldwide fatal accidents (50%) occurred during the approach and landing phases of flight [see ref. 2 for a more detailed analysis].

14.1.3 The fatal accident rates for African and South/Central American operators were considerably higher than for operators from other world regions.

14.1.4 The fatal accident rate for freight, ferry and positioning flights was estimated to be 8 times higher than that for passenger flights.

14.2 Primary causal factors

14.2.1 The most frequently identified primary causal factor was "Lack of positional awareness in air" which was generally related to Controlled Flight Into Terrain, closely followed by "Omission of action / inappropriate action". This second causal factor usually referred to the crew continuing their descent below the Decision Height or Minimum Decision Altitude without visual reference or when visual clues were lost.

14.2.2 "Press-on-itis" was identified as being the primary causal factor in 18% of accidents to Eastern-built aircraft, compared with an average of 6% for the other aircraft classes.

14.3 Causal factors (including primary)

14.3.1 Nearly 40% of accidents involved "Lack of positional awareness in air" as a causal factor although there appeared to be a decreasing trend in the percentage of accidents with this causal factor over the 1990s.

14.3.2 "Design shortcomings" and "Post crash fire" were identified as causal factors in over 10% of accidents.

14.3.3 “Flight handling” was the most frequently identified causal factor for North American operators, evident in 39% of the fatal accidents.

14.4 Circumstantial factors

14.4.1 Nearly 40% of all accidents involved "Non-fitment of presently available safety equipment", and referred mainly to GPWS and enhanced GPWS.

14.4.2 “Failure in CRM” was the most frequently identified circumstantial factor for African and Asian operators.

14.5 Consequences

14.5.1 The most frequently identified consequences were “Collision with terrain/water/ obstacle” and “Controlled Flight Into Terrain”, followed by “Loss of control in flight”.

14.5.2 “Post crash fire” occurred in 22% of fatal accidents.

14.5.3 “Controlled Flight Into Terrain” appears to have shown a decreasing trend during the 1990’s, in terms of the percentage of accidents involving this consequence.

14.6 Causal group analysis

14.6.1 Of the 589 fatal accidents with sufficient information, 76% involved a *crew* primary causal factor and in 88% of accidents the *crew* was identified as a causal factor.

14.6.2 Of the 589 fatal accidents with sufficient information,11% involved an *aircraft* primary causal factor and in 40% of accidents the *aircraft* was identified as a causal factor.

14.7 Western-built jets

14.7.1 In 1996 there were 1,336 fatalities, which was over twice the average number of fatalities per year of 628.

14.7.2 There were no fatal accidents involving Australasian operators during the time period considered.

14.7.3 North American and European operators have achieved the lowest fatal accident rates of 0.37 and 0.52 fatal accidents per million flights respectively.

14.7.4 The fatal accident rate of 0.35 fatal accidents per million flights for JAA full member operators was lower than 0.37 for US operators, and 8 times lower than that for operators from the rest of Europe.

14.7.5 The fatal accident rate for African operators was 9 times higher than that for North American operators and nearly 7 times higher than that for European operators.

DEFINITIONS

Africa

The countries included in the African region are as follows:

Algeria	Angola	Benin	Botswana
Burkina Faso	Burundi	Cameroon	Cape Verde Islands
Central African Rep.	Chad	Ciskei	Comoros
Congo	Dem. Rep. of Congo	Djibouti	Egypt
Ethiopia	Gabon	Gambia	Ghana
Guinea	Guinea-Bissau	Ivory Coast	Kenya
Lesotho	Liberia	Libya	Madagascar
Malawi	Mali	Mauritania	Mauritius
Morocco	Mozambique	Namibia	Niger
Nigeria	Rep. Bophuthatswana	Rwanda	Sao Tome and Principe
Senegal	Seychelles	Sierra Leone	Somalia
South Africa	Sudan	Swaziland	Tanzania
Togo	Tunisia	Uganda	Zambia
Zimbabwe			

Asia

The countries included in the Asian region are as follows:

Afghanistan	Bahrain	Bangladesh	Bhutan
Brunei	Cambodia	China	Hong Kong
India	Indonesia	Iran	Iraq
Israel	Japan	Jordan	Korea
Kuwait	Laos	Lebanon	Macau
Malaysia	Maldives	Mongolia	Myanmar
Nepal	Oman	Pakistan	Palestine
Philippines	Qatar	Saudi Arabia	Singapore
Sri Lanka	Syria	Taiwan	Thailand
Vietnam	Yemen		

Australasia

The countries included in the Australasian region are as follows:

American Samoa	Australia	Cook Islands
Fiji	French Polynesia	Guam
Kiribati	Marshall Islands	Nauru
New Caledonia	New Zealand	Northern Marianas Islands
Pacific Islands	Palau	Papua New Guinea
Solomon Islands	Tonga	Vanuatu
Western Samoa		

Causal factor
An event or item which was directly instrumental in the causal chain of events leading to the accident.

Circumstantial factor
An event or item which was not directly in the causal chain of events but could have contributed to the accident.

CIS (Commonwealth of Independent States) countries

Armenia	Azerbaijan	Belarus	Georgia
Kazakstan	Kyrgyzstan	Rep. of Moldova	Russian Federation
Tajikistan	Turkmenistan	Ukraine	Uzbekistan

Consequence
Outcome of the accident.

Europe
The countries included in the European region are as follows (JAA full member countries in **bold** and CIS countries in underlined):

Albania	Armenia	**Austria**	Azerbaijan
Belarus	**Belgium**	Bosnia-Herzegovina	Bulgaria
Croatia	Cyprus	Czechoslovakia	Czech republic
Denmark	Estonia	Faroe Islands	**Finland**
France	Georgia	**Germany**	Gibraltar
Greece	Greenland	Hungary	**Iceland**
Ireland	**Italy**	Kazakstan	Kyrgyzstan
Latvia	Lichtenstein	Lithuania	**Luxembourg**
Macedonia	Malta	Moldova	**Monaco**
Montenegro	**Netherlands**	**Norway**	Poland
Portugal	Romania	Russia	Serbia
Slovakia	Slovenia	**Spain**	**Sweden**
Switzerland	Tajikistan	Turkey	Turkmenistan
Ukraine	**United Kingdom**	USSR	Uzbekistan
Yugoslavia			

JAA full member countries

Austria	Belgium	Denmark	Finland
France	Germany	Greece	Iceland
Ireland	Italy	Luxembourg	Monaco
Netherlands	Norway	Portugal	Spain
Sweden	Switzerland	United Kingdom	

Level of confidence
The level of confidence in the accident summary and the consequent factors allocated by the group.

North America
The countries included in the North American region are as follows:

Anguilla	Antigua & Barbuda	Aruba	Bahamas
Barbados	Bermuda	Canada	Cayman islands
Cuba	Dominica	Dominican Republic	Grenada
Guadeloupe	Haiti	Jamaica	Martinique
Montserrat	Puerto Rico	St. Kitts & Nevis	St. Lucia
St. Pierre & Miquelon		Trinidad & Tobago	
St. Vincent & the Grenadines		Turks & Caicos Islands	
USA		Virgin islands	

Operator region
The world region from which the operator originates.

Primary causal factor
The dominant causal factor of the accident as judged by the group.

Rest of Europe
All European countries other than the JAA full members but including all CIS countries.

South/Central America
The countries included in the South/Central American region are as follows:

Argentina	Belize	Bolivia	Brazil
Chile	Colombia	Costa Rica	Ecuador
El Salvador	Falkland islands	French Guyana	Guatemala
Guyana	Honduras	Mexico	Nicaragua
Panama	Paraguay	Peru	Suriname
Uruguay	Venezuela		

Western-built jets
The following aircraft are included:

Airbus A300, A310, A319, A320, A321, A330, A340
Avro RJ
BAC-111
BAe146
BAe (DH) Comet
BAe (HS) Trident
BAe (Vickers) VC-10
BAe/Aerospatiale Concorde
Boeing B707, B720, B727, B737, B747, B757, B767, B777
Canadair RJ
Caravelle
CV880, CV990
Fokker F.28, FK70, FK100
Lockheed L-1011 Tristar
McDonnell Douglas DC-8, DC-9, DC-10, MD-11, MD-80, MD-90

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APPENDIX

List of factors attributed to worldwide fatal accidents - 1980 to 1996

List of Factors Attributed to Worldwide Fatal Accidents - 1980 to 1996

(Each accident usually has more than one factor)

A	Causal factors			Primary	Causal	Total accidents
A.1	Aircraft systems	1.1	System failure - affecting controllability	10	15	25
		1.2	System failure - flight deck information	8	12	20
		1.3	System failure - other	1	18	19
A.2	ATC / Ground aids	2.1	Incorrect or inadequate instruction/advice	2	22	24
		2.2	Misunderstood / missed communication	1	7	8
		2.3	Failure to provide separation - air	5	4	9
		2.4	Failure to provide separation - ground	2	3	5
		2.5	Ground aid malfunction or unavailable	0	6	6
A.3	Environmental	3.1	Structural overload	1	2	3
		3.2	Wind shear / upset / turbulence	12	26	38
		3.3	Icing	7	14	21
		3.4	Wake turbulence - aircraft spacing	1	1	2
		3.5	Volcanic ash / sand / precipitation etc.	0	9	9
		3.6	Birds	4	0	4
		3.7	Lightning	1	0	1
		3.8	Runway condition unknown to crew	1	4	5
A.4	Crew	4.1	Lack of positional awareness - in air	123	121	244
		4.2	Lack of positional awareness - on ground	2	3	5
		4.3	Lack of awareness of circumstances in flight	0	7	7
		4.4	Incorrect selection on instrument / navaid	6	6	12
		4.5	Action on wrong control / instrument	1	2	3
		4.6	Slow / delayed action	5	44	49
		4.7	Omission of action / inappropriate action	116	100	216
		4.8	"Press-on-itis"	46	51	97
		4.9	Failure in CRM (cross-check / co-ordinate)	8	93	101
		4.10	Poor professional judgement/airmanship	22	112	134
		4.11	Disorientation or visual illusion	2	12	14
		4.12	Fatigue	0	13	13
		4.13	State of mind	2	3	5
		4.14	Interaction with automation	4	16	20
		4.15	Fast and/or high on approach	0	31	31
		4.16	Slow and/or low on approach	1	112	113
		4.17	Loading incorrect	8	12	20
		4.18	Flight handling	76	98	174
		4.19	Lack of qualification / training / experience	2	45	47
		4.20	Incapacitation / medical or other factors reducing crew performance	6	6	12
		4.21	Failure in look-out	3	12	15
		4.22	Deliberate non-adherence to procedures	14	58	72
A.5	Engine	5.1	Engine failure or malfunction	6	41	47
		5.2	Propeller failure	4	1	5
		5.3	Damage due to non-containment	7	4	11
		5.4	Fuel contamination	1	0	1
		5.5	Engine failure simulated	0	11	11
A.6	Fire	6.1	Engine fire or overheat	3	6	9
		6.2	Fire due to aircraft systems	4	2	6
		6.3	Fire - other cause	8	3	11
		6.4	Post crash fire	0	63	63
A.7	Maintenance / ground handling	7.1	Failure to complete due maintenance	2	3	5
		7.2	Maintenance or repair error / oversight / inadequacy	10	18	28
		7.3	Ground staff or passenger(s) struck by aircraft	2	0	2

A	Causal factors			Primary	Causal	Total accidents
A.7	Maintenance / ground handling	7.4	Loading error	4	6	10
		7.5	Bogus parts	1	0	1
A.8	Structure	8.1	Corrosion / fatigue	5	6	11
		8.2	Overload failure	2	22	24
		8.3	Flutter	0	2	2
A.9	Infrastructure	9.1	Incorrect , inadequate or misleading information to crew	2	29	31
		9.2	Inadequate aerodrome support	1	19	20
A.10	Design	10.1	Design shortcomings	13	54	67
		10.2	Unapproved modification	1	3	4
		10.3	Manufacturing defect	0	6	6
A.11	Performance	11.1	Unable to maintain speed / height	5	33	38
		11.2	A/c becomes uncontrollable	0	34	34
A.12	Other	12.1	Caused by other aircraft	5	3	8
		12.2	Non-adherence to cabin safety procedures	0	10	10

B	Circumstantial factors			Accidents
B.1	Aircraft systems	1.1	Non-fitment of presently available safety equipment (GPWS, TCAS, windshear warning etc.)	247
		1.2	Failure / inadequacy of safety equipment	11
B.2	ATC / ground aids	2.1	Lack of ATC	6
		2.2	Lack of ground aids	92
B.3	Environmental	3.1	Poor visibility	124
		3.2	Other weather	194
		3.3	Runway condition (ice, slippery, standing water etc.)	18
B.4	Crew	4.1	Training inadequate	40
		4.2	Presented with situation beyond training	28
		4.3	Failure in CRM (cross-check / co-ordinate)	234
B.5	Infrastructure	5.1	Incorrect / inadequate procedures	51
		5.2	Company management failure	135
		5.3	Inadequate regulation	53
		5.4	Inadequate regulatory oversight	153
B.6	Other	6.1	Illegal / unauthorised / drug smuggling flight	4

C	Consequences	Accidents
C.1	Controlled Flight Into Terrain (CFIT)	219
C.2	Collision with terrain / water / obstacle	289
C.3	Mid-air collision	13
C.4	Ground collision with other aircraft	11
C.5	Ground collision with object / obstacle	39
C.6	Loss of control in flight	178
C.7	Fuel exhaustion	20
C.8	Overrun	55
C.9	Undershoot	53
C.10	Structural failure	27
C.11	Post crash fire	134
C.12	Fire / smoke during operation	24
C.13	Emergency evacuation difficulties	17
C.14	Forced landing - land or water	30
C.15	Other cause of fatality	6

Level of confidence

300	***High***	67	***Low***
222	***Medium***	32	***Insufficient information***