CAP 776

Global Fatal Accident Review 1997 - 2006

Civil Aviation Authority

Safety Regulation Group

CAP 776

Global Fatal Accident Review 1997–2006

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Executive Summary

The main risks to large public transport aeroplanes are identified through analysis of worldwide fatal accidents, which is a task carried out annually by the CAA Accident Analysis Group (AAG). The output of the AAG forms a key part of the CAA Safety Planning process in that these main risks are assessed for their relevance to the UK aviation system and, where appropriate, safety interventions are identified to mitigate them. These safety interventions can be found in the CAA Safety Plan.

This document summarises a study of AAG analysed worldwide fatal accidents to jet and turboprop aeroplanes above 5,700 kg engaged in passenger, cargo and ferry/positioning flights for the ten-year period 1997 to 2006. The style and content of the document are similar to the previous Global Fatal Accident Review (CAP 681). The main findings of the study are listed below.

1 Worldwide Fatal Accident Numbers

1.1 There was a total of 283 worldwide fatal accidents, which resulted in 8,599 fatalities to passengers and crewmembers onboard the aircraft. The proportion of aircraft occupants killed in these fatal accidents was 69%.

1.2 There was an overall decreasing trend in both the number of fatal accidents and fatalities, although there was more fluctuation in the number of fatalities.

1.3 The approach, landing and go-around phases accounted for 47% of all fatal accidents and 42% of all onboard fatalities. Take-off and climb accounted for a further 30% of the fatal accidents and 29% of the onboard fatalities.

2 Worldwide Aircraft Utilisation

2.1 In the ten-year period from 1997 to 2006, the number of flights flown increased by 17%, which equated to an average annual growth of 1.5%. The equivalent values for hours flown were 31% for overall growth and 2.8% for average annual growth.

3 Worldwide Fatal Accident Rates

3.1 The overall fatal accident rate for the ten-year period 1997 to 2006 was 0.79 fatal accidents per million flights flown or 0.49 when expressed as per million hours flown.

3.2 There was a decreasing trend in both the overall rate of fatal accidents and onboard fatalities.

3.3 On average, the fatal accident rate for turboprops was three times that for jets, based on flights flown, and nearly seven times greater when using hours flown as the rate measure.

3.4 On average, the fatal accident rate for aircraft with maximum take-off weight below 15 tonnes was twice that for aircraft with maximum take-off weight above 27 tonnes, based on flights flown, and over four times greater when using hours flown as the rate measure.

3.5 On average, the fatal accident rate for cargo flights was six times greater than for passenger flights (applicable for both rate measures).

3.6 The fatal accident rate for African operators was over seven times greater than that for all operators combined and over 30 times greater than that for North American operators, which had the lowest fatal accident rate of all the regions.

4 Factors and Consequences

4.1 Two-thirds of all fatal accidents involved a flight crew related *primary* causal factor and 7% involved an aircraft related *primary* causal factor.

4.2 The most frequently identified primary causal factor was "Omission of action/inappropriate action", which was allocated in 22% of all fatal accidents. This generally related to flight crew continuing their descent below the decision height or minimum descent/safety heights without visual reference, failing to fly a missed approach or omitting to set the correct aircraft configuration for take-off.

4.3 Three-quarters of all fatal accidents involved at least one flight crew related causal factor and 42% involved at least one aircraft related causal factor.

4.4 The most frequently identified causal factors were "Omission of action/inappropriate action", "Flight handling" and "Lack of positional awareness - in air", which were allocated in 39%, 29% and 27% of all fatal accidents respectively. "Flight handling" tended to be associated with inadequate speed, pitch attitude and/or directional control, often following an engine failure, resulting in the aircraft stalling.

4.5 These three causal factors were also the most prominent in the previous Global Fatal Accident Review. However, "Lack of positional awareness - in air" was involved in proportionally fewer fatal accidents in this study, which reflected a decrease in the proportion of Controlled Flight Into Terrain (CFIT) accidents.

4.6 The most frequently identified circumstantial factor was "Non-fitment of presently available aircraft safety equipment", which was allocated in 33% of all fatal accidents. The majority of these related to non-fitment of the latest Terrain Awareness and Warning Systems.

4.7 "Post crash fire" and "Loss of control in flight" were the two most frequently identified consequences, each appearing in approximately 40% of all fatal accidents. "CFIT" was the third most common consequence, accounting for 25% of all fatal accidents.

4.8 Compared to the previous Global Fatal Accident Review, "Post crash fire" and "Loss of control in flight" were involved in proportionally more fatal accidents, whilst "CFIT" was involved in proportionally fewer fatal accidents.

Chapter 1 Introduction

1 The main risks to large public transport aeroplanes are identified through analysis of worldwide fatal accidents, which is a task carried out annually by the CAA Accident Analysis Group (AAG). The output of the AAG forms a key part of the CAA Safety Planning process in that these main risks are assessed for their relevance to the UK aviation system and, where appropriate, safety interventions are identified to mitigate them. These safety interventions can be found in the CAA Safety Plan, which is published on the CAA website.

2 This document summarises a study of AAG analysed worldwide fatal accidents covering the ten-year period 1997 to 2006. The style and content of the document are similar to the previous Global Fatal Accident Review (CAP 681) but there are, however, some differences and these are outlined in Appendix 1.

3 The main objectives of the study were to provide a statistical overview of global fatal accidents and identify the most prevalent factors that contributed to these accidents. The CAA has deliberately avoided drawing conclusions from the statistics and invites the reader to draw their own inferences.

4 The criteria for an accident to be included in the study dataset were as follows:

- Jet and turboprop aeroplanes
- Maximum take-off weight above 5,700 kg
- Civil passenger, cargo and ferry/positioning flights
- At least one fatality to an aircraft occupant
- Excluding accidents known to have resulted from acts of terrorism or sabotage

5 The AAG uses a systematic process to analyse worldwide fatal accidents, which involves the allocation of primary causal factors, other causal factors, circumstantial factors and consequences. When allocating factors, it is not the intention of the AAG to apportion blame. The analysis process is described in greater detail in Appendix 1.

6 There are various terms used in this study with respect to fatal accidents and their analysis. Explanations for these terms can be found in the Definitions section in Appendix 2. There is also a Glossary of acronyms contained in Appendix 3.

7 The raw accident and aircraft utilisation data used in this study originated from Ascend (formerly Airclaims[1]) and was supplemented by accident briefs and reports from other sources. All sources other than the CAA have been referenced in this document and are hereby acknowledged for the information supplied.

8 The CAA welcomes any comments regarding this study and in particular on how the document could be improved in the future. Comments can be forwarded by e-mail to Safety.Analysis@caa.co.uk.

1. The Airclaims Client Aviation System Enquiry (CASE) database was the source of raw fatal accident data.

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Chapter 2 Fatal Accident Statistics

1 Introduction

1.1 This chapter presents high-level statistics on the number and, where practicable, the rate of fatal accidents and fatalities, broken down by: year, type of aircraft, nature of flight, phase of flight, accident location and operator region of origin. There is also a brief section on aircraft utilisation.

1.2 The section on numbers of fatal accidents refers to all fatal accidents in the dataset. However, the section on rates excludes fatal accidents involving ferry or positioning flights and business jet aircraft. This is due to unavailability of consistent utilisation data for these types of operation and aircraft. The section on rates contains greater detail on fatal accident trends.

2 Worldwide Fatal Accident Numbers

2.1 Number of Worldwide Fatal Accidents and Fatalities by Year

2.1.1 There was a total of 283 worldwide fatal accidents in the ten-year period 1997 to 2006, which resulted in 8,599 fatalities to passengers and crewmembers onboard the aircraft. The proportion of aircraft occupants killed in these fatal accidents was 69%, which indicates that, on average, 31% of occupants survived. A further 206 casualties were incurred on the ground[1] and six on other aircraft that were involved in collisions but whose size or type of operation excluded them from the dataset.

2.1.2 Figures 1 and 2 show, respectively, the annual numbers of fatal accidents and onboard fatalities, together with a three-year moving average trend line. There was an overall decreasing trend in both the number of fatal accidents and fatalities, although there was more fluctuation in the number of fatalities.

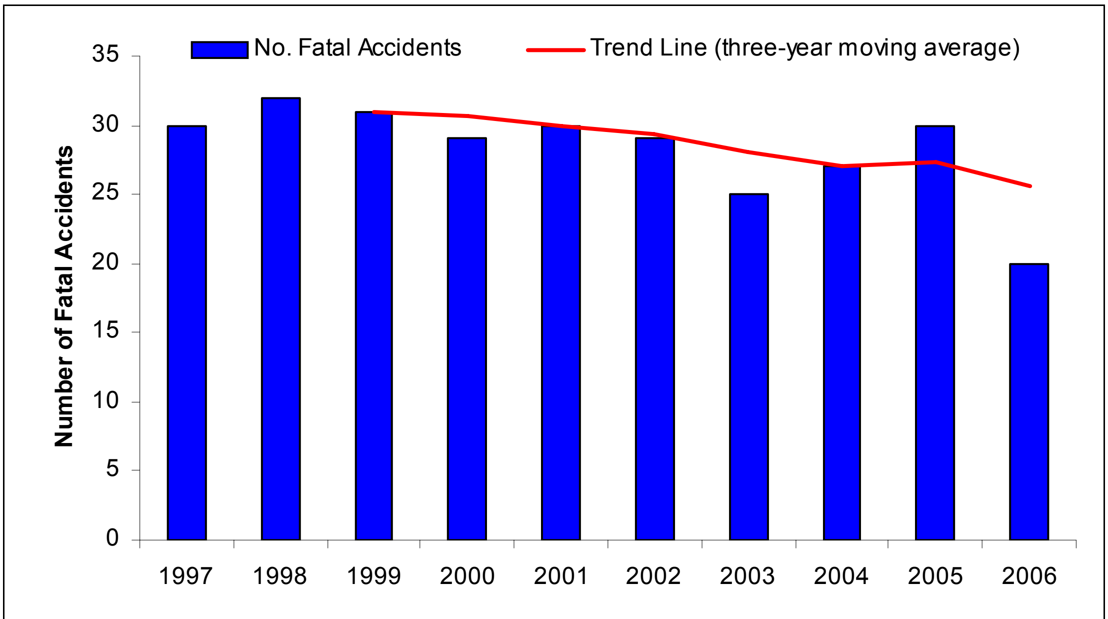

Figure 1 Annual numbers of worldwide fatal accidents

1. The number of ground casualties should be treated with caution due to uncertainty in the number of fatalities reported for some fatal accidents.

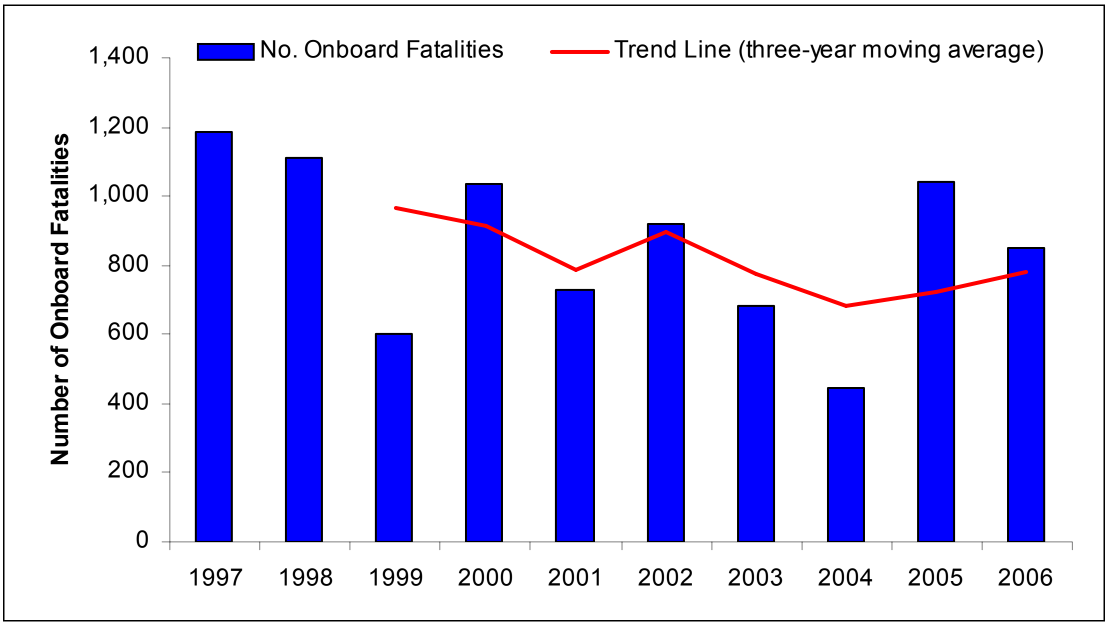

Figure 2 Annual numbers of onboard fatalities for worldwide fatal accidents

2.1.3 There were six fatal accidents in which more than 200 aircraft occupants were killed and 32 where the onboard fatality count was greater than 100. The average number of onboard fatalities per fatal accident was 30. The worst accident, in terms of the total number of fatalities, was to an Airbus A300B4-605R at Queens, New York on 12 November 2001 in which all 260 aircraft occupants and five people on the ground were killed.

2.1.4 Of the 283 fatal accidents in total, 167 (59%) occurred during daylight, 100 (35%) occurred in darkness and the remaining 16 (6%) took place at an unknown time. Of the 100 fatal accidents that occurred in darkness, 51 took place during the approach (38%), landing (6%) and go-around (7%), and a further 28 occurred during take-off (4%) and climb (24%).

2.2 Number of Worldwide Fatal Accidents and Fatalities by Aircraft Class, Age and Weight Group

2.2.1 Figure 3 shows the annual numbers of fatal accidents broken down by aircraft class, which includes jets, turboprops and business jets. A list of the aircraft types that featured against each class of aircraft can be found in Appendix 4. Fatal accident rates for jets and turboprops only are presented later in this Chapter in Section 4.

2.2.2 Considering the overall ten-year period, 1997 to 2006, jets were involved in 108 fatal accidents (or 38% of the total number of fatal accidents), turboprops in 140 (49%) and business jets in 35 (12%)[1].

2.2.3 On average, jets were involved in 11 fatal accidents per year, turboprops in 14 and business jets in four.

2.2.4 Considering the overall ten-year period 1997 to 2006, fatal accidents involving jets resulted in 6,798 onboard fatalities (or 79% of the total number of onboard fatalities), those involving turboprops resulted in 1,696 (or 20%) and those involving business jets resulted in 105 (or 1%). The proportion of aircraft occupants killed in jets was 69%, 69% in turboprops and 83% in business jets.

1. Percentages sometimes do not add up to 100%, which is due to rounding to the nearest whole number.

2.2.5 The average number of onboard fatalities per fatal accident involving jets, between 1997 and 2006, was 63. The largest number of onboard fatalities in a single fatal accident involving jets was 260, which resulted from loss of control, on an Airbus A300, shortly after take-off following the in-flight separation of the vertical stabiliser and rudder. This occurred at Queens, New York in the USA, in 2001.

2.2.6 The average number of onboard fatalities per fatal accident involving turboprops, between 1997 and 2006, was 12. The largest number of onboard fatalities in a single fatal accident involving turboprops was 62, which resulted from an Antonov An-24 impacting terrain shortly after take-off, in Equatorial Guinea in 2005.

2.2.7 The average number of onboard fatalities per fatal accident involving business jets, between 1997 and 2006, was three. The largest number of onboard fatalities in a single fatal accident involving business jets was 18, which resulted from a Gulfstream III impacting a hill whilst on a VOR/DME approach into Aspen, USA in 2001.

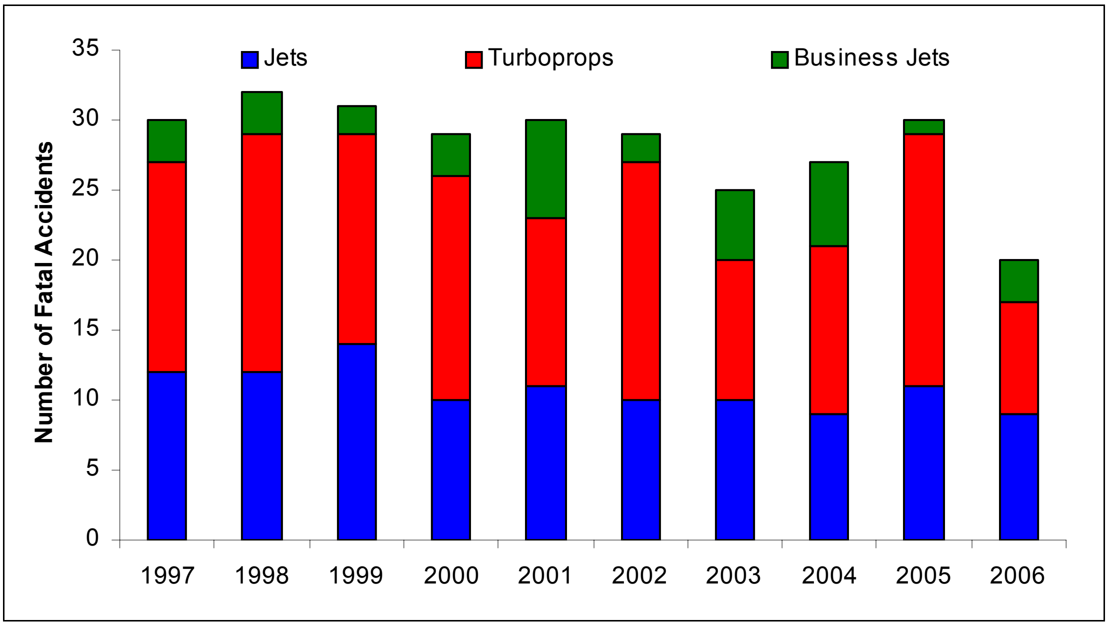

Figure 3 Annual numbers of worldwide fatal accidents broken down by aircraft class

2.2.8 Figure 4 shows the overall numbers of fatal accidents involving aircraft in predefined age groups for each of jets, turboprops and business jets. The average age of all aircraft involved in fatal accidents in the ten-year period was 20 years. The equivalent value for jets was 18 years, 20 years for turboprops and 26 years for business jets.

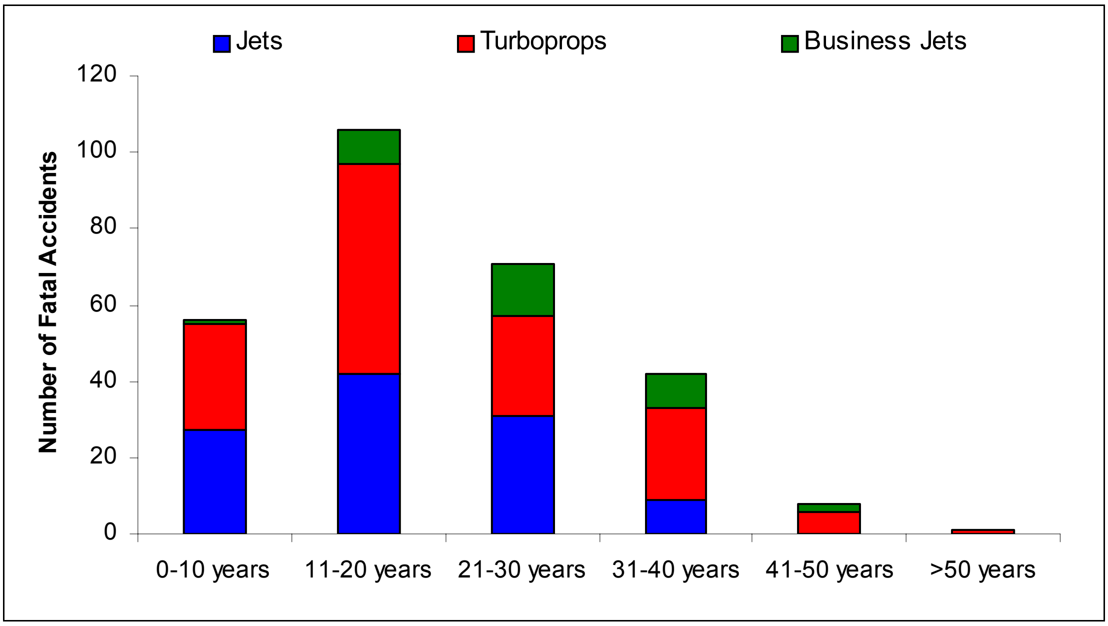

Figure 4 Numbers of worldwide fatal accidents broken down by aircraft age and class for the ten-year period 1997 to 2006

2.2.9 Figure 5 shows the overall numbers of fatal accidents broken down by aircraft weight group for each of jets, turboprops and business jets. Considering the overall ten-year period 1997 to 2006, aircraft with a maximum take-off weight authorised (MTWA) below 15 tonnes accounted for 35% of all fatal accidents, aircraft with MTWA above 15 tonnes and below 27 tonnes accounted for 19% and aircraft with MTWA above 27 tonnes accounted for 46%.

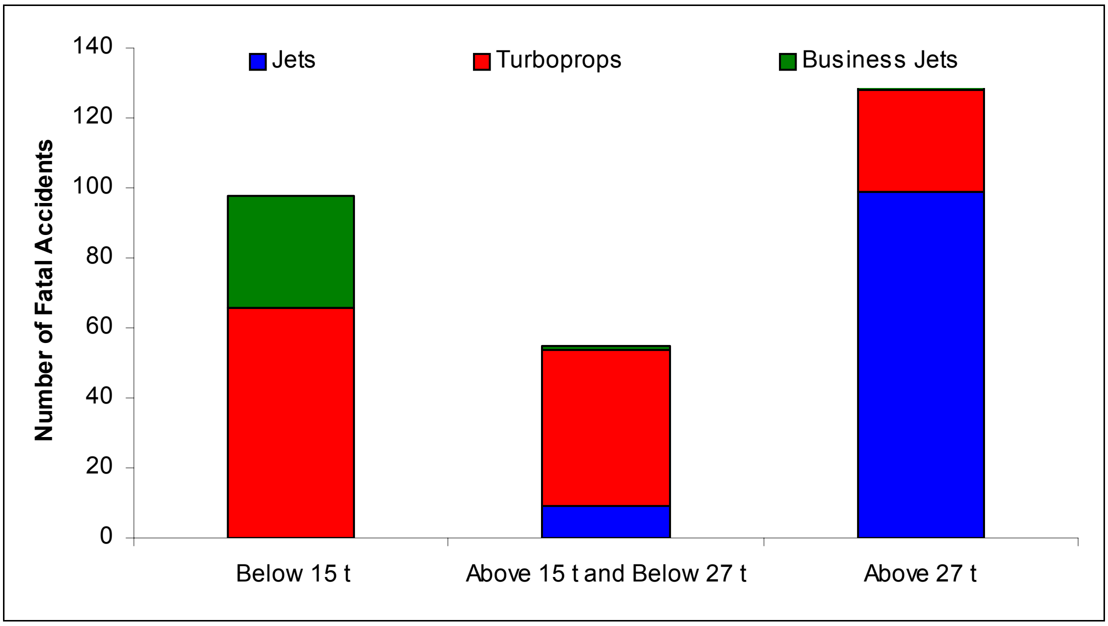

Figure 5 Numbers of worldwide fatal accidents broken down by aircraft class and weight group for the ten-year period 1997 to 2006

2.3 Number of Worldwide Fatal Accidents and Fatalities by Nature of Flight

2.3.1 Figure 6 shows the annual numbers of fatal accidents broken down by nature of flight, which includes passenger, cargo and ferry/positioning flights. Fatal accident rates for passenger and cargo flights only are presented later in Section 4.

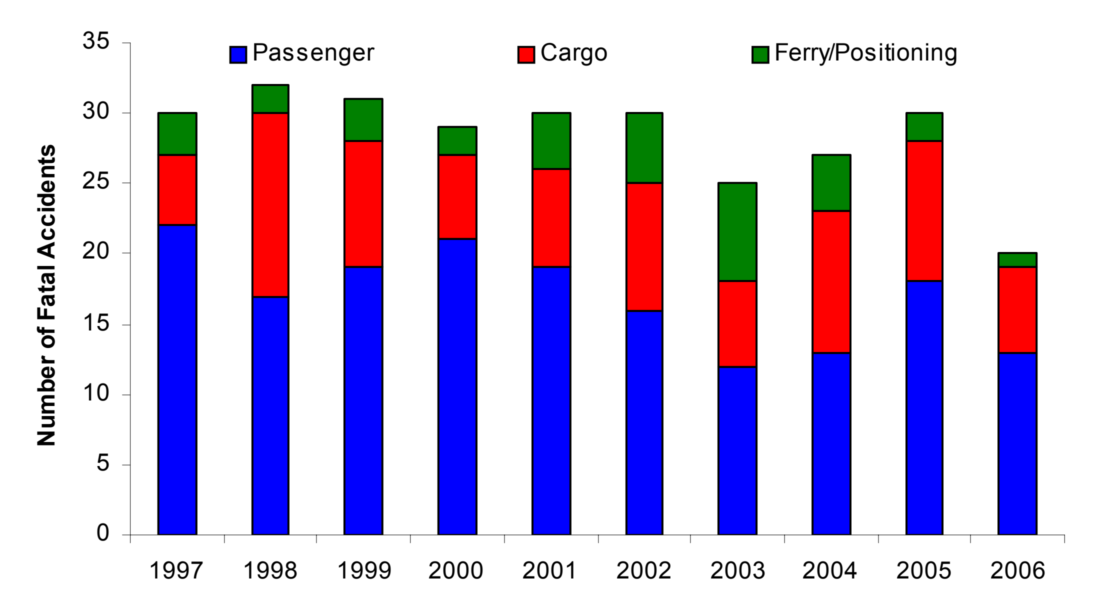

Figure 6 Annual numbers of worldwide fatal accidents broken down by nature of flight

2.3.2 Considering the overall ten-year period 1997 to 2006, passenger flights were involved in 170 fatal accidents (or 60% of the total), cargo flights in 81 (29%) and ferry/positioning flights in 33 (12%)[1].

2.3.3 On average, passenger flights were involved in 17 fatal accidents per year, cargo flights in eight and ferry/positioning flights in three.

2.3.4 Considering the overall ten-year period 1997 to 2006, fatal accidents involving passenger flights resulted in 8,109 onboard fatalities (or 94% of the total number of onboard fatalities), those involving cargo flights resulted in 384 (or 4%) and those involving ferry/positioning flights resulted in 106 (or 1%). The proportion of aircraft occupants killed in passenger flights was 68%, 74% for cargo flights and 93% for ferry/positioning flights.

2.3.5 Of the fatal accidents involving passenger flights, 117 (or 69%) occurred on domestic sectors and 53 (or 31%) on international sectors. Scheduled passenger flights accounted for 108 fatal accidents (or 64% of the passenger flight total) and non-scheduled flights accounted for 62 (or 36%).

2.3.6 Of the fatal accidents involving cargo flights, 48 (or 59%) occurred on domestic sectors and 33 (or 41%) on international sectors. Scheduled cargo flights accounted for 11 fatal accidents (or 14% of the cargo flight total) and non-scheduled flights accounted for 70 (or 86%).

2.3.7 All but seven of the fatal accidents involving ferry/positioning flights occurred on domestic sectors.

1. The sum of fatal accidents by nature of flight was 284, one more than the total stated in Section 2.1.1. This was due to a mid-air collision that involved a passenger and a cargo flight, which was counted against each category. This mid-air collision was treated as one fatal accident in the overall statistics.

2.3.8 Figure 7 shows the overall numbers of fatal accidents broken down by nature of flight and aircraft class. Fatal accidents involving passenger flights were fairly evenly split between jets and turboprops. However, those involving cargo and ferry/positioning flights were far more biased towards turboprops and business jets respectively.

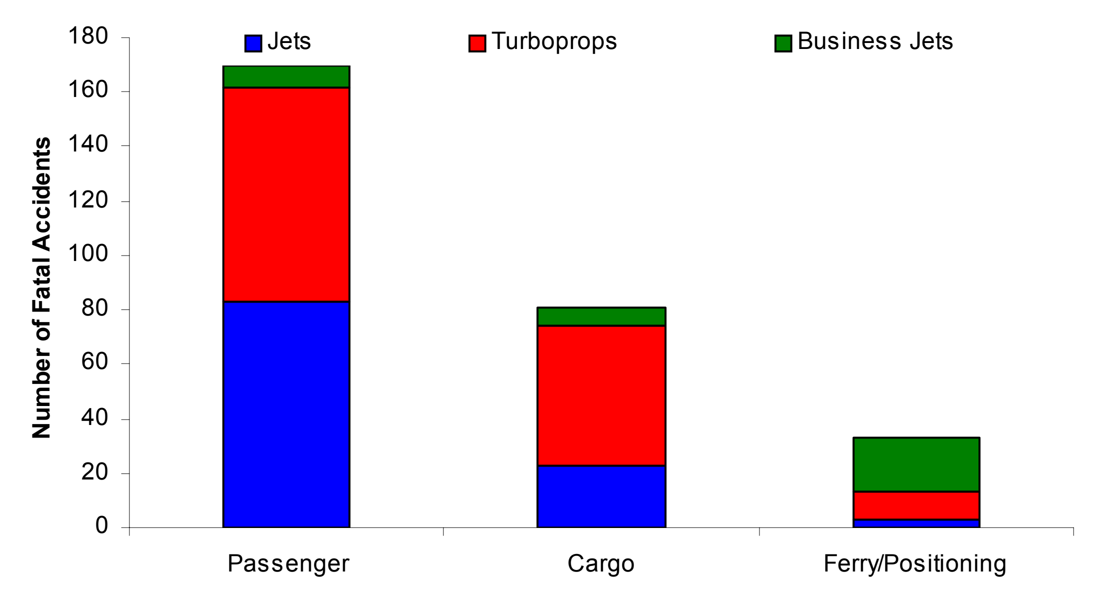

Figure 7 Numbers of worldwide fatal accidents broken down by nature of flight and aircraft class for the ten-year period 1997 to 2006

2.4 Number of Worldwide Fatal Accidents and Fatalities by Phase of Flight

2.4.1 Figures 8 and 9, respectively, show the overall numbers of fatal accidents and onboard fatalities broken down by aircraft phase of flight. The approach, landing and go-around phases accounted for 47% of all fatal accidents and 42% of all onboard fatalities. Take-off and climb accounted for a further 30% of the fatal accidents and 29% of the onboard fatalities. Of the 133 fatal accidents that occurred during approach, landing or go-around, 26 (or 20%) involved a non-precision approach and 18 (or 14%) occurred on at least the second attempt to land.

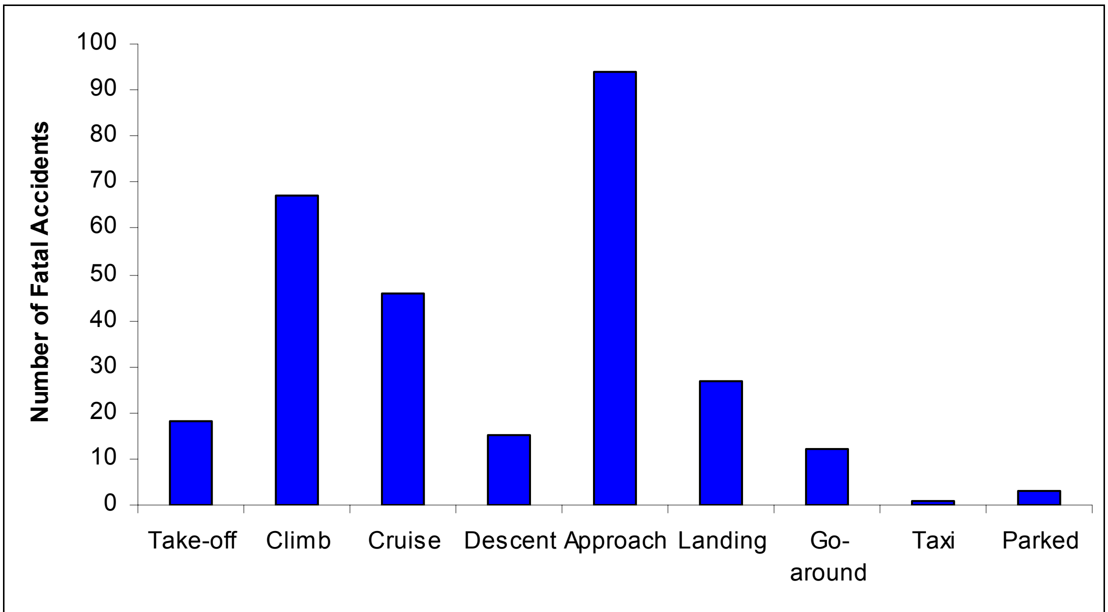

Figure 8 Numbers of worldwide fatal accidents broken down by phase of flight for the ten-year period 1997 to 2006

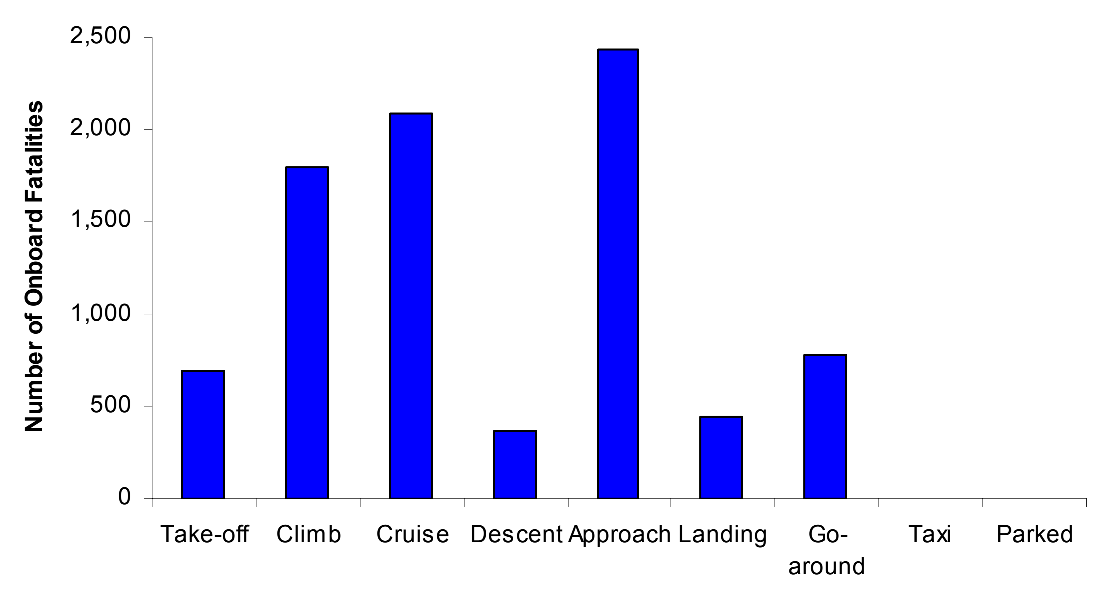

Figure 9 Numbers of onboard fatalities for worldwide fatal accidents broken down by phase of flight for the ten-year period 1997 to 2006

NOTE: The number of onboard fatalities for the taxi and parked phases of flight were one and three respectively.

2.4.2 A total of 19 fatal accidents (or 7%) occurred during a diversion following a problem and 15 (or 5%) occurred whilst attempting a return to the departure airport. The values for onboard fatalities were 556 (or 6%) and 232 (or 3%) respectively.

2.5 Number of Worldwide Fatal Accidents and Fatalities by Accident Location

2.5.1 Figure 10 shows the overall numbers of fatal accidents broken down by location. The regions are based on those defined by the ICAO Safety Indicators Study Group and a list of the countries that form these regions can be found in Appendix 2. For the purposes of this study, the Asia and Middle East regions were joined together, as were the Caribbean and Central America and South America regions.

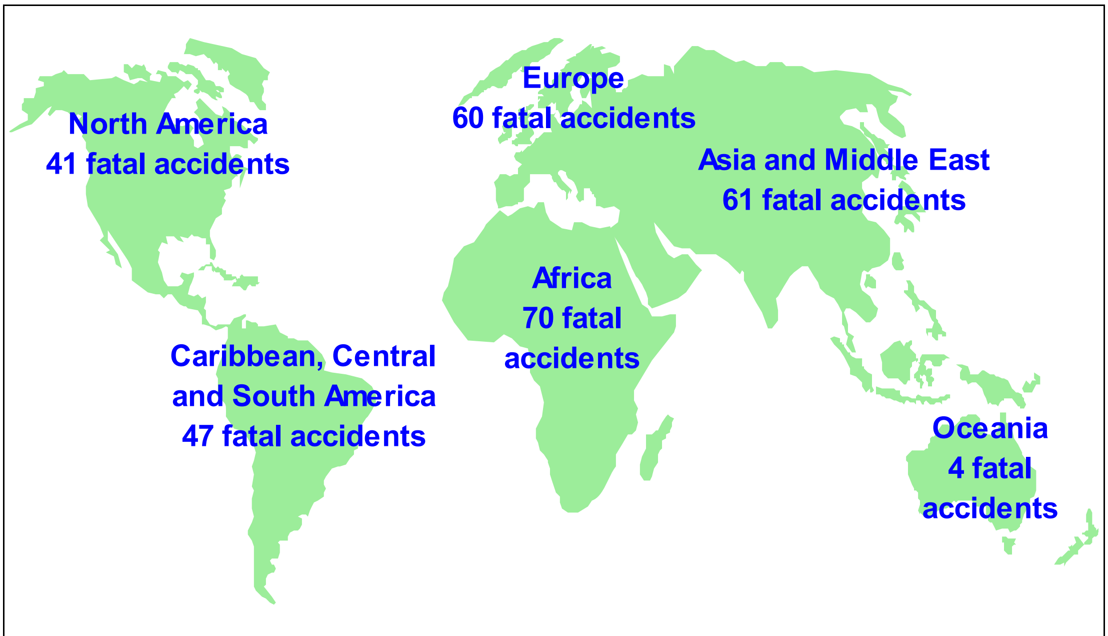

Figure 10 Numbers of worldwide fatal accidents broken down by location region for the ten-year period 1997 to 2006

2.5.2 In terms of the percentage of all fatal accidents involving each location region (with the percentage of onboard fatalities in brackets):

- 25% of fatal accidents occurred in Africa (20% of onboard fatalities)
- 22% occurred in Asia and the Middle East (32%)
- 21% occurred in Europe (19%)
- 17% occurred in the Caribbean, Central and South America (14%)
- 14% occurred in North America (12%)
- 1% occurred in Oceania (3%)

2.6 Number of Worldwide Fatal Accidents and Fatalities by Operator Region

2.6.1 Figure 11 shows the overall numbers of fatal accidents broken down by operator region[1]. Fatal accident rates for each operator region are presented later in Section 4.

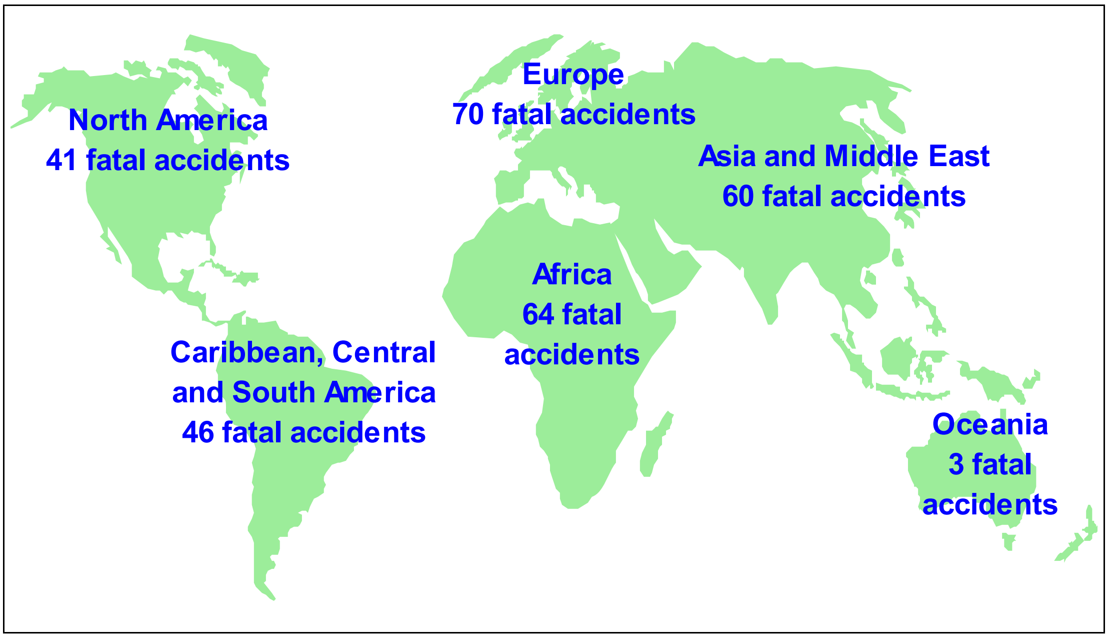

Figure 11 Numbers of worldwide fatal accidents broken down by operator region for the ten-year period 1997 to 2006

2.6.2 In terms of the percentage of all fatal accidents involving each operator region (with the percentage of onboard fatalities in brackets):

- 25% of fatal accidents involved European operators (23% of onboard fatalities)
- 23% involved African operators (22%)
- 21% involved Asian and Middle Eastern operators (34%)
- 16% involved Caribbean, Central and South American operators (14%)
- 14% involved North American operators (7%)
- 1% involved Oceania operators (0.2%)

1. The sum of fatal accidents by operator region of origin was 284, one more than the total stated in Section 2.1.1. This was due to a mid-air collision that involved a European and Middle Eastern operator, which was counted against each category. This mid-air collision was treated as one fatal accident in the overall statistics.

3 Worldwide Aircraft Utilisation

3.1 Introduction

3.1.1 The utilisation data presented in this section originated from Ascend and covers jet (excluding business jets) and turboprop aeroplanes engaged in passenger and cargo operations only.

3.2 Overall Flights and Hours Flown

3.2.1 Figure 12 shows the annual numbers of flights and hours flown for jets and turboprops combined. In the ten-year period from 1997 to 2006, the number of flights flown increased by 17%, which equated to an average annual growth of 1.5%. The equivalent values for hours flown were 31% for overall growth and 2.8% for average annual growth.

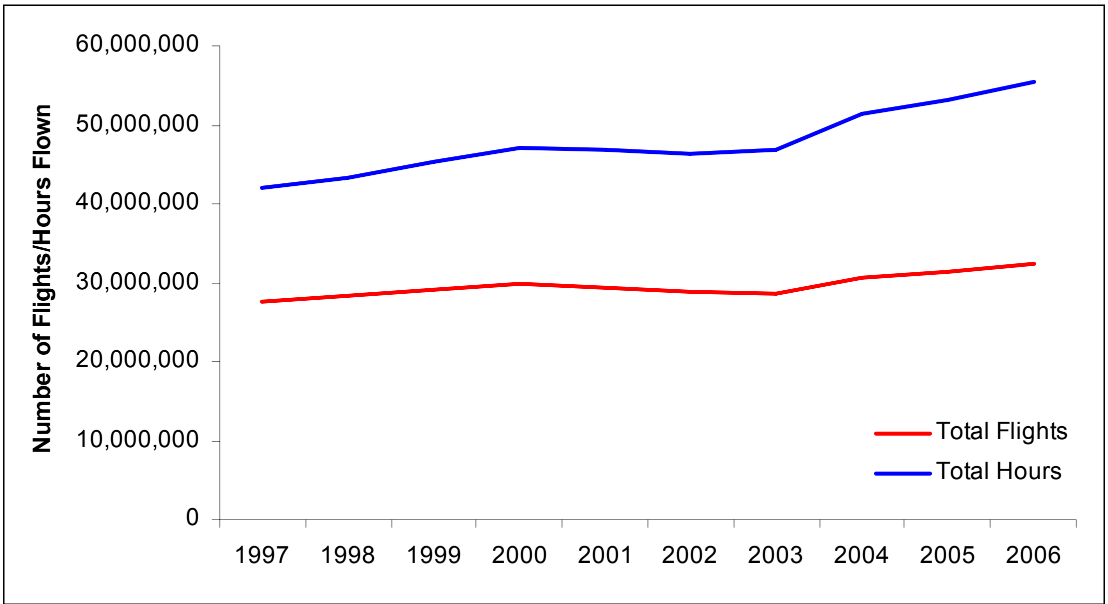

Figure 12 Annual numbers of flights and hours flown by jets and turboprops engaged in passenger and cargo operations

3.2.2 The total number of flights flown by jets and turboprops on passenger and cargo operations for the ten-year period 1997 to 2006 was 295,995,303 and the total number of hours flown was 478,070,852. The average flight duration for this period was one hour 37 minutes.

3.3 Worldwide Flights and Hours Flown by Aircraft Class

3.3.1 Figure 13 shows the annual numbers of flights flown broken down by aircraft class (the equivalent chart for hours flown has not been shown as it has an almost identical distribution to that for flights flown). In the ten-year period from 1997 to 2006, the number of flights flown by jets increased by 37%, which equated to an average annual growth of 3.2%. However, in the same period, the number of flights flown by turboprops decreased by 23%, which equated to an average annual reduction of 2.6%.

3.3.2 In the ten-year period from 1997 to 2006, the number of hours flown by jets increased by 45%, which equated to an average annual growth of 3.8%. However, in the same period, the number of hours flown by turboprops decreased by 24%, which equated to an average annual reduction of 2.8%.

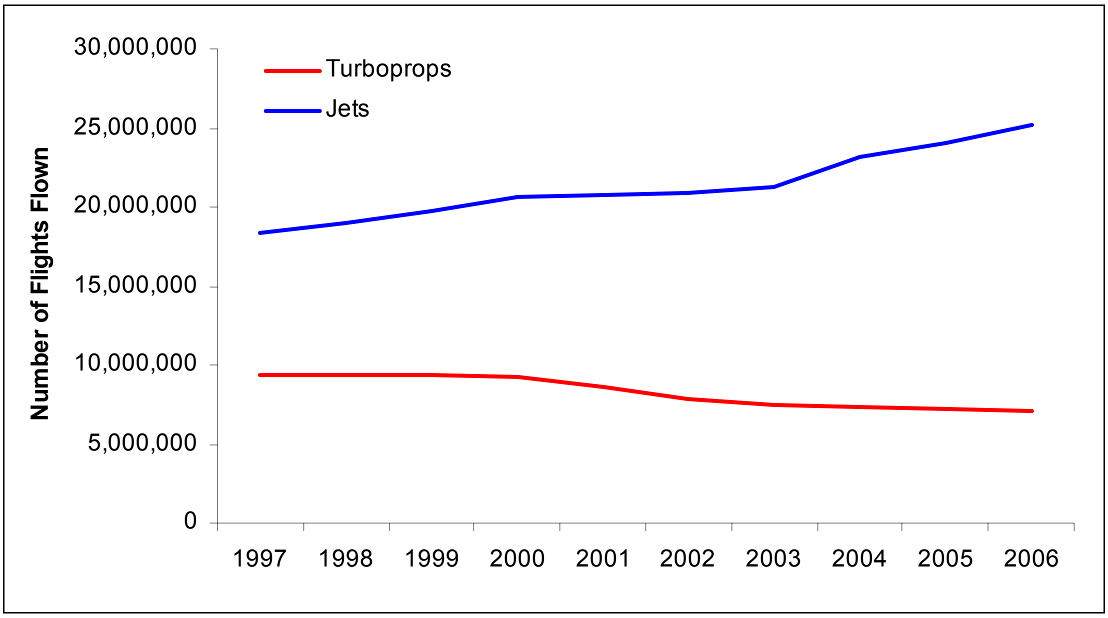

Figure 13 Annual numbers of flights flown broken down by aircraft class (for passenger and cargo operations combined)

3.3.3 The total number of flights flown by jets on passenger and cargo operations for the ten-year period 1997 to 2006 was 213,020,482 and the total number of hours flown was 403,498,465. The average duration of a jet flight for this period was one hour 54 minutes.

3.3.4 The total number of flights flown by turboprops on passenger and cargo operations for the ten-year period 1997 to 2006 was 82,974,821 and the total number of hours flown was 74,572,387. The average duration of a turboprop flight for this period was 54 minutes.

3.4 Worldwide Flights and Hours Flown by Nature of Flight

3.4.1 Figure 14 shows the annual numbers of flights flown broken down by nature of flight (the equivalent chart for hours flown has not been shown as it has an almost identical distribution to that for flights flown). In the ten-year period from 1997 to 2006, the number of passenger flights flown increased by 17%, which equated to an average annual growth of 1.6%. In the same period, the number of cargo flights flown increased by 13%, which equated to an average annual growth of 1.2%.

3.4.2 In the ten-year period from 1997 to 2006, the number of hours flown on passenger flights increased by 32%, which equated to an average annual growth of 2.8%. In the same period, the number of hours flown on cargo flights increased by 29%, which equated to an average annual growth of 2.6%.

3.4.3 The total number of passenger flights flown by jets and turboprops for the ten-year period 1997 to 2006 was 275,912,591 and the total number of hours flown was 441,980,855. The average duration of a passenger flight for this period was one hour 36 minutes.

3.4.4 The total number of cargo flights flown by jets and turboprops for the ten-year period 1997 to 2006 was 20,082,712 and the total number of hours flown was 36,089,997. The average duration of a cargo flight for this period was one hour 48 minutes.

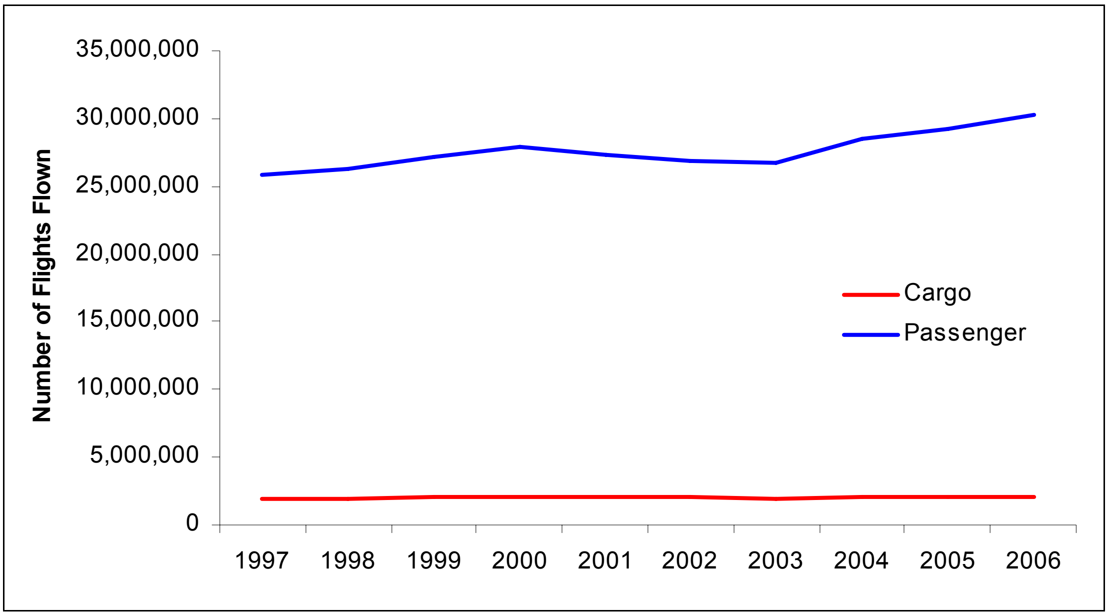

Figure 14 Annual numbers of flights flown broken down by nature of flight (for jets and turboprops combined)

4 Worldwide Fatal Accident Rates

4.1 Introduction

4.1.1 This section focuses on fatal accident rates and covers jet and turboprop aeroplanes engaged in passenger and cargo flights only. Fatal accidents involving business jets and ferry or positioning flights were excluded from the rate calculations due to unavailability of consistent utilisation data for these types of aircraft and operation.

4.2 Worldwide Fatal Accident and Fatality Rates by Year

4.2.1 Table 1 shows a summary of the number and rate of fatal accidents and onboard fatalities, for jets and turboprops combined, for the ten-year period 1997 to 2006.

Table 1 Summary of the overall number and rate of fatal accidents and fatalities for the ten-year period 1997 to 2006

	Overall
Number of Fatal Accidents	235
Number of Onboard Fatalities	8,435
Number of Flights Flown	295,995,303
Number of Hours Flown	478,070,852
Fatal Accident Rate (per million flights flown)	0.79
Fatal Accident Rate (per million hours flown)	0.49
Fatality Rate (per million flights flown)	28.50
Fatality Rate (per million hours flown)	17.64

4.2.2 Figures 15 and 16 show, respectively, the fatal accident rate and onboard fatality rate (per million flights and hours flown) for jets and turboprops combined, using a three-year moving average. There was a decreasing trend in both the rate of fatal accidents and onboard fatalities.

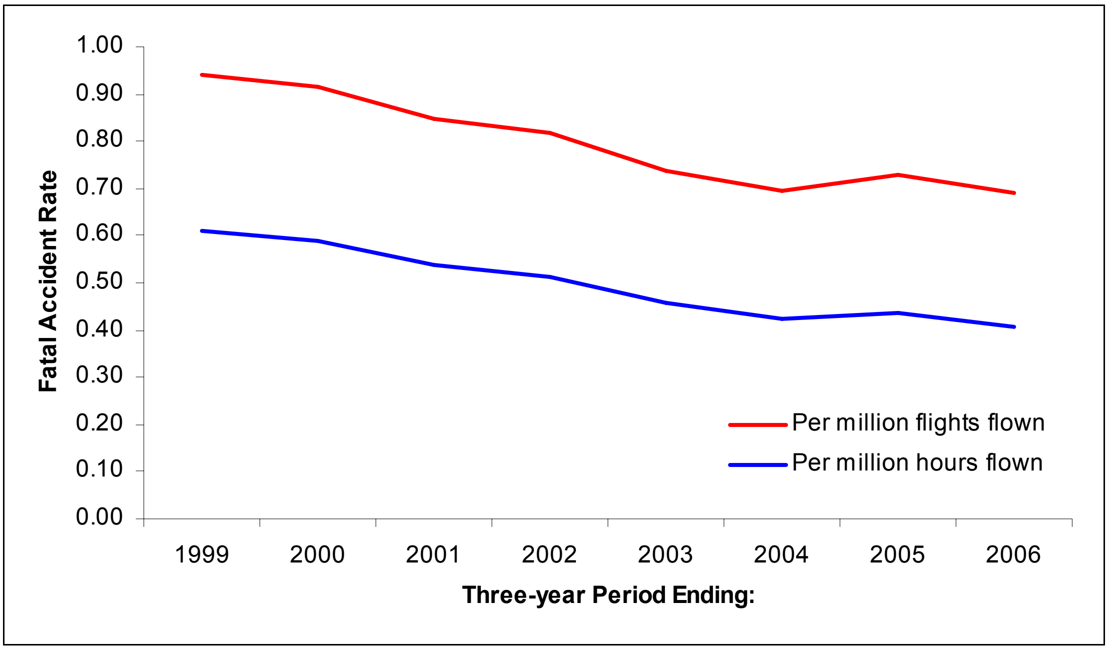

Figure 15 Overall fatal accident rate (per million flights and hours flown) for the ten-year period 1997 to 2006

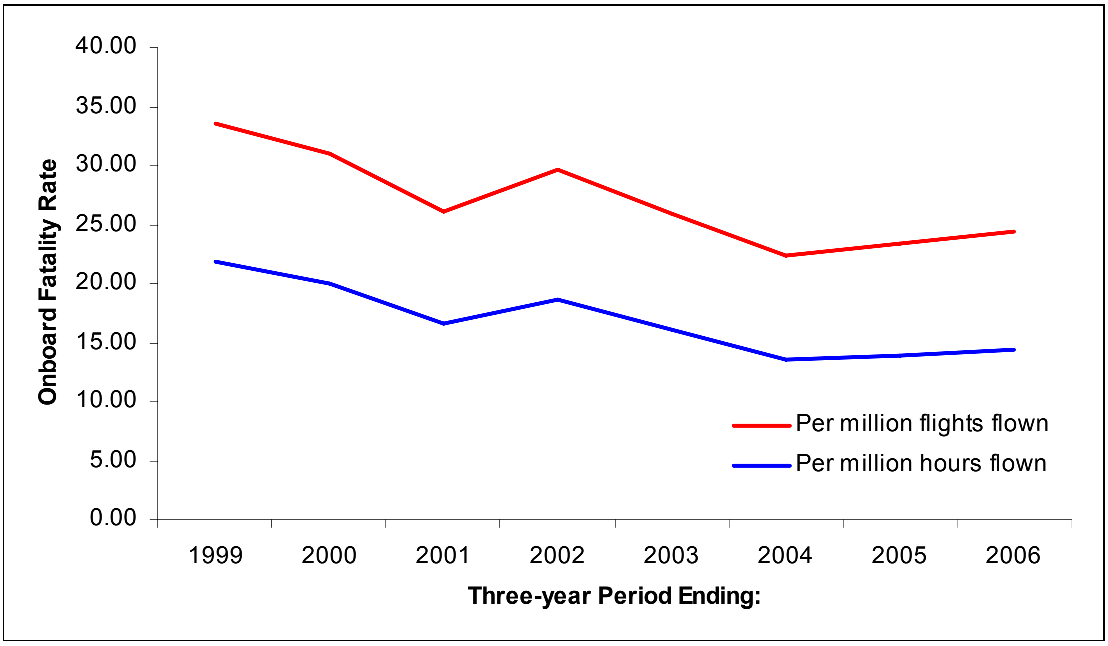

Figure 16 Overall onboard fatality rate (per million flights and hours flown) for the ten-year period 1997 to 2006

4.3 Worldwide Fatal Accident and Fatality Rates by Aircraft Class and Weight Group

4.3.1 Table 2 shows a summary of the number and rate of fatal accidents and onboard fatalities for the ten-year period 1997 to 2006 broken down by aircraft class.

4.3.2 Jet aircraft generated 72% of flights flown (and 84% of hours flown) and were involved in 45% of the fatal accidents. Turboprop aircraft generated 28% of flights flown (and 16% of hours flown) but were involved in 55% of the fatal accidents. On average, the fatal accident rate for turboprops was three times that for jets, based on flights flown, and nearly seven times greater when using hours flown as the rate measure.

Table 2 Summary of the number and rate of fatal accidents and fatalities broken down by aircraft class for the ten-year period 1997 to 2006

	Jets	Turboprops
Number of Fatal Accidents	105	130
Number of Onboard Fatalities	6,775	1,660
Number of Flights Flown	213,020,482	82,974,821
Number of Hours Flown	403,498,465	74,572,387
Fatal Accident Rate (per million flights flown)	0.49	1.57
Fatal Accident Rate (per million hours flown)	0.26	1.74
Fatality Rate (per million flights flown)	31.80	20.01
Fatality Rate (per million hours flown)	16.79	22.26

4.3.3 Figures 17 and 18 show, respectively, the fatal accident rate and onboard fatality rate (per million flights flown) broken down by aircraft class, using a three-year moving average. There was a decreasing trend in both the fatal accident rate and the onboard fatality rate for jets. However, the fatal accident rate and onboard fatality rate for turboprops remained relatively stable, with a slight increasing trend observed in the last three years.

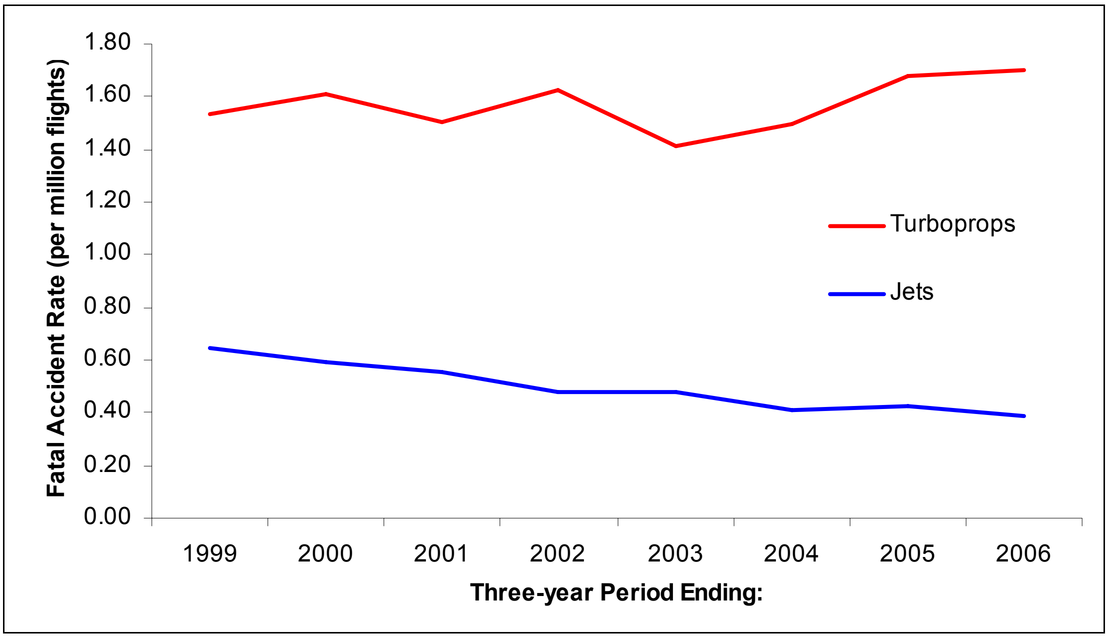

Figure 17 Fatal accident rate (per million flights flown) broken down by aircraft class for the ten-year period 1997 to 2006

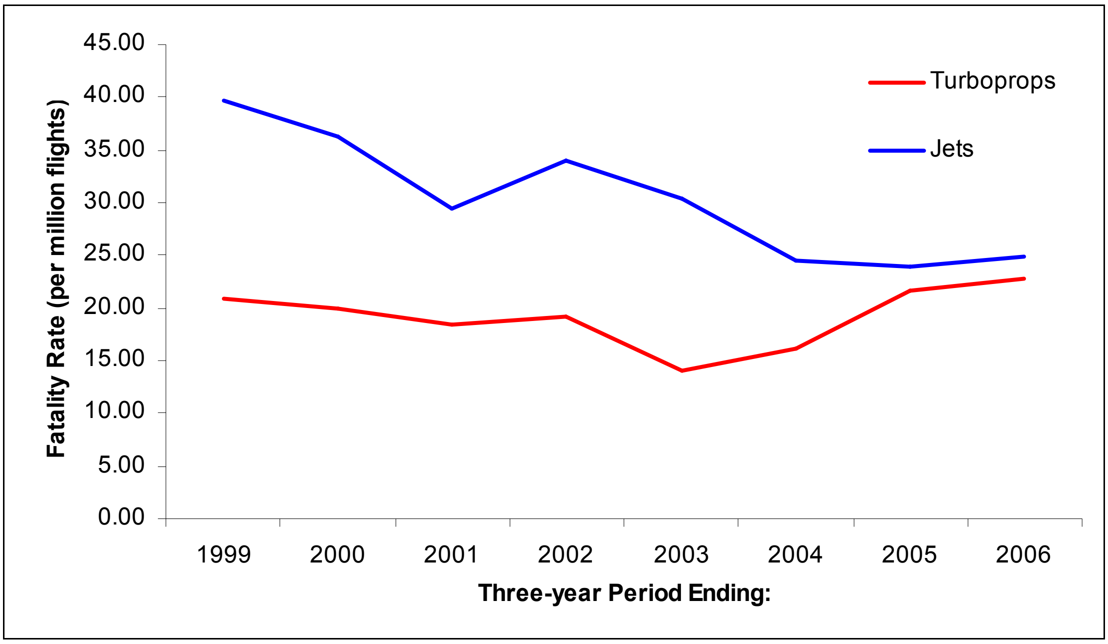

Figure 18 Onboard fatality rate (per million flights flown) broken down by aircraft class for the ten-year period 1997 to 2006

4.3.4 Table 3 shows a summary of the number and rate of fatal accidents and onboard fatalities for the ten-year period 1997 to 2006 broken down by aircraft weight group. On average, the fatal accident rate for aircraft with MTWA below 15 tonnes was twice that for aircraft with MTWA above 27 tonnes, based on flights flown, and over four times greater when using hours flown as the rate measure.

Table 3 Summary of the number and rate of fatal accidents and fatalities broken down by aircraft weight group for the ten-year period 1997 to 2006

	Below 15 t	**Above 15 t and Below 27 t**	**Above 27 t**
No. of Fatal Accidents	58	52	125
No. of Onboard Fatalities	569	1,020	6,846
No. of Flights Flown	45,719,846	59,327,628	190,947,829
No. of Hours Flown	38,850,806	60,823,585	378,396,461
Fatal Accident Rate (per million flights flown)	1.27	0.88	0.65
Fatal Accident Rate (per million hours flown)	1.49	0.85	0.33
Fatality Rate (per million flights flown)	12.45	17.19	35.85
Fatality Rate (per million hours flown)	14.65	16.77	18.09

4.3.5 Figure 19 shows the fatal accident rate (per million flights flown) broken down by aircraft weight group, using a three-year moving average. There was a generally decreasing trend in the fatal accident rate for aircraft with MTWA above 15 tonnes but an increasing trend for aircraft with MTWA below 15 tonnes.

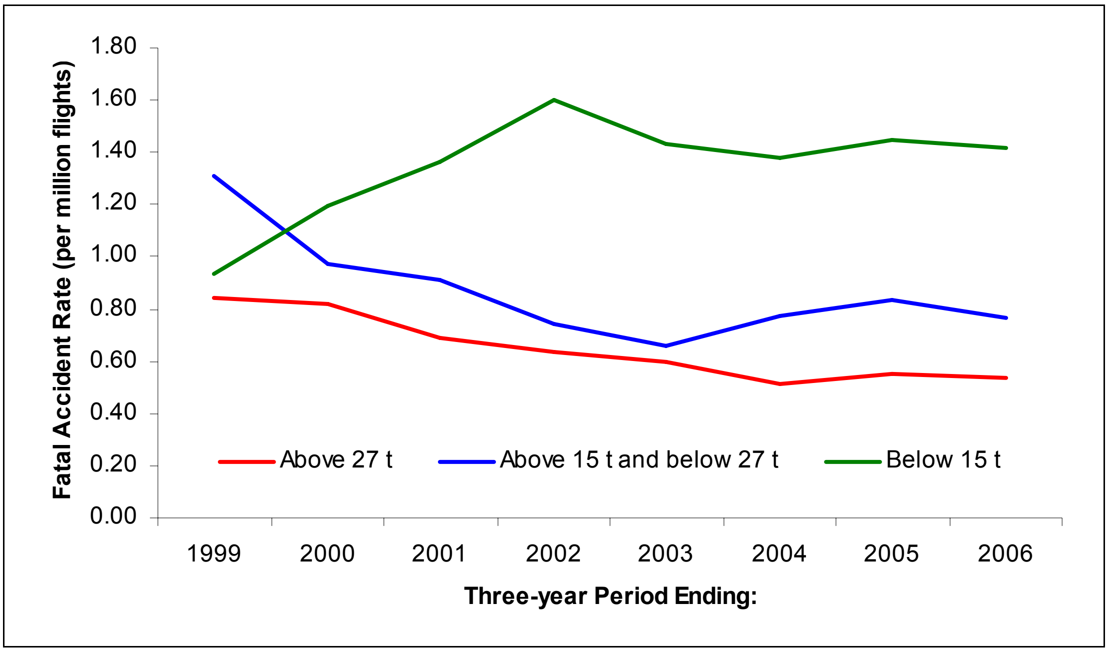

Figure 19 Fatal accident rate (per million flights flown) broken down by aircraft weight group for the ten-year period 1997 to 2006

4.4 Worldwide Fatal Accident and Fatality Rates by Nature of Flight

4.4.1 Table 4 shows a summary of the number and rate of fatal accidents and onboard fatalities for the ten-year period 1997 to 2006 broken down by nature of flight[1].

4.4.2 Passenger flights generated 93% of flights flown (and 92% of hours flown) and were involved in 69% of the fatal accidents. Cargo flights generated 7% of flights flown (and 8% of hours flown) but were involved in 31% of the fatal accidents. On average, the fatal accident rate for cargo flights was six times greater than for passenger flights (applicable for both rate measures).

Table 4 Summary of the number and rate of fatal accidents and fatalities broken down by nature of flight for the ten-year period 1997 to 2006

	Passenger	Cargo
Number of Fatal Accidents	162	74
Number of Onboard Fatalities	8,071	364
Number of Flights Flown	275,912,591	20,082,712
Number of Hours Flown	441,980,855	36,089,997
Fatal Accident Rate (per million flights flown)	0.59	3.68
Fatal Accident Rate (per million hours flown)	0.37	2.05
Fatality Rate (per million flights flown)	29.25	18.13
Fatality Rate (per million hours flown)	18.26	10.09

1. The sum of fatal accidents by nature of flight was 236, one more than the total stated in Table 1 in Section 4.2.1. This was due to a mid-air collision that involved a passenger and a cargo flight, which was counted against each category. This mid-air collision was treated as one fatal accident in the overall statistics.

4.4.3 Figures 20 and 21 show, respectively, the fatal accident rate and onboard fatality rate (per million flights flown) broken down by nature of flight, using a three-year moving average. There was a decreasing trend in both the fatal accident rate and the onboard fatality rate for passenger flights. However, the fatal accident rate and onboard fatality rate for cargo flights showed an increasing trend in the last five years.

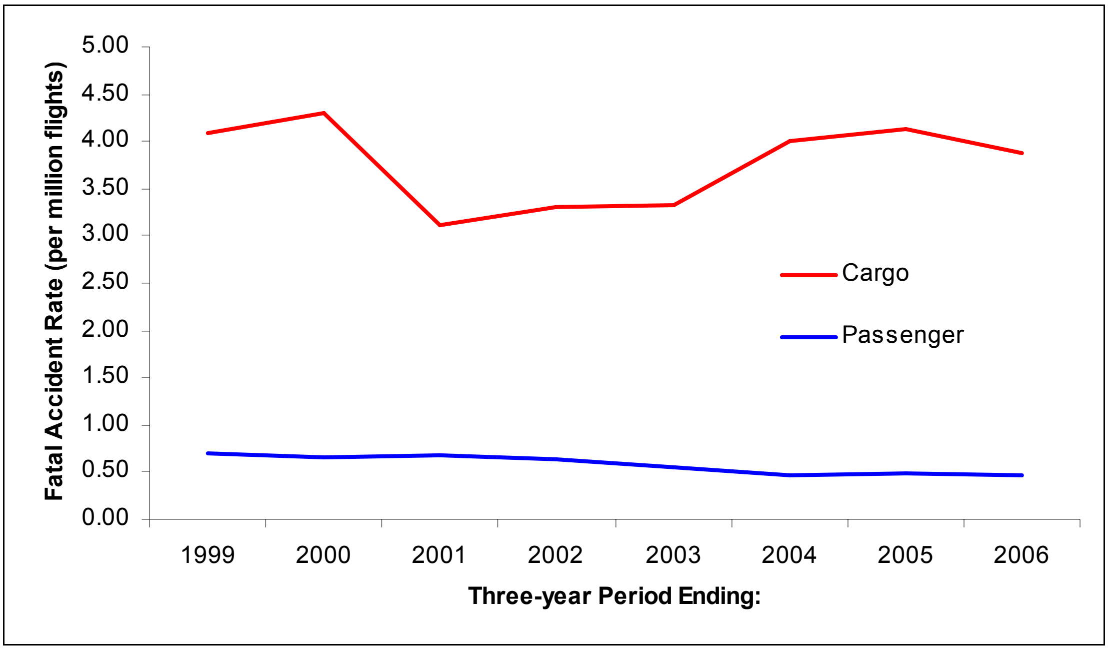

Figure 20 Fatal accident rate (per million flights flown) broken down by nature of flight for the ten-year period 1997 to 2006

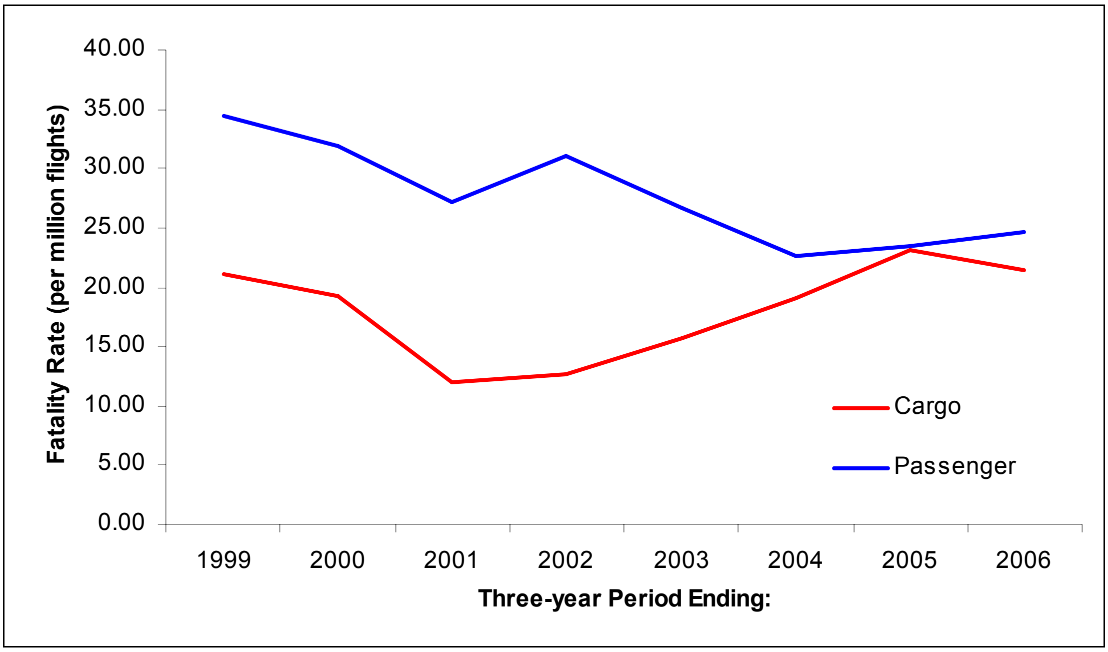

Figure 21 Onboard fatality rate (per million flights flown) broken down by nature of flight for the ten-year period 1997 to 2006

4.4.4 Table 5 takes the information presented in Table 4 and breaks it down further by aircraft class. It shows that the fatal accident rate (per million flights flown) for turboprop cargo flights was over 13 times greater than that for jet passenger flights (25 times greater when using hours flown as the rate measure). These aircraft class-nature of flight combinations represented the two extremes of the dataset in terms of safety performance.

Table 5 Summary of the number and rate of fatal accidents and fatalities broken down by nature of flight and aircraft class for the ten-year period 1997 to 2006

	Passenger		Cargo	
	Jets	Turboprops	Jets	Turboprops
No. of Fatal Accidents	83	79	23	51
No. of Onboard Fatalities	6,638	1,433	137	227
No. of Flights Flown	202,185,533	73,727,058	10,834,949	9,247,763
No. of Hours Flown	376,603,701	65,377,154	26,894,764	9,195,233
Fatal Accident Rate (per million flights flown)	0.41	1.07	2.12	5.51
Fatal Accident Rate (per million hours flown)	0.22	1.21	0.86	5.55
Fatality Rate (per million flights flown)	32.83	19.44	12.64	24.55
Fatality Rate (per million hours flown)	17.63	21.92	5.09	24.69

4.5 Worldwide Fatal Accident and Fatality Rates by Operator Region

4.5.1 Table 6 shows a summary of the number and rate of fatal accidents and onboard fatalities for the ten-year period 1997 to 2006 broken down by operator region[1].

4.5.2 The data for European operators was broken down further into European Union (EU) member states. For the purposes of this study, the EU was taken to be the 15 member states prior to inclusion of the accession states. Had the 12 accession states been part of the EU for the whole study period, then the fatal accident rate for EU operators would have increased from 0.34 to 0.42 fatal accidents per million flights flown or from 0.21 to 0.25 when expressed as per million hours flown.

1. The sum of fatal accidents by operator region of origin was 236, one more than the total stated in Table 1 in Section 4.2.1. This was due to a mid-air collision that involved a European and Middle Eastern operator, which was counted against each category. This mid-air collision was treated as one fatal accident in the overall statistics.

Table 6 Summary of the number and rate of fatal accidents and fatalities broken down by operator region for the ten-year period 1997 to 2006

	Africa	Asia and Middle East	Caribbean, Central and South America
No. of Fatal Accidents	59	59	35
No. of Onboard Fatalities	1,835	2,943	1,146
No. of Flights Flown	9,952,030	45,802,647	24,746,876
No. of Hours Flown	15,159,810	82,889,132	30,814,553
Fatal Accident Rate (per million flights flown)	5.93	1.29	1.41
Fatal Accident Rate (per million hours flown)	3.89	0.71	1.14
Fatality Rate (per million flights flown)	184.38	64.25	46.31
Fatality Rate (per million hours flown)	121.04	35.51	37.19

	Europe (EU)	North America	Oceania
No. of Fatal Accidents	59 (20)	21	3
No. of Onboard Fatalities	1,948 (391)	544	19
No. of Flights Flown	80,173,302 (58,032,348)	125,159,190	10,161,258
No. of Hours Flown	135,332,282 (96,313,801)	199,344,383	14,530,692
Fatal Accident Rate (per million flights flown)	0.74 (0.34)	0.17	0.30
Fatal Accident Rate (per million hours flown)	0.44 (0.21)	0.11	0.21
Fatality Rate (per million flights flown)	24.30 (6.74)	4.35	1.87
Fatality Rate (per million hours flown)	14.39 (4.06)	2.73	1.31

4.5.3 Figure 22 shows the overall fatal accident rate (per million flights flown) broken down by operator region. The rate for African operators was over seven times greater than that for all operators combined and over 30 times greater than that for North American operators, which had the lowest fatal accident rate of all the regions.

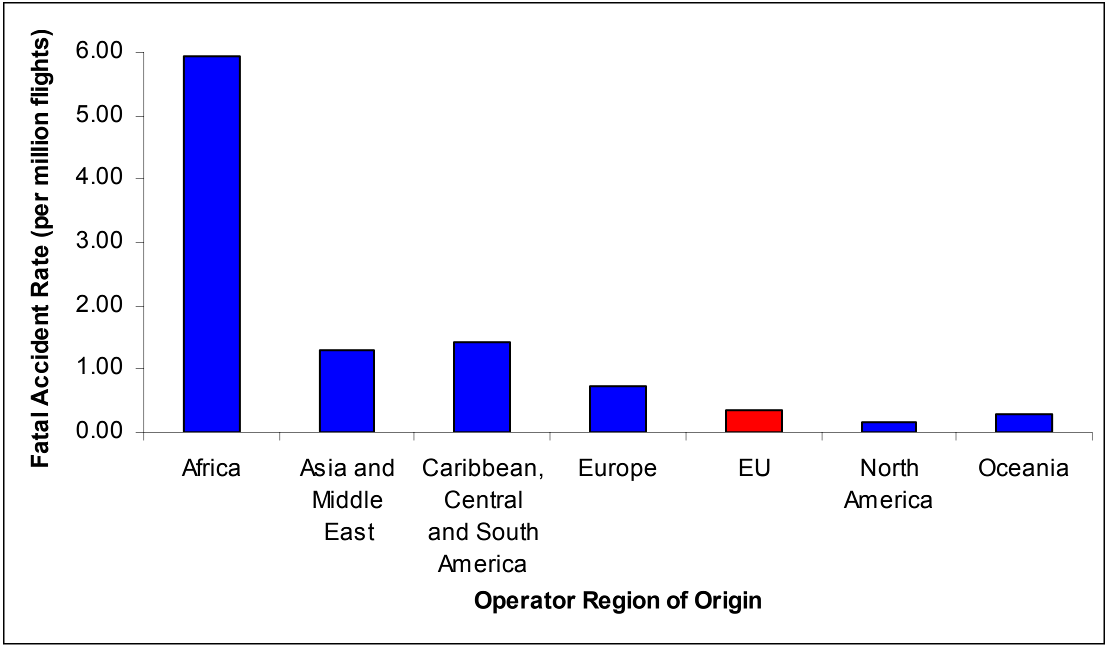

Figure 22 Overall fatal accident rate (per million flights flown) broken down by operator region for the ten-year period 1997 to 2006

4.5.4 Figure 23 shows the fatal accident rate (per million flights flown) broken down by operator region, using a three-year moving average. The fatal accident rates for Asian and Middle Eastern, European and Caribbean, Central and South American operators all showed a decreasing trend over the ten-year period 1997 to 2006. The rate for North American operators remained relatively stable, whilst the rates for African and Oceania operators showed an increasing trend. The trend for Oceania should be treated with caution as operators from this region only had three fatal accidents.

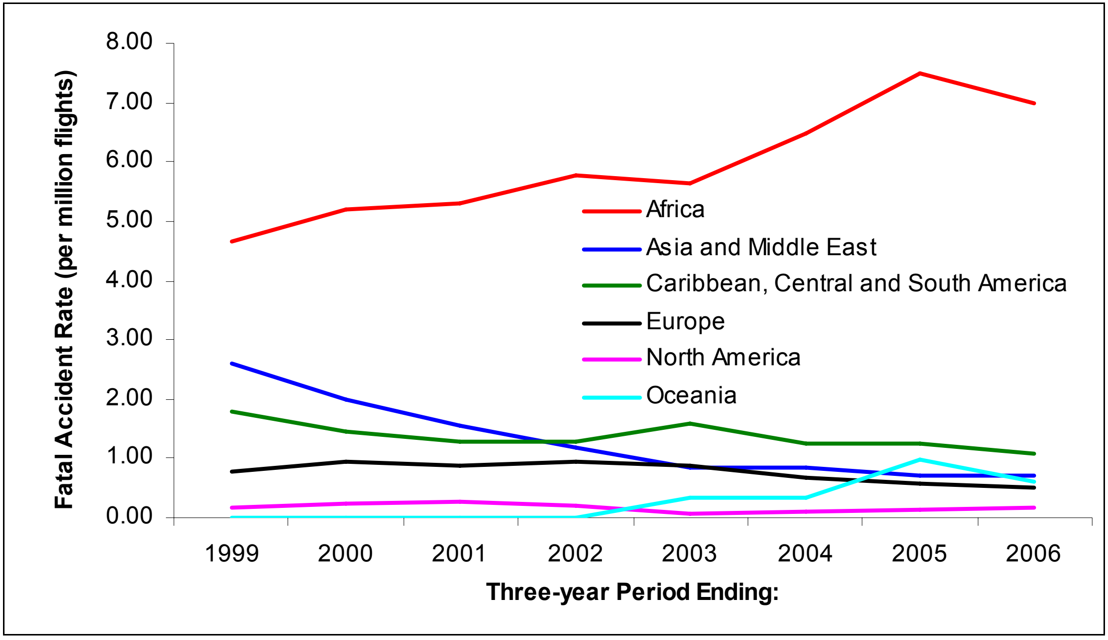

Figure 23 Fatal accident rate (per million flights flown) broken down by operator region for the ten-year period 1997 to 2006

4.5.5 The relative difference in fatal accident rates between cargo and passenger operations was far greater for operators from Europe and Oceania (14 and 22 times greater, respectively, for cargo operations). The relative difference for the other regions ranged from four to seven times greater for cargo operations.

4.6 Worldwide Mortality Risk for Passenger Flights

4.6.1 Whilst fatal accident rates are an established and useful measure of aviation safety performance, they do not distinguish between an accident that kills one passenger among 100 and another that kills everyone onboard. Use of fatality rates goes someway to addressing this, but it could still be argued that an accident that kills 50 out of 300 should not automatically assume more significance than one that kills all 40 persons onboard. *Barnett*[1] argues that mortality risk, which is the probability of a passenger not surviving a randomly chosen flight, could be a more appropriate measure. This statistic ignores the length and the duration of a flight, which are unrelated to mortality risk, and weights each accident by the proportion of passengers killed. An accident that kills everyone onboard is counted as one fatal accident, whereas one that kills a quarter of the passengers is counted as the equivalent of one quarter of a fatal accident.

4.6.2 Table 7 shows the mortality risk for passenger flights expressed in three ways: (1) a pure probability, (2) the number of randomly chosen passenger flights it would take, on average, for an aircraft occupant to be killed and (3) the number of years that would pass if such a flight was taken every day. For the purposes of this study, the mortality risk statistic was applied to both passengers and crewmembers.

4.6.3 On average, a jet aircraft occupant could expect to travel on nearly three times the number of flights as a turboprop aircraft occupant before being killed in a fatal accident. However, all the values contained in Table 7 indicate that fatal aircraft accidents are a low probability event.

Table 7 Mortality risk for passenger flights for the ten-year period 1997 to 2006 broken down by aircraft class and operator region

	Per Flight	Number of Flights	Number of Years
All passenger flights	4.3×10^{-7}	2.3 million	6,423
Jet passenger flights	3.0×10^{-7}	3.4 million	9,200
Turboprop passenger flights	7.8×10^{-7}	1.3 million	3,514
African operator passenger flights	2.7×10^{-6}	0.4 million	1,024
Asian and Middle Eastern operator passenger flights	7.8×10^{-7}	1.3 million	3,490
Caribbean, Central and South American operator passenger flights	8.9×10^{-7}	1.1 million	3,092
European operator passenger flights (EU)	3.4×10^{-7} (1.3×10^{-7})	2.9 million (7.6 million)	8,032 (20,946)
North American operator passenger flights	9.5×10^{-8}	10.5 million	28,722
Oceania operator passenger flights	1.1×10^{-7}	9.3 million	25,536

1. Barnett, A. and Wang A.; Passenger Mortality Risk Estimates Provide Estimates about Airline Safety, Flight Safety Digest, April 2000, p. 1-12, Flight Safety Foundation.

Chapter 3 Analysis of Primary Causal Factors

1 Primary Causal Groups

1.1 Any number of causal factors may have been allocated for each fatal accident, of which only one was identified as the primary causal factor. Of the 283 fatal accidents that formed the dataset, 245 (or 87%) had sufficient information to allow allocation of primary causal factors. A complete list of all primary causal factors together with the number of times they were allocated can be found in Appendix 5.

1.2 Figure 1 shows the proportion of all fatal accidents allocated a primary causal factor from each of the causal groups. There are five individual aircraft related causal groups, which have been split out for clarity. Two-thirds of all fatal accidents involved a flight crew related primary causal factor and 7% involved a primary causal factor taken from the aircraft related causal groups.

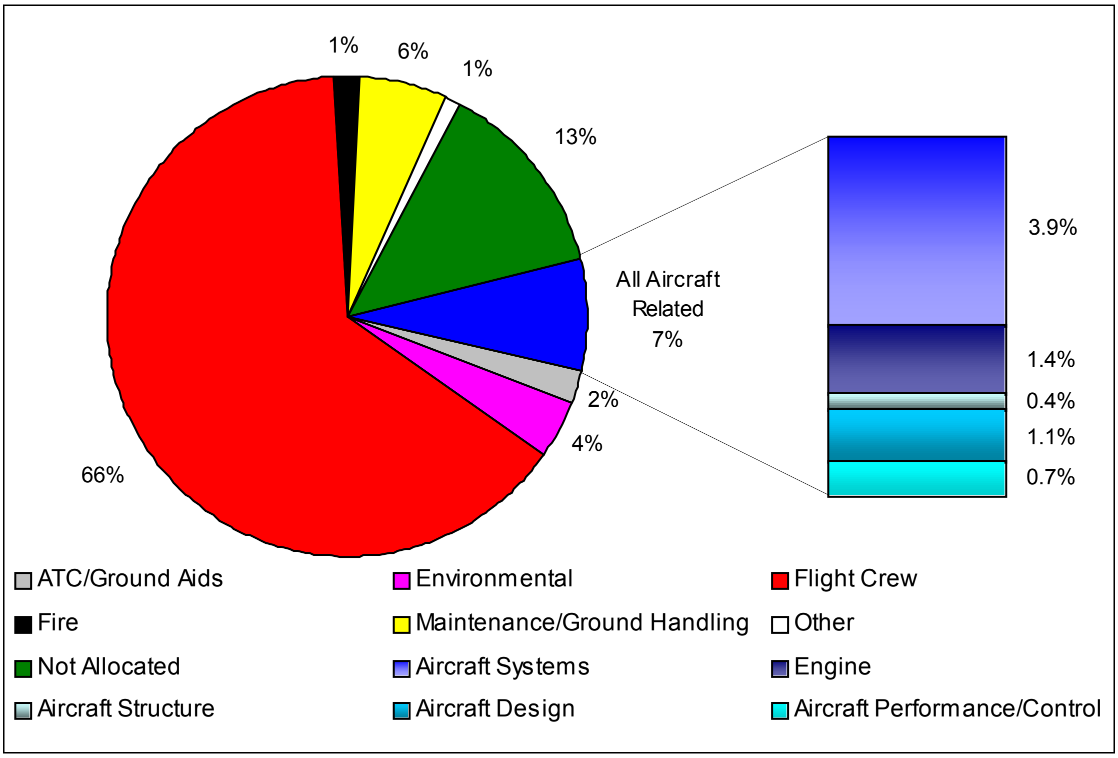

Figure 1 Breakdown of all fatal accidents by causal group (for primary causal factors only) for the ten-year period 1997 to 2006

1.3 The proportions for individual aircraft classes and natures of flight were similar to those shown in Figure 1. The main difference being the proportion of accidents for which a primary causal factor was not allocated. This was highest for turboprop cargo flights and reflected a number of accidents, particularly in Africa, for which there was insufficient information to allow allocation of factors.

2 Primary Causal Factors

2.1 Primary Causal Factors for All Fatal Accidents

2.1.1 Table 1 shows the top-ten individual primary causal factors allocated for all fatal accidents, together with the causal group to which they belong. These primary causal factors accounted for approximately three-quarters of all fatal accidents and nearly 90% of those that had a primary causal factor allocated.

2.1.2 There will be greater discussion of the scenarios behind the allocation of certain factors later on in Chapters 4 and 6.

Table 1 Top-ten primary causal factors allocated for all fatal accidents for the ten-year period 1997 to 2006

Rank	Causal Group	Primary Causal Factor	No. Fatal Accidents	%
1	Flight crew	Omission of action/inappropriate action	63	22.3%
2	Flight crew	Lack of positional awareness – in air	40	14.1%
3	Flight crew	Flight handling	39	13.8%
4	Flight crew	Poor professional judgement/airmanship	16	5.7%
5	Maintenance/ ground handling	Maintenance or repair error/oversight/inadequacy	12	4.2%
6	Environmental	Windshear/upset/turbulence/gusts	6	2.1%
7=	Flight crew	Loading incorrect	5	1.8%
7=	Flight crew	Deliberate non-adherence to procedures	5	1.8%
7=	Maintenance/ ground handling	Loading error	5	1.8%
10=	Aircraft systems	System failure – flight deck information	4	1.4%
10=	Aircraft systems	System failure – other	4	1.4%
10=	ATC/ground aids	Incorrect or inadequate instruction/advice (ATC)	4	1.4%
10=	Flight crew	Lack of awareness of circumstances in flight	4	1.4%
10=	Flight crew	Disorientation or visual illusion	4	1.4%

2.1.3 Table 2 shows the top-ten individual primary causal factors in terms of the number of onboard fatalities incurred.

Table 2 Top-ten primary causal factors, in terms of onboard fatalities, allocated for all fatal accidents for the ten-year period 1997 to 2006

Rank	Causal Group	Primary Causal Factor	Onboard Fatalities	%
1	Flight crew	Omission of action/inappropriate action	1,927	22.4%
2	Flight crew	Flight handling	1,552	18.0%
3	Flight crew	Lack of positional awareness – in air	1,154	13.4%
4	Maintenance/ ground handling	Maintenance or repair error/oversight/inadequacy	499	5.8%
5	ATC/ground aids	Incorrect or inadequate instruction/advice (ATC)	330	3.8%
6	Flight crew	State of mind	321	3.7%
7	Environmental	Windshear/upset/turbulence/gusts	294	3.4%
8	Flight crew	Poor professional judgement/airmanship	258	3.0%
9	Fire	Fire due to aircraft systems	240	2.8%
10	Flight crew	Lack of awareness of circumstances in flight	171	2.0%

2.2 Primary Causal Factors by Aircraft Class

2.2.1 Table 3 shows the top-five individual primary causal factors allocated for each aircraft class. Data shown includes rank, number of fatal accidents allocated with the primary causal factor and percentage of all fatal accidents that this represents.

Table 3 Top-five primary causal factors allocated by aircraft class for the ten-year period 1997 to 2006

Primary Causal Factor	All Classes	Jets	Turboprops	Business Jets
Omission of action/inappropriate action	1 [63] [22%]	1 [33] [31%]	1 [21] [15%]	1= [9] [26%]
Lack of positional awareness - in air	2 [40] [14%]	3 [13] [12%]	3 [18] [13%]	1= [9] [26%]
Flight handling	3 [39] [14%]	2 [15] [14%]	2 [19] [14%]	3 [5] [14%]
Poor professional judgement/airmanship	4 [16] [6%]	4 [6] [6%]	4 [8] [6%]	4= [2] [6%]
Maintenance or repair error/oversight/inadequacy	5 [12] [4%]	5 [4] [4%]	5 [7] [5%]	
Disorientation or visual illusion	10= [4] [1%]			4= [2] [6%]

2.2.2 Jets and turboprops had the same top-five primary causal factors, although jet aircraft had a higher proportion of fatal accidents with the "Omission of action/inappropriate action" primary causal factor. Business jets had a higher proportion of fatal accidents with the "Lack of positional awareness - in air" primary causal factor, which reflected the higher proportion of Controlled Flight Into Terrain (CFIT) accidents involving this class of aircraft (see also Chapter 6).

2.3 Primary Causal Factors by Nature of Flight

2.3.1 Table 4 shows the top-five individual primary causal factors allocated for each nature of flight. Data shown includes rank, number of fatal accidents allocated with the primary causal factor and percentage of all fatal accidents that this represents.

Table 4 Top-five primary causal factors allocated by nature of flight for the ten-year period 1997 to 2006

Primary Causal Factor	All Natures of Flight	Passenger	Cargo	Ferry/ Positioning
Omission of action/inappropriate action	1 [63] [22%]	1 [39] [23%]	1 [16] [20%]	1 [8] [24%]
Lack of positional awareness – in air	2 [40] [14%]	2 [30] [18%]	3 [7] [9%]	3= [3] [9%]
Flight handling	3 [39] [14%]	3 [29] [17%]	4= [4] [5%]	2 [6] [18%]
Poor professional judgement/airmanship	4 [16] [6%]	5= [4] [2%]	2 [9] [11%]	3= [3] [9%]
Maintenance or repair error/oversight/inadequacy	5 [12] [4%]	4 [8] [5%]		5 [2] [6%]
Windshear/upset/ turbulence/gusts	6 [6] [2%]	5= [4] [2%]		
Loading error (ground handling)	7= [5] [2%]		4= [4] [5%]	

2.3.2 "Omission of action/inappropriate action" was the most frequently allocated primary causal factor for each of the different natures of flight. Cargo flights contributed to all but one of the five fatal accidents with a "Loading error (ground handling)" primary causal factor.

2.4 Primary Causal Factors by Operator Region

2.4.1 Table 5 shows the top-five individual primary causal factors allocated for each operator region. Data shown includes rank, number of fatal accidents allocated with the primary causal factor and percentage of all fatal accidents that this represents.

2.4.2 "Omission of action/inappropriate action" was the most frequently allocated primary causal factor for each of the different operator regions. Primary causal factors from the flight crew causal group tended to dominate for most operator regions.

2.4.3 Results for Oceania operators should be treated with caution due to the low number of fatal accidents for this region.

Table 5 Top-five primary causal factors allocated by operator region for the ten-year period 1997 to 2006 (continued on next page)

Primary Causal Factor	All Regions	Africa	Asia and Middle East	Caribbean, Central and South America
Omission of action/ inappropriate action	1 [63] [22%]	1= [8] [13%]	1 [14] [23%]	1 [11] [24%]
Lack of positional awareness – in air	2 [40] [14%]	3 [6] [9%]	2= [12] [20%]	2 [10] [22%]
Flight handling	3 [39] [14%]	1= [8] [13%]	2= [12] [20%]	3 [7] [15%]
Poor professional judgement/airmanship	4 [16] [6%]	4 [4] [6%]		4 [5] [11%]
Maintenance or repair error/oversight/ inadequacy	5 [12] [4%]		4 [3] [5%]	
Windshear/upset/ turbulence/gusts	6 [6] [2%]			5= [1] [2%]
Loading incorrect (flight crew)	7= [5] [2%]	5= [3] [5%]		5= [1] [2%]
Loading error (ground handling)	7= [5] [2%]	5= [3] [5%]		5= [1] [2%]
System failure – flight deck information	10= [4] [1%]			5= [1] [2%]
Incorrect or inadequate instruction/advice (ATC)	10= [4] [1%]		5= [2] [3%]	
Lack of awareness of circumstances in flight	10= [4] [1%]			5= [1] [2%]
Design shortcomings	15= [3] [1%]		5= [2] [3%]	
Failure to provide separation – air (ATC)	25= [1] [0.4%]			5= [1] [2%]
Damage due to non-containment	25= [1] [0.4%]			5= [1] [2%]

Table 5 Top-five primary causal factors allocated by operator region for the ten-year period 1997 to 2006 (continued from previous page)

Primary Causal Factor	All Regions	Europe	North America	Oceania
Omission of action/ inappropriate action	1 [63] [22%]	1 [20] [29%]	1 [9] [22%]	1= [1] [33%]
Lack of positional awareness – in air	2 [40] [14%]	2 [9] [13%]	4= [3] [7%]	
Flight handling	3 [39] [14%]	3 [5] [7%]	2 [7] [17%]	
Poor professional judgement/airmanship	4 [16] [6%]		4= [3] [7%]	1= [1] [33%]
Maintenance or repair error/oversight/ inadequacy	5 [12] [4%]		3 [5] [12%]	
Incorrect or inadequate instruction/advice (ATC)	10= [4] [1%]	4= [3] [4%]		
Lack of awareness of circumstances in flight	10= [4] [1%]	4= [3] [4%]		
Icing	15= [3] [1%]			1= [1] [33%]

NOTE 1: Accident reporting criteria are not consistent throughout the world, so the number of factors assigned to fatal accidents may vary widely amongst the different operator regions. Care should be taken when drawing conclusions from this data.

NOTE 2: The sum, by individual operator region, of the number of fatal accidents allocated with "Incorrect or inadequate instruction/advice (ATC)" was five, one more than the total stated in the All Regions column of Table 5. This was due to a mid-air collision that involved a European and Middle Eastern operator, for which this primary causal factor was counted against each region. This mid-air collision was treated as one fatal accident in the overall statistics.

Chapter 4 Analysis of All Causal Factors

1 Causal Groups

1.1 Any number of causal factors may have been allocated for each fatal accident. Frequently, an accident results from a combination of causal factors and it is important to see the whole picture rather than just focus on the single primary causal factor. For the purposes of this study, primary causal factors have been included with the other causal factors in this Chapter.

1.2 Of the 283 fatal accidents that formed the whole dataset, 254 (or 90%) had sufficient information to allow allocation of at least one causal factor. The average number of causal factors allocated per fatal accident was 3.6 and the largest number for one fatal accident was 13. A complete list of all causal factors together with the number of times they were allocated can be found in Appendix 5.

1.3 Figure 1 shows the number of fatal accidents allocated at least one causal factor from each of the causal groups. The causal groups are not mutually exclusive as each fatal accident could have been allocated a causal factor from more than one causal group. The "Aircraft Related" group refers to the number of fatal accidents that had at least one causal factor from one of the five individual aircraft groups.

1.4 Three-quarters of all fatal accidents involved at least one flight crew related causal factor and 42% involved at least one aircraft related causal factor.

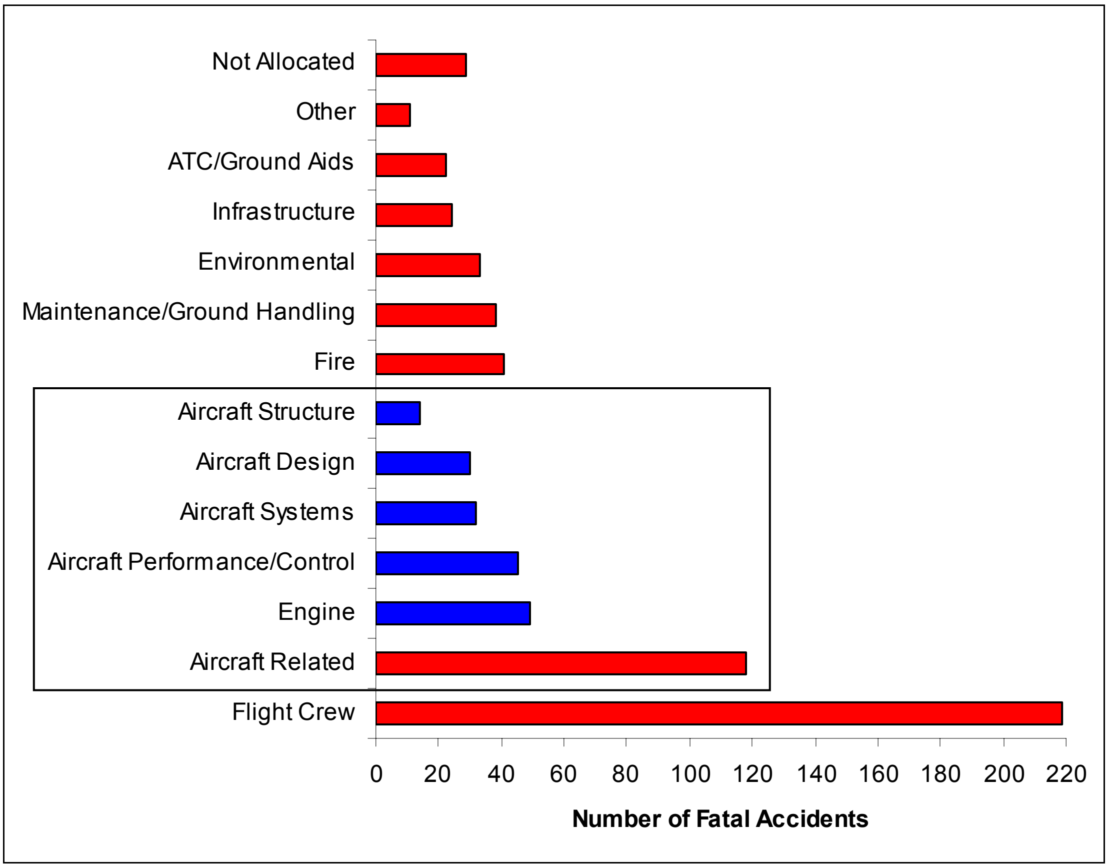

Figure 1 Breakdown of all fatal accidents by causal group (for all causal factors) for the ten-year period 1997 to 2006

NOTE: These causal groups are not mutually exclusive.

1.5 Figure 2 shows a breakdown, by aircraft class, of the proportion of fatal accidents allocated at least one causal factor from each of the causal groups. The "Aircraft Related" group refers to the proportion of fatal accidents that had at least one causal factor from one of the five individual aircraft groups.

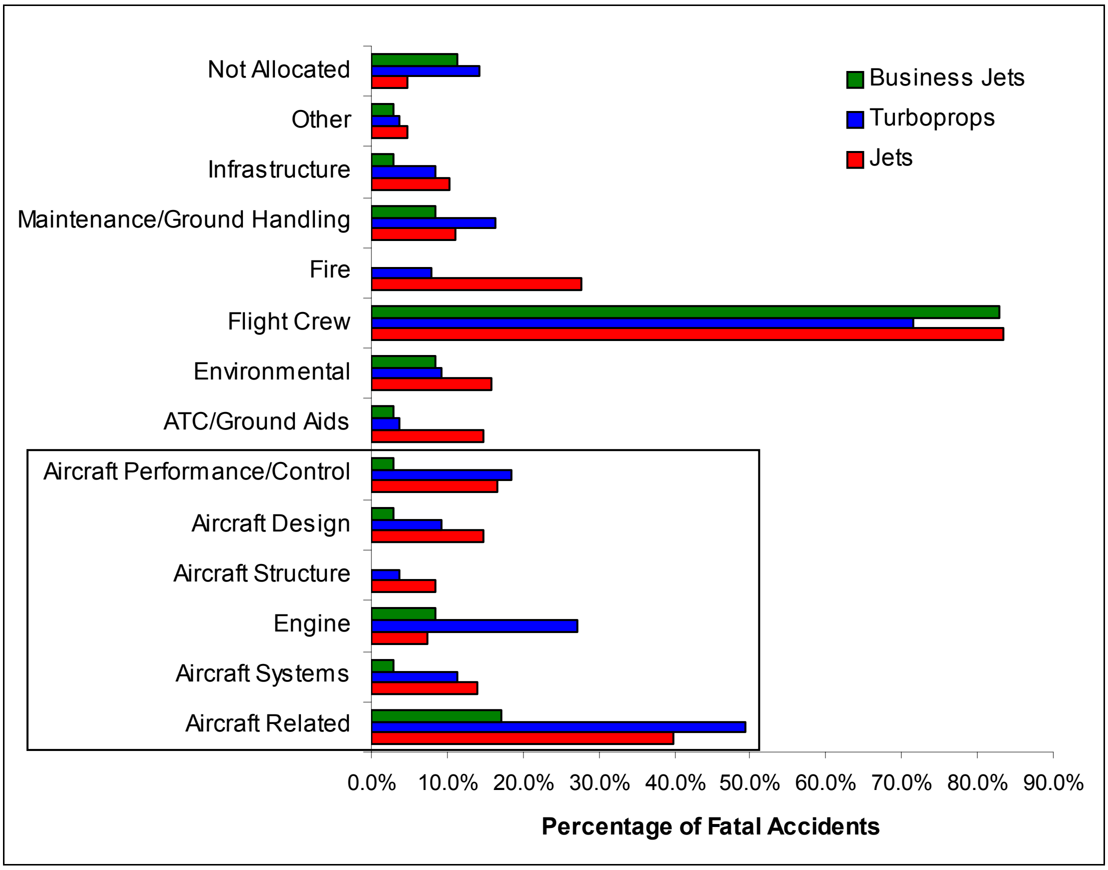

Figure 2 Breakdown of fatal accidents by aircraft class and causal group (for all causal factors) for the ten-year period 1997 to 2006

NOTE: These causal groups are not mutually exclusive.

1.6 Flight crew related causal factors were the most frequently allocated for all aircraft classes. Turboprop aircraft had a higher proportion of engine related causal factors and jets were involved in proportionally more fatal accidents with fire and ATC/ground aid related causal factors.

1.7 Figure 3 shows a breakdown, by nature of flight, of the proportion of fatal accidents allocated at least one causal factor from each of the causal groups. The "Aircraft Related" group refers to the proportion of fatal accidents that had at least one causal factor from one of the five individual aircraft groups.

1.8 Again, causal factors associated with flight crew error were the most frequently allocated for all natures of flight, followed by causal factors from the aircraft related groups. Passenger flights had a higher proportion of fire related causal factors, which reflected the greater chance on such flights of at least one aircraft occupant sustaining fatal injuries during a post crash fire due to the greater number of occupants onboard.

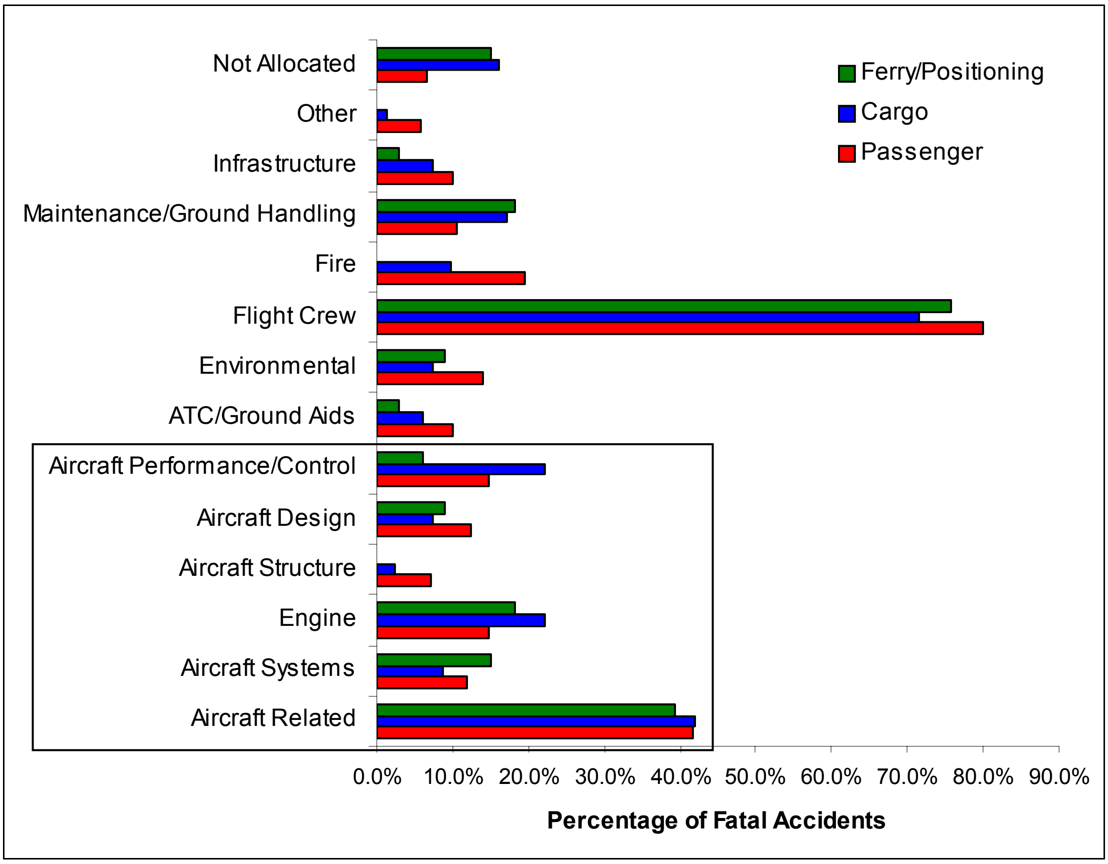

Figure 3 Breakdown of fatal accidents by nature of flight and causal group (for all causal factors) for the ten-year period 1997 to 2006

NOTE: These causal groups are not mutually exclusive.

2 Causal Factors

2.1 Causal Factors for All Fatal Accidents

2.1.1 Table 1 shows the top-ten individual causal factors allocated for all fatal accidents, together with the causal group to which they belong. These causal factors accounted for 78% of all fatal accidents and 87% of those that had at least one causal factor allocated. The causal factors are not mutually exclusive as each fatal accident could have been allocated more than one causal factor.

2.1.2 All but three of the top-ten causal factors came from the flight crew group. The most frequently allocated causal factor was "Omission of action/inappropriate action", which generally related to flight crew continuing their descent below the decision height or minimum descent/safety heights without visual reference, failing to fly a missed approach or omitting to set the correct aircraft configuration for take-off.

2.1.3 "Flight handling" was the second most common causal factor. Of the 82 fatal accidents allocated this causal factor, 26 (or 32%) involved inadequate flight crew handling of an engine failure or loss of power, at least 24 (or 29%) resulted in the aircraft stalling, 10 (or 12%) involved flight crew disorientation and eight (or 10%) occurred during go-arounds.

2.1.4 The "Engine failure or malfunction" causal factor, which was allocated in 17% of all fatal accidents, was used in cases where the aircraft should have been capable of continued safe flight. The intention was to capture situations where, for whatever reason, the loss of an engine was not handled successfully. This was in addition to scenarios where a catastrophic outcome was more likely. Of the 48 fatal accidents with the "Engine failure or malfunction" causal factor, 39 involved aircraft with two engines and 26 of these involved the loss of power on one engine only. Loss of power on all engines occurred in 18 fatal accidents.

2.1.5 Over 12% of the fatal accidents involved fatal injuries sustained during a "Post crash fire" with the deceased having survived the initial impact.

Table 1 Top-ten causal factors allocated for all fatal accidents for the ten-year period 1997 to 2006

Rank	Causal Group	Causal Factor	No. Fatal Accidents	%
1	Flight crew	Omission of action/inappropriate action	111	39.2%
2	Flight crew	Flight handling	82	29.0%
3	Flight crew	Lack of positional awareness – in air	76	26.9%
4=	Flight crew	Failure in CRM (cross check/co-ordinate)	63	22.3%
4=	Flight crew	Poor professional judgement/airmanship	63	22.3%
6	Engine	Engine failure or malfunction	48	17.0%
7=	Flight crew	Press-on-itis	35	12.4%
7=	Fire	Post crash fire	35	12.4%
9	Flight crew	Slow and/or low on approach	34	12.0%
10	Aircraft design	Design shortcomings	30	10.6%

NOTE: These causal factors are not mutually exclusive.

2.1.6 Table 2 shows the top-ten individual causal factors in terms of the number of onboard fatalities incurred.

Table 2 Top-ten causal factors, in terms of onboard fatalities, allocated for all fatal accidents for the ten-year period 1997 to 2006

Rank	Causal Group	Causal Factor	Onboard Fatalities	%
1	Flight crew	Omission of action/inappropriate action	3,470	40.4%
2	Flight crew	Flight handling	2,534	29.5%
3	Flight crew	Failure in CRM (cross check/co-ordinate)	2,533	29.5%
4	Flight crew	Lack of positional awareness – in air	2,455	28.5%
5	Fire	Post crash fire	1,933	22.5%
6	Flight crew	Poor professional judgement/ airmanship	1,873	21.8%
7	Flight crew	Lack of/inadequate qualification/ training/experience	1,565	18.2%
8	Aircraft design	Design shortcomings	1,494	17.4%
9	Aircraft Performance/ Control	Aircraft becomes uncontrollable	1,131	13.2%
10	Flight crew	Press-on-itis	1,063	12.4%

NOTE: These causal factors are not mutually exclusive.

2.2 Causal Factors by Aircraft Class

2.2.1 Table 3 shows the top-five individual causal factors allocated for each aircraft class. Data shown includes rank, number of fatal accidents allocated with the causal factor and percentage of all fatal accidents that this represents.

Table 3 Top-five causal factors allocated by aircraft class for the ten-year period 1997 to 2006

Causal Factor	All Classes	Jets	Turboprops	Business Jets
Omission of action/ inappropriate action	1 [111] [39%]	1 [52] [48%]	2 [39] [28%]	1 [20] [57%]
Flight handling	2 [82] [29%]	3= [29] [27%]	1 [43] [31%]	3= [10] [29%]
Lack of positional awareness - in air	3 [76] [27%]	3= [29] [27%]	4 [32] [23%]	2 [15] [43%]
Failure in CRM (cross check/co-ordinate)	4= [63] [22%]	2 [30] [28%]		3= [10] [29%]
Poor professional judgement/airmanship	4= [63] [22%]	5= [27] [25%]	5 [29] [21%]	
Engine failure or malfunction	6 [48] [17%]		3 [37] [26%]	
Post crash fire	7= [35] [12%]	5= [27] [25%]		
Slow/low on approach	9 [34] [12%]			5 [9] [26%]

NOTE: These causal factors are not mutually exclusive.

2.2.2 "Omission of action/inappropriate action" was the most frequently allocated causal factor for jets and business jets. "Flight handling" was the most common causal factor for turboprops, and of the 43 fatal accidents that involved this factor, 20 were also coded with the "Engine failure or malfunction" causal factor.

2.3 Causal Factors by Nature of Flight

2.3.1 Table 4 shows the top-five individual causal factors allocated for each aircraft class. Data shown includes rank, number of fatal accidents allocated with the causal factor and percentage of all fatal accidents that this represents.

Table 4 Top-five causal factors allocated by nature of flight for the ten-year period 1997 to 2006

Causal Factor	All Natures of Flight	Passenger	Cargo	Ferry/ Positioning
Omission of action/ inappropriate action	1 [111] [39%]	1 [70] [41%]	1 [24] [30%]	1 [17] [52%]
Flight handling	2 [82] [29%]	3 [49] [29%]	2 [23] [28%]	3 [10] [30%]
Lack of positional awareness – in air	3 [76] [27%]	2 [50] [29%]	4 [18] [22%]	4 [8] [24%]
Failure in CRM (cross check/co-ordinate)	4= [63] [22%]	4 [43] [25%]		5 [7] [21%]
Poor professional judgement/airmanship	4= [63] [22%]	5 [32] [19%]	3 [19] [23%]	2 [12] [36%]
Engine failure or malfunction	6 [48] [17%]		5 [17] [21%]	

NOTE: These causal factors are not mutually exclusive.

2.3.2 "Omission of action/inappropriate action" was the most frequently allocated causal factor for each of the different natures of flight. With the exception of "Engine failure or malfunction", which was the fifth most common causal factor for cargo flights, all other top-five causal factors came from the flight crew causal group.

2.4 Causal Factors by Operator Region

2.4.1 Table 5 shows the top-five individual causal factors allocated for each operator region. Data shown includes rank, number of fatal accidents allocated with the causal factor and percentage of all fatal accidents that this represents.

2.4.2 "Omission of action/inappropriate action" was either the most frequently or joint most frequently allocated causal factor for all operator regions apart from Africa, for which "Engine failure or malfunction" was the most common causal factor. Flight crew related causal factors tended to dominate for most operator regions.

2.4.3 Results for Oceania operators should be treated with caution due to the low number of fatal accidents for this region.

Table 5 Top-five causal factors allocated by operator region for the ten-year period 1997 to 2006 (continued on next page)

Causal Factor	All Regions	Africa	Asia and Middle East	Caribbean, Central and South America
Omission of action/ inappropriate action	1 [111] [39%]	4= [12] [19%]	1= [22] [37%]	1 [19] [41%]
Flight handling	2 [82] [29%]	2 [15] [23%]	1= [22] [37%]	4 [11] [24%]
Lack of positional awareness – in air	3 [76] [27%]	4= [12] [19%]	3 [20] [33%]	2 [18] [39%]
Failure in CRM (cross check/co-ordinate)	4= [63] [22%]		4= [13] [22%]	5 [10] [22%]
Poor professional judgement/airmanship	4= [63] [22%]	3 [13] [20%]		3 [12] [26%]
Engine failure or malfunction	6 [48] [17%]	1 [16] [25%]		
Post crash fire	7= [35] [12%]		4= [13] [22%]	

Table 5 Top-five causal factors allocated by operator region for the ten-year period 1997 to 2006 (continued from previous page)

Causal Factor	All Regions	Europe	North America	Oceania
Omission of action/ inappropriate action	1 [111] [39%]	1 [36] [51%]	1 [20] [49%]	1= [2] [67%]
Flight handling	2 [82] [29%]	3= [17] [24%]	2= [15] [37%]	1= [2] [67%]
Lack of positional awareness – in air	3 [76] [27%]	3= [17] [24%]		
Failure in CRM (cross check/co-ordinate)	4= [63] [22%]	2 [18] [26%]	2= [15] [37%]	1= [2] [67%]
Poor professional judgement/airmanship	4= [63] [22%]	5 [16] [23%]	4 [10] [24%]	1= [2] [67%]
Press-on-itis	7= [35] [12%]		5= [9] [22%]	
Design shortcomings	10 [30] [11%]		5= [9] [22%]	1= [2] [67%]
Lack of/inadequate qualification/training/ experience	11= [25] [9%]			1= [2] [67%]
Aircraft becomes uncontrollable	13= [24] [8%]		5= [9] [22%]	
Incorrect, inadequate or misleading information to crew	16= [18] [6%]			1= [2] [67%]
Overload failure	29= [11] [4%]			1= [2] [67%]

NOTE 1: Accident reporting criteria are not consistent throughout the world, so the number of factors assigned to fatal accidents may vary widely amongst the different operator regions. Care should be taken when drawing conclusions from this data.

NOTE 2: These causal factors are not mutually exclusive.

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Chapter 5 Analysis of Circumstantial Factors

1 Circumstantial Factors for All Fatal Accidents

1.1 A circumstantial factor was an event or aspect, which was not directly in the causal chain of events but could have contributed to the fatal accident. A fatal accident may have been allocated any number of circumstantial factors in any combination.

1.2 Of the 283 fatal accidents that formed the whole dataset, 229 (or 81%) had at least one circumstantial factor. The average number of circumstantial factors allocated per fatal accident was 2.4 and the largest number for one fatal accident was nine. A complete list of all circumstantial factors together with the number of times they were allocated can be found in Appendix 5.

1.3 Table 1 shows the top-ten individual circumstantial factors allocated for all fatal accidents. These circumstantial factors accounted for 78% of all fatal accidents and 97% of those that had at least one circumstantial factor allocated. The circumstantial factors are not mutually exclusive as each fatal accident could have been allocated more than one circumstantial factor.

Table 1 Top-ten circumstantial factors allocated for all fatal accidents for the ten-year period 1997 to 2006

Rank	Circumstantial Factor	No. Fatal Accidents	%
1	Non-fitment of presently available aircraft safety equipment (e.g. TAWS)	94	33.2%
2	Poor visibility or lack of external visual reference	89	31.4%
3	Failure in CRM (cross-check/co-ordinate)	81	28.6%
4	Other weather	79	27.9%
5	Company management failure	76	26.9%
6	Inadequate regulatory oversight	69	24.4%
7	Incorrect/inadequate procedures	31	11.0%
8	Training inadequate	30	10.6%
9	Inadequate regulation	26	9.2%
10	Non-fitment of presently available ATC system or equipment (e.g. MSAW)	25	8.8%

NOTE: These circumstantial factors are not mutually exclusive.

1.4 The most frequently allocated circumstantial factor was "Non-fitment of presently available aircraft safety equipment". Of the 94 fatal accidents that had this circumstantial factor, 80 (or 85%) referred to non-fitment of the latest Terrain Awareness and Warning Systems (TAWS), such as the Enhanced Ground Proximity Warning System (EGPWS). This circumstantial factor was used even if an aircraft was not required to have the safety equipment fitted, or if the equipment was not available at the time of the accident. The intention was to identify fatal accidents where use of more advanced technology or extending the coverage of requirements for an existing technology might have helped to prevent the catastrophic outcome.

1.5 The third most frequently allocated circumstantial factor was "Failure in CRM (cross-check/co-ordinate)", which is the only factor that appears in both the causal and circumstantial factor lists. If an accident investigation report clearly cited failure in CRM as a causal factor, then the AAG would also judge it to be a causal factor.

However, if this was not the case, but the AAG felt that had CRM been to a higher standard during the situation such that the accident might have been prevented, then CRM would be cited as a circumstantial factor.

1.6 Table 2 shows the top-ten individual circumstantial factors in terms of the number of onboard fatalities incurred.

Table 2 Top-ten circumstantial factors, in terms of onboard fatalities, allocated for all fatal accidents for the ten-year period 1997 to 2006

Rank	Circumstantial Factor	Onboard Fatalities	%
1	Poor visibility or lack of external visual reference	2,833	32.9%
2	Non-fitment of presently available aircraft safety equipment (e.g. TAWS)	2,787	32.4%
3	Inadequate regulatory oversight	2,552	29.7%
4	Other weather	2,374	27.6%
5	Company management failure	2,208	25.7%
6	Failure in CRM (cross-check/co-ordinate)	2,137	24.9%
7	Training inadequate	1,588	18.5%
8	Inadequate regulation	1,497	17.4%
9	Non-fitment of presently available ATC system or equipment (e.g. MSAW)	1,281	14.9%
10	Non-precision approach flown	1,070	12.4%

NOTE: These circumstantial factors are not mutually exclusive.

2 Circumstantial Factors by Aircraft Class

2.1 Table 3 shows the top-five individual circumstantial factors allocated for each aircraft class. Data shown includes rank, number of fatal accidents allocated with the circumstantial factor and percentage of all fatal accidents that this represents.

Table 3 Top-five circumstantial factors allocated by aircraft class for the ten-year period 1997 to 2006

Circumstantial Factor	All Classes	Jets	Turboprops	Business Jets
Non-fitment of presently available aircraft safety equipment	1 [94] [33%]	1 [39] [36%]	4= [38] [27%]	1= [17] [49%]
Poor visibility or lack of external visual reference	2 [89] [31%]	2 [32] [30%]	2 [40] [29%]	1= [17] [49%]
Failure in CRM (cross-check/co-ordinate)	3 [81] [29%]	3 [30] [28%]		3 [14] [40%]
Other weather	4 [79] [28%]	4 [29] [27%]	4= [38] [27%]	4 [12] [34%]
Company management failure	5 [76] [27%]	5= [27] [25%]	1 [43] [31%]	5 [6] [17%]
Inadequate regulatory oversight	6 [69] [24%]	5= [27] [25%]	3 [39] [28%]	

NOTE: These circumstantial factors are not mutually exclusive.

2.2 "Non-fitment of presently available aircraft safety equipment" was the most frequently allocated circumstantial factor for jets and business jets and "Company management failure" was the most common for turboprops. "Poor visibility or lack of external visual reference" and "Other weather" featured in the top-five circumstantial factors for all classes of aircraft.

3 Circumstantial Factors by Nature of Flight

3.1 Table 4 shows the top-five individual circumstantial factors allocated for each nature of flight. Data shown includes rank, number of fatal accidents allocated with the circumstantial factor and percentage of all fatal accidents that this represents.

Table 4 Top-five circumstantial factors allocated by nature of flight for the ten-year period 1997 to 2006

Circumstantial Factor	All Natures of Flight	Passenger	Cargo	Ferry/ Positioning
Non-fitment of presently available aircraft safety equipment	1 [94] [33%]	1 [63] [37%]	4= [20] [25%]	2= [11] [33%]
Poor visibility or lack of external visual reference	2 [89] [31%]	2 [54] [32%]	3 [22] [27%]	1 [13] [39%]
Failure in CRM (cross-check/co-ordinate)	3 [81] [29%]	4= [45] [26%]	1 [25] [31%]	2= [11] [33%]
Other weather	4 [79] [28%]	3 [52] [31%]		4 [10] [30%]
Company management failure	5 [76] [27%]	4= [45] [26%]	2 [24] [30%]	5 [8] [24%]
Inadequate regulatory oversight	6 [69] [24%]		4= [20] [25%]	

NOTE 1: The sum, by individual nature of flight, of the number of fatal accidents allocated with "Company management failure" was 77, one more than the total stated in the All Natures of Flight column of Table 4. This was due to a mid-air collision that involved a passenger and cargo flight, for which this circumstantial factor was counted against each nature of flight. This mid-air collision was treated as one fatal accident in the overall statistics.

NOTE 2: These circumstantial factors are not mutually exclusive.

3.2 "Poor visibility or lack of external visual reference" appeared in the top-three circumstantial factors for all natures of flight. "Failure in CRM (cross-check/co-ordinate)" featured more highly for cargo and ferry/positioning flights than for passenger flights.

4 Circumstantial Factors by Operator Region

4.1 Table 5 shows the top-five individual circumstantial factors allocated for each operator region. Data shown includes rank, number of fatal accidents allocated with the circumstantial factor and percentage of all fatal accidents that this represents.

4.2 "Non-fitment of presently available aircraft safety equipment", "Poor visibility or lack of external visual reference", "Other weather" and "Company management failure" featured in the top-five circumstantial factors for all operator regions.

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

4.4 Results for Oceania operators should be treated with caution due to the low number of fatal accidents for this region.

Table 5 Top-five circumstantial factors allocated by operator region for the ten-year period 1997 to 2006 (continued on next page)

Circumstantial Factor	All Regions	Africa	Asia and Middle East	Caribbean, Central and South America
Non-fitment of presently available aircraft safety equipment	1 [94] [33%]	5 [14] [22%]	1 [22] [37%]	1 [22] [48%]
Poor visibility or lack of external visual reference	2 [89] [31%]	1= [17] [27%]	4 [19] [32%]	3 [16] [35%]
Failure in CRM (cross-check/co-ordinate)	3 [81] [29%]		2= [21] [35%]	2 [19] [41%]
Other weather	4 [79] [28%]	4 [15] [23%]	2= [21] [35%]	4 [12] [26%]
Company management failure	5 [76] [27%]	1= [17] [27%]	5= [14] [23%]	5 [8] [17%]
Inadequate regulatory oversight	6 [69] [24%]	3 [16] [25%]	5= [14] [23%]	

Table 5 Top-five circumstantial factors allocated by operator region for the ten-year period 1997 to 2006 (continued from previous page)

Circumstantial Factor	All Regions	Europe	North America	Oceania
Non-fitment of presently available aircraft safety equipment	1 [94] [33%]	2 [22] [31%]	4 [13] [32%]	5= [1] [33%]
Poor visibility or lack of external visual reference	2 [89] [31%]	3= [21] [30%]	2= [14] [34%]	2= [2] [67%]
Failure in CRM (cross-check/co-ordinate)	3 [81] [29%]	3= [21] [30%]		
Other weather	4 [79] [28%]	5 [17] [24%]	5 [12] [29%]	2= [2] [67%]
Company management failure	5 [76] [27%]	1 [23] [33%]	2= [14] [34%]	5= [1] [33%]
Inadequate regulatory oversight	6 [69] [24%]		1 [16] [39%]	2= [2] [67%]
Incorrect/inadequate procedures	7 [31] [11%]			1 [3] [100%]
Training inadequate	8 [30] [11%]			5= [1] [33%]
Inadequate regulation	9 [26] [9%]			5= [1] [33%]
Non-precision approach flown	11 [20] [7%]			5= [1] [33%]

NOTE 1: The sum, by individual operator region, of the number of fatal accidents allocated with "Company management failure" was 77, one more than the total stated in the All Regions column of Table 5. This was due to a mid-air collision that involved a European and Middle Eastern operator, for which this circumstantial factor was counted against each region. This mid-air collision was treated as one fatal accident in the overall statistics.

NOTE 2: Accident reporting criteria are not consistent throughout the world, so the number of factors assigned to fatal accidents may vary widely amongst the different operator regions. Care should be taken when drawing conclusions from this data.

NOTE 3: These circumstantial factors are not mutually exclusive.

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Chapter 6 Analysis of Consequences

1 Consequences for All Fatal Accidents

1.1 A list of consequences was used to record the outcomes of the fatal accidents. Although the consequences are not part of the cause of an accident, they are relevant to a complete understanding of the accident history, and in many cases the outcome is all that is known about an accident.

1.2 At least one consequence was allocated for each of the 283 fatal accidents that formed the whole dataset. The average number of consequences allocated per fatal accident was 1.7 and the largest number for one fatal accident was four. A complete list of all consequences together with the number of times they were allocated can be found in Appendix 5.

1.3 Table 1 shows the top-ten consequences allocated for all fatal accidents and Figure 1 shows the same information but in a graphical format. These consequences accounted for 96% of all fatal accidents.

1.4 The "Loss of control in flight" consequence was broken down into four subcategories, three of which ("Following technical failure", "Following non-technical failure" and "Following icing") reflect the loss of control categories used in the CAA Safety Plan.

1.5 The "Collision with terrain/water/obstacle" consequence was used differently in this study compared to the previous Global Fatal Accident Review (CAP 681) in that it was only allocated in cases where a more specific consequence did not apply.

Table 1 Top-ten consequences for all fatal accidents for the ten-year period 1997 to 2006

Rank	Consequence	No. Fatal Accidents	%
1	Post crash fire	120	42.4%
2	Loss of control in flight (all)	110	38.9%
	• Following technical failure	47	16.6%
	• Following non-technical failure	47	16.6%
	• Following icing	8	2.8%
	• Unknown reason	8	2.8%
3	Controlled Flight Into Terrain (CFIT)	71	25.1%
4=	Runway excursion	32	11.3%
4=	Collision with terrain/water/obstacle	32	11.3%
6	Ground collision with object/obstacle	29	10.2%
7	Forced landing - land or water	22	7.8%
8	Structural failure	20	7.1%
9	Emergency evacuation difficulties	16	5.7%
10	Fire/smoke/fumes during operation	10	3.5%

NOTE: These consequences are not mutually exclusive (apart from the "Loss of control in flight" subcategories).

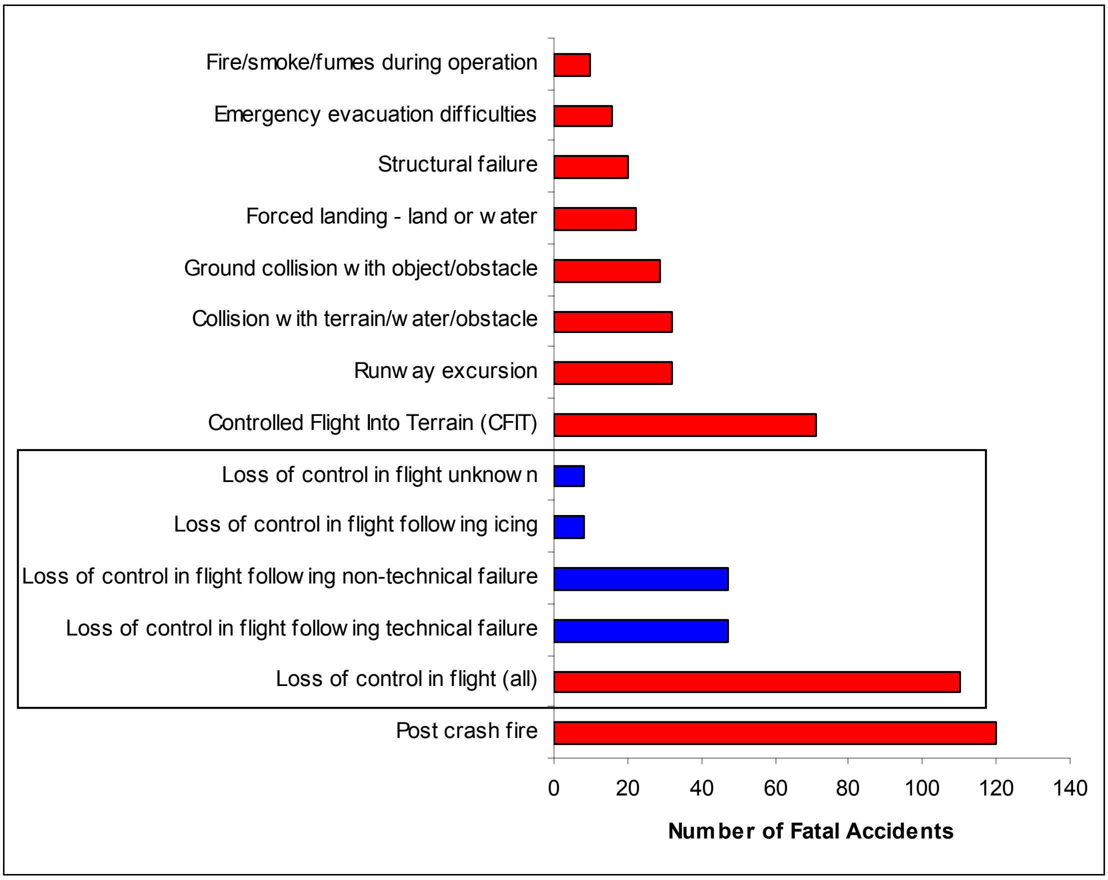

Figure 1 Top-ten consequences for all fatal accidents for the ten-year period 1997 to 2006

NOTE: These consequences are not mutually exclusive (apart from the “Loss of control in flight” subcategories).

1.6 “Post crash fire” and “Loss of control in flight” were the two most frequently identified consequences, each appearing in approximately 40% of all fatal accidents. “Controlled Flight Into Terrain (CFIT)” was the third most common consequence, accounting for 25% of all fatal accidents. Compared to the previous Global Fatal Accident Review, “Post crash fire” and “Loss of control in flight” were involved in proportionally more fatal accidents, whilst “CFIT” was involved in proportionally less.

1.7 The fatal accidents allocated with “Loss of control in flight” were evenly split between those that followed technical (e.g. engine failure) and non-technical (e.g. flight crew’s inadequate speed control) failure. There were eight fatal accidents that involved loss of control following some form of icing related issue.

1.8 Figure 2 shows the top-ten consequences allocated for all fatal accidents in terms of the number of onboard fatalities. The three most common consequences were the same as in Figure 1. “Post crash fire” was a consequence, although not necessarily a cause, in accidents resulting in 4,379 onboard fatalities (or 51% of the total number of onboard fatalities). The equivalent values for “Loss of control in flight” and “CFIT” were 3,954 (46%) and 2,348 (27%) respectively. The main difference in Figure 2, compared to Figure 1, was the elevation of “Structural failure”. This consequence was allocated in 7% of all fatal accidents but was involved in 14% of all onboard fatalities.

1.9 Two notable consequences that do not feature in either of Figures 1 or 2 were "Mid-air collision" and "Ground collision with other aircraft". There were five fatal mid-air collision accidents, which resulted in 244 onboard fatalities and two fatalities on other aircraft that were excluded from the dataset (on account of their size). There were two fatal accidents involving collisions between aircraft on the ground, which resulted in 111 onboard fatalities, four fatalities on the ground and four fatalities on another aircraft that was excluded from the dataset (on account of its size).

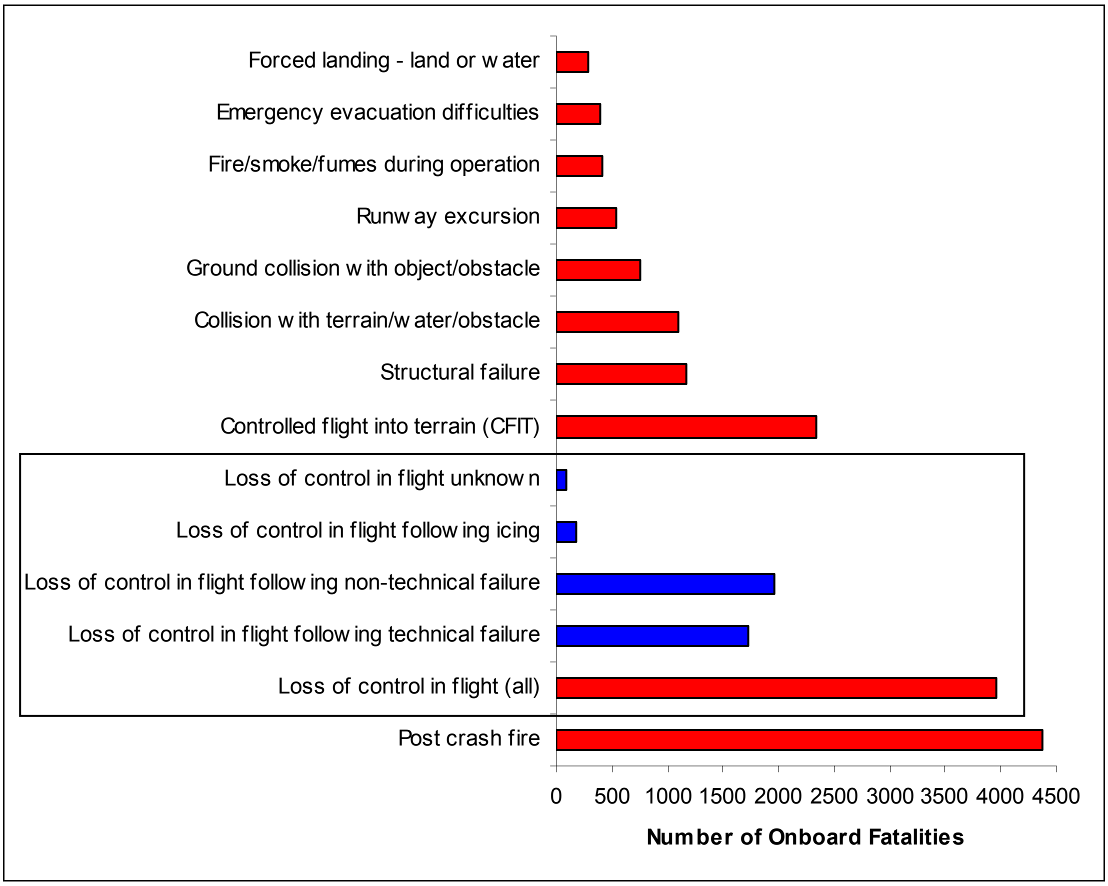

Figure 2 Top-ten consequences for all fatal accidents for the ten-year period 1997 to 2006 in terms of the number of onboard fatalities

NOTE: These consequences are not mutually exclusive (apart from the "Loss of control in flight" subcategories).

2 Consequences by Aircraft Class

2.1 Table 2 shows the top-five individual consequences allocated for each aircraft class. Data shown includes rank, number of fatal accidents allocated with the consequence and percentage of all fatal accidents that this represents.

2.2 "Loss of control in flight" was the most frequently identified consequence for turboprop aircraft and of the 55 fatal accidents that had this consequence allocated, 32 (or 58%) involved some form of technical failure. "Loss of control in flight" was the second most common consequence for jet aircraft accounting for 40 fatal accidents, of which 23 (or 58%) followed some form of non-technical failure.

2.3 "CFIT" featured in a higher proportion of fatal accidents involving business jets than for the other aircraft classes, which was a reflection of a lower level of TAWS equipage on these aircraft types.

Table 2 Top-five consequences allocated by aircraft class for the ten-year period 1997 to 2006

Consequence	All Classes	Jets	Turboprops	Business Jets
Post crash fire	1 [120] [42%]	1 [53] [49%]	2 [48] [34%]	1 [19] [54%]
Loss of control in flight (all)	2 [110] [39%]	2 [40] [37%]	1 [55] [39%]	2 [15] [43%]
• Following technical failure	[47] [17%]	[11] [10%]	[32] [23%]	[4] [11%]
• Following non-technical failure	[47] [17%]	[23] [21%]	[17] [12%]	[7] [20%]
• Following icing	[8] [3%]	[4] [4%]	[3] [2%]	[1] [3%]
• Unknown reason	[8] [3%]	[2] [2%]	[3] [2%]	[3] [9%]
Controlled Flight Into Terrain (CFIT)	3 [71] [25%]	3 [27] [25%]	3 [30] [21%]	3 [14] [40%]
Runway excursion	4= [32] [11%]	4 [15] [14%]		4= [3] [9%]
Collision with terrain/water/obstacle	4= [32] [11%]		4 [19] [14%]	
Ground collision with object/obstacle	6 [29] [10%]	5 [14] [13%]		4= [3] [9%]
Forced landing – land or water	7 [22] [8%]		5 [17] [12%]	

NOTE: These consequences are not mutually exclusive (apart from the "Loss of control in flight" subcategories).

3 Consequences by Nature of Flight

3.1 Table 3 shows the top-five individual consequences allocated for each nature of flight. Data shown includes rank, number of fatal accidents allocated with the consequence and percentage of all fatal accidents that this represents.

3.2 "Post crash fire", "Loss of control in flight" and "CFIT" were the three most frequently allocated consequences for all natures of flight. Passenger flights experienced proportionally more "CFIT" and proportionally less "Loss of control in flight" fatal accidents compared with cargo and ferry/positioning flights.

Table 3 Top-five consequences allocated by nature of flight for the ten-year period 1997 to 2006

Consequence	All Natures of Flight	Passenger	Cargo	Ferry/ Positioning
Post crash fire	1 [120] [42%]	1 [65] [38%]	1 [43] [53%]	2 [13] [39%]
Loss of control in flight (all)	2 [110] [39%]	2 [60] [35%]	2 [35] [43%]	1 [15] [45%]
• Following technical failure	[47] [17%]	[30] [18%]	[12] [15%]	[5] [15%]
• Following non-technical failure	[47] [17%]	[23] [14%]	[17] [21%]	[7] [21%]
• Following icing	[8] [3%]	[5] [3%]	[2] [2%]	[1] [3%]
• Unknown reason	[8] [3%]	[2] [1%]	[4] [5%]	[2] [6%]
Controlled Flight Into Terrain (CFIT)	3 [71] [25%]	3 [50] [29%]	3 [15] [19%]	3 [6] [18%]
Runway excursion	4= [32] [11%]	4 [21] [12%]		4= [4] [12%]
Collision with terrain/water/obstacle	4= [32] [11%]		4 [10] [12%]	4= [4] [12%]
Ground collision with object/obstacle	6 [29] [10%]	5 [20] [12%]		4= [4] [12%]
Forced landing – land or water	7 [22] [8%]		5 [9] [11%]	

NOTE 1: The sum, by individual nature of flight, of the number of fatal accidents allocated with "Post crash fire" was 121, one more than the total stated in the All Natures of Flight column of Table 3. This was due to a mid-air collision that involved a passenger and cargo flight, for which this consequence was counted against each nature of flight. This mid-air collision was treated as one fatal accident in the overall statistics.

NOTE 2: These consequences are not mutually exclusive (apart from the "Loss of control in flight" subcategories).

4 Consequences by Operator Region

4.1 Table 4 shows the top-five individual consequences allocated for each operator region. Data shown includes rank, number of fatal accidents allocated with the consequence and percentage of all fatal accidents that this represents.

4.2 Either "Post crash fire" or "Loss of control in flight" was the most frequently identified consequence for all operator regions except the Caribbean, Central and South America, for which "CFIT" was the most common consequence.

4.3 European operators experienced more fatal loss of control accidents following non-technical failures than as a result of technical failures. The reverse was true for North American operators.

4.4 Results for Oceania operators should be treated with caution due to the low number of fatal accidents for this region.

Table 4 Top-five consequences allocated by operator region for the ten-year period 1997 to 2006 (continued on next page)

Consequence	All Regions	Africa	Asia and Middle East	Caribbean, Central and South America
Post crash fire	1 [120] [42%]	1 [23] [36%]	1 [27] [45%]	3 [14] [30%]
Loss of control in flight (all)	2 [110] [39%]	2 [19] [30%]	2 [20] [33%]	2 [16] [35%]
• Following technical failure	[47] [17%]	[10] [16%]	[9] [15%]	[5] [11%]
• Following non-technical failure	[47] [17%]	[6] [9%]	[9] [15%]	[9] [20%]
• Following icing	[8] [3%]		[2] [3%]	[1] [2%]
• Unknown reason	[8] [3%]	[3] [5%]		[1] [2%]
Controlled Flight Into Terrain (CFIT)	3 [71] [25%]	4 [10] [16%]	3 [18] [30%]	1 [17] [37%]
Runway excursion	4= [32] [11%]	5 [9] [14%]		4= [5] [11%]
Collision with terrain/water/obstacle	4= [32] [11%]	3 [16] [25%]	4= [6] [10%]	4= [5] [11%]
Ground collision with object/obstacle	6 [29] [10%]			4= [5] [11%]
Forced landing - land or water	7 [22] [8%]		4= [6] [10%]	

Table 4 Top-five consequences allocated by operator region for the ten-year period 1997 to 2006 (continued from previous page)

Consequence	All Regions	Europe	North America	Oceania
Post crash fire	1 [120] [42%]	2 [28] [40%]	1 [28] [68%]	3= [1] [33%]
Loss of control in flight (all)	2 [110] [39%]	1 [30] [43%]	2 [23] [56%]	1= [2] [67%]
• Following technical failure	[47] [17%]	[12] [17%]	[11] [27%]	
• Following non-technical failure	[47] [17%]	[16] [23%]	[6] [15%]	[1] [33%]
• Following icing	[8] [3%]	[2] [3%]	[2] [5%]	[1] [33%]
• Unknown reason	[8] [3%]		[4] [10%]	
Controlled Flight Into Terrain (CFIT)	3 [71] [25%]	3 [16] [23%]	3 [9] [22%]	3= [1] [33%]
Runway excursion	4= [32] [11%]	4 [8] [11%]	4= [5] [12%]	
Ground collision with object/obstacle	6 [29] [10%]	5= [7] [10%]	4= [5] [12%]	
Structural failure	8 [20] [7%]		4= [5] [12%]	1= [2] [67%]
Emergency evacuation difficulties	9 [16] [6%]	5= [7] [10%]		
Fire/smoke/fumes during operation	10 [10] [4%]			1= [2] [67%]

NOTE 1: The sum, by individual operator region, of the number of fatal accidents allocated with "Post crash fire" was 121, one more than the total stated in the All Regions column of Table 4. This was due to a mid-air collision that involved a European and Middle Eastern operator, for which this consequence was counted against each region. This mid-air collision was treated as one fatal accident in the overall statistics.

NOTE 2: Accident reporting criteria are not consistent throughout the world, so the number of factors assigned to fatal accidents may vary widely amongst the different operator regions. Care should be taken when drawing conclusions from this data.

NOTE 3: These consequences are not mutually exclusive (apart from the "Loss of control in flight" subcategories).

5 Consequential Analysis

5.1 Introduction

5.1.1 It is recognised that accidents are generally the consequence of a chain of events, and not the result of just one causal factor. Four of the most frequently identified consequences in this study are shown in terms of the most commonly allocated causal and circumstantial factors for those fatal accidents (see Figures 3-6).

5.1.2 The numbers under each causal and circumstantial factor refer to the number of fatal accidents allocated with that factor and consequence.

5.1.3 In some of the charts, "Failure in CRM" has been shown both as a causal and 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, never both for an individual fatal accident.

5.2 Loss of Control In Flight

5.2.1 Figure 3 shows the most common causal and circumstantial factors allocated for all fatal accidents with a "Loss of control in flight following technical failure" consequence.

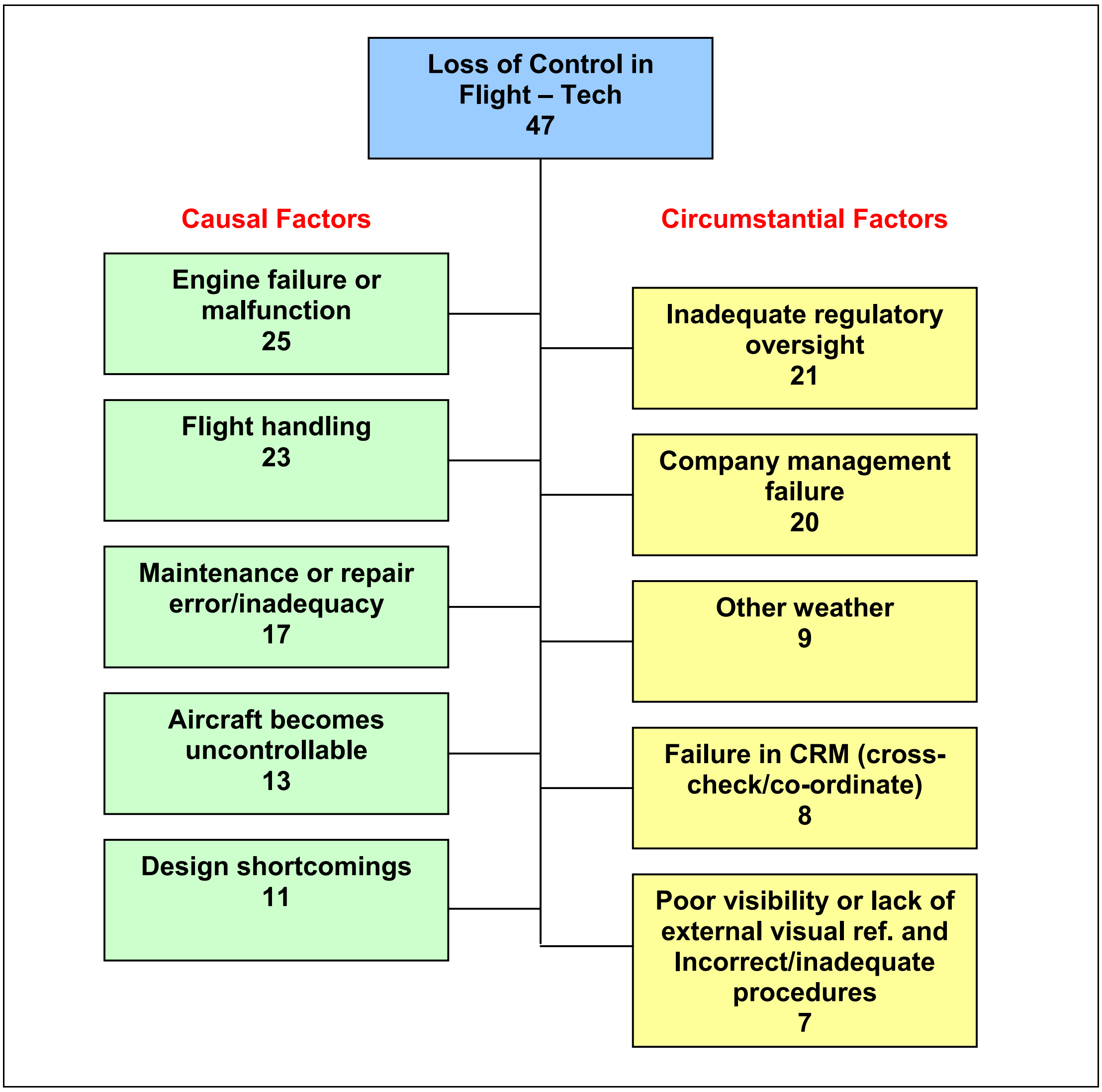

Figure 3 Top-five causal and circumstantial factors associated with fatal accidents with a "Loss of control in flight following technical failure" consequence

NOTE: These factors are not mutually exclusive.

5.2.2 Of the 25 fatal accidents with an "Engine failure or malfunction" causal factor, 19 (or 76%) involved turboprops.

5.2.3 Of the 23 fatal accidents with a "Flight handling" causal factor, 19 (or 83%) also had an "Engine failure or malfunction" causal factor.

5.2.4 Figure 4 shows the most common causal and circumstantial factors allocated for all fatal accidents with a "Loss of control in flight following non-technical failure" consequence.

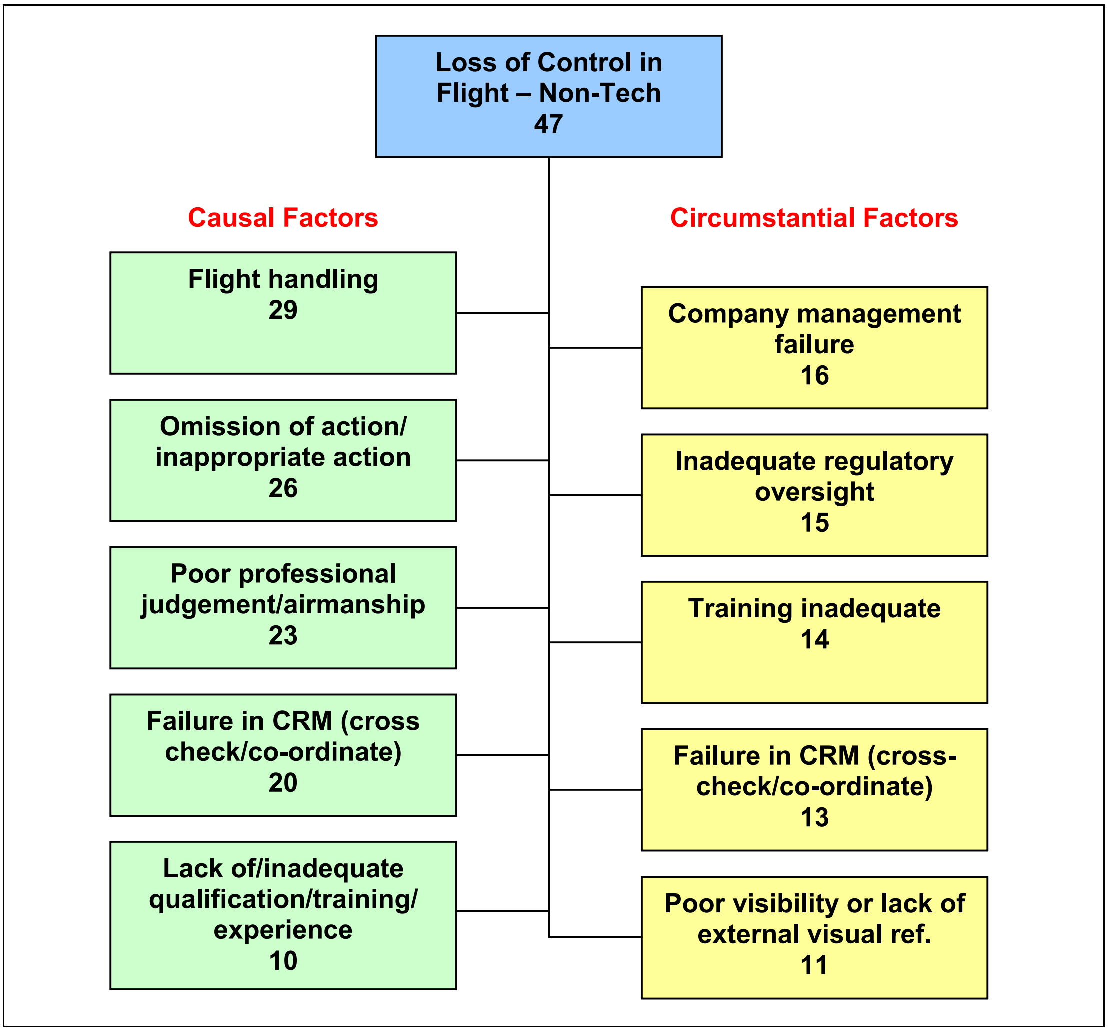

Figure 4 Top-five causal and circumstantial factors associated with fatal accidents with a "Loss of control in flight following non-technical failure" consequence

NOTE: These factors are not mutually exclusive (apart from "Failure in CRM").

5.2.5 Of the 29 fatal accidents with a "Flight handling" causal factor, 18 (or 62%) had no aircraft, maintenance nor fire related causal factors.

5.2.6 Of the 26 fatal accidents with an "Omission of action/inappropriate action" causal factor, seven (or 27%) involved misuse of flaps (e.g. failure to select flaps for take-off). Other issues included inappropriate use of power below flight idle on turboprops whilst airborne and incorrect response to warnings (e.g. stall warning).

5.3 Controlled Flight Into Terrain (CFIT)

5.3.1 Figure 5 shows the most common causal and circumstantial factors allocated for all fatal accidents with a "CFIT" consequence.

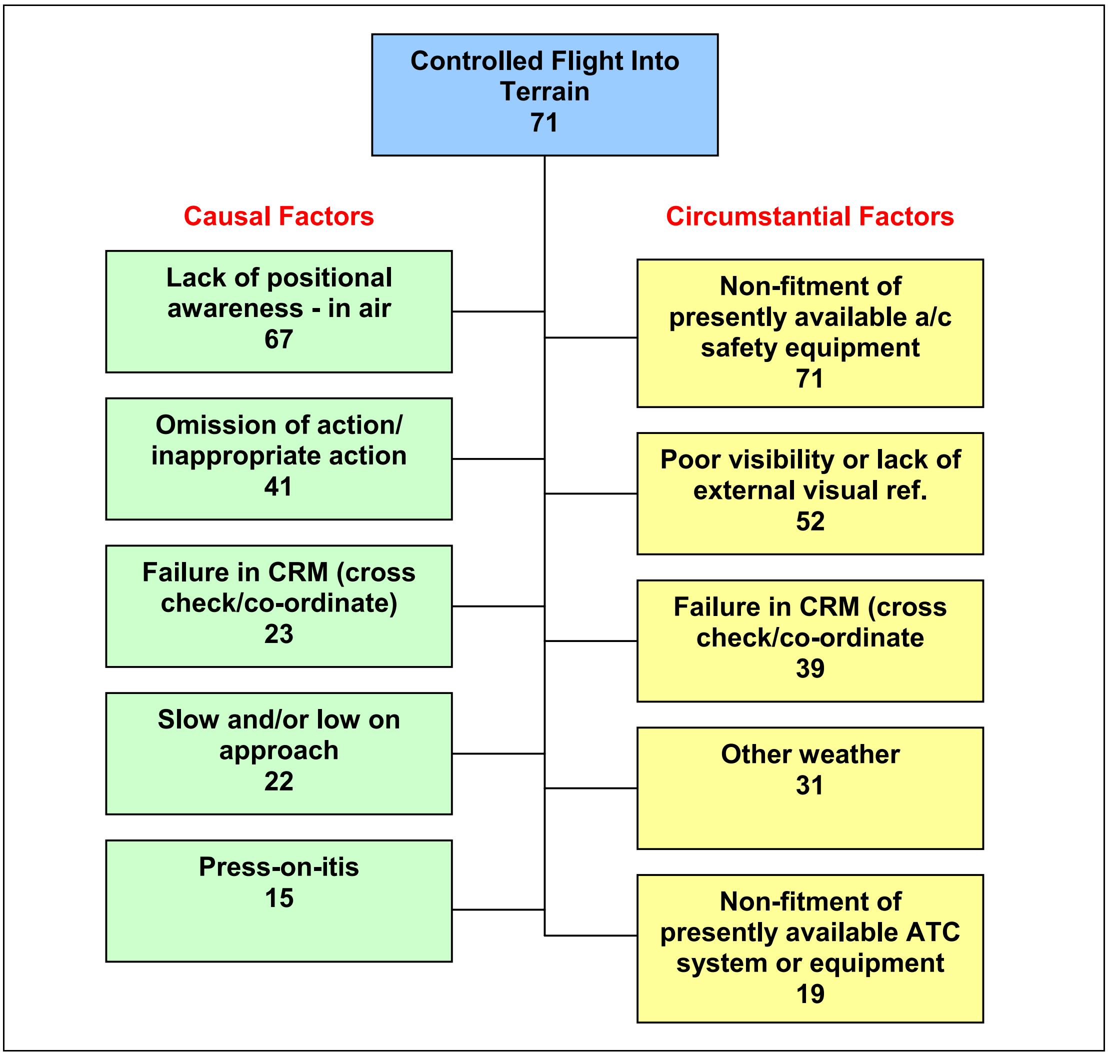

Figure 5 Top-five causal and circumstantial factors associated with fatal accidents with a "CFIT" consequence

NOTE: These factors are not mutually exclusive (apart from "Failure in CRM").

5.3.2 Of the 71 fatal "CFIT" accidents, 55 (or 77%) occurred during the descent or approach phases of flight and at least 17 (or 24%) involved non-precision approaches. Over half (40 or 56%) occurred during the day and 28 (or 39%) took place at night.

5.3.3 Of the 41 fatal accidents with an "Omission of action/inappropriate action" causal factor, 30 (or 73%) involved continued descent below the decision height or minimum descent/safety heights without visual reference and/or failure to fly a missed approach.

5.3.4 All of the "Non-fitment of presently available aircraft safety equipment" circumstantial factors referred to a possible non-fitment of the latest TAWS equipment. Available evidence shows that there has yet to be a genuine fatal "CFIT" accident involving a TAWS equipped aircraft.

5.4 Runway Excursion

5.4.1 Figure 6 shows the most common causal and circumstantial factors allocated for all fatal accidents with a "Runway excursion" consequence. The term "Runway excursion" included aircraft running off the end and side of the runway, both during take-off and landing.

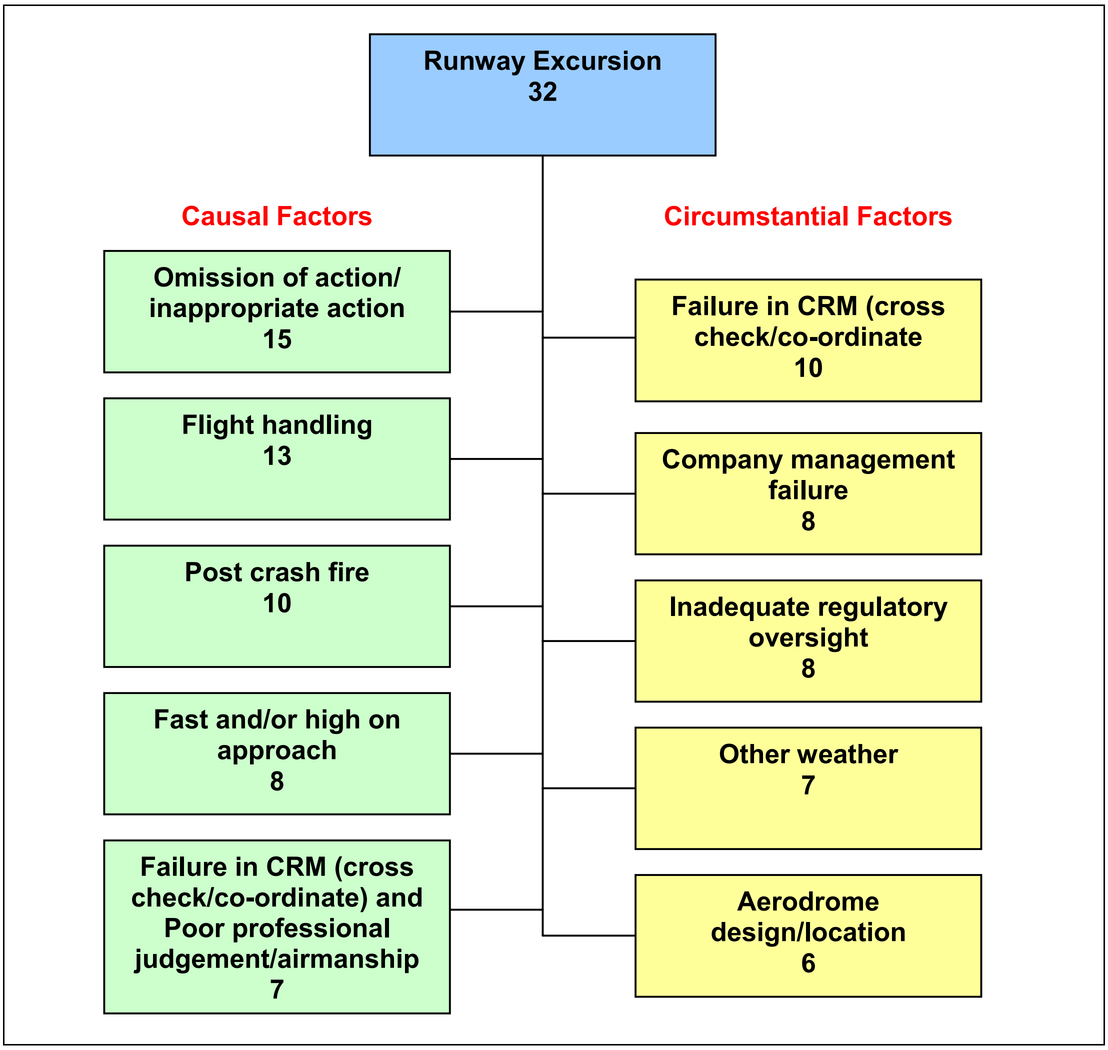

Figure 6 Top-five causal and circumstantial factors associated with fatal accidents with a "Runway excursion" consequence

NOTE: These factors are not mutually exclusive (apart from "Failure in CRM").

5.4.2 Of the 32 fatal "Runway excursion" accidents, 17 (or 53%) occurred during landing and 15 (47%) during take-off; 20 (63%) involved running off the end and 12 (37%) off the side of the runway. Seven (22%) of the 32 fatal accidents involved a wet runway, although this was deemed to be a causal factor in only one case and circumstantial in a further three.

5.4.3 Of the 15 fatal accidents with an "Omission of action/inappropriate action" causal factor, six (or 40%) involved failure to fly a missed approach and five (33%) involved failure to set the correct aircraft configuration for take-off.

5.4.4 Of the 13 fatal accidents with a "Flight handling" causal factor, seven (or 54%) either involved landing hard, long, fast and/or to the side of the centreline.

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Chapter 7 Summary

1 The Global Fatal Accident Review 1997-2006 was carried out to provide a ten-year overview of worldwide fatal accidents to large jet and turboprop aeroplanes engaged in passenger, cargo and ferry/positioning flights. The key findings are summarised below.

2 Worldwide Fatal Accident Numbers

2.1 There was a total of 283 worldwide fatal accidents in the ten-year period 1997 to 2006, which resulted in 8,599 fatalities to passengers and crewmembers onboard the aircraft. The proportion of aircraft occupants killed in these fatal accidents was 69%, which indicates that, on average, 31% of occupants survived.

2.2 There was an overall decreasing trend in both the number of fatal accidents and fatalities, although there was more fluctuation in the number of fatalities.

2.3 Jets were involved in 38% of all the fatal accidents and accounted for 79% of the onboard fatalities whilst turboprops were involved in 49% of all the fatal accidents and accounted for 20% of the onboard fatalities. The equivalent values for business jets were 12% of all the fatal accidents and 1% of the onboard fatalities.[1]

2.4 Passenger flights were involved in 60% of all the fatal accidents and accounted for 94% of the onboard fatalities whilst cargo flights were involved in 29% of all the fatal accidents and accounted for 4% of the onboard fatalities. The equivalent values for ferry/positioning flights were 12% of all the fatal accidents and 1% of the onboard fatalities.

2.5 The approach, landing and go-around phases accounted for 47% of all fatal accidents and 42% of all onboard fatalities. Take-off and climb accounted for a further 30% of the fatal accidents and 29% of the onboard fatalities.

3 Worldwide Aircraft Utilisation

3.1 In the ten-year period from 1997 to 2006, the number of flights flown increased by 17%, which equated to an average annual growth of 1.5%. The equivalent values for hours flown were 31% for overall growth and 2.8% for average annual growth.

3.2 In the ten-year period from 1997 to 2006, the number of flights flown by jets increased by 37%, which equated to an average annual growth of 3.2%. In the same period, the number of flights flown by turboprops decreased by 23%, which equated to an average annual reduction of 2.6%.

3.3 In the ten-year period from 1997 to 2006, the number of passenger flights flown increased by 17%, which equated to an average annual growth of 1.6%. In the same period, the number of cargo flights flown increased by 13%, which equated to an average annual growth of 1.2%.

1. Some of the percentages do not add up to 100% due to rounding to the nearest whole number.

4 Worldwide Fatal Accident Rates

4.1 The overall fatal accident rate for the ten-year period 1997 to 2006 was 0.79 fatal accidents per million flights flown or 0.49 when expressed as per million hours flown. The corresponding onboard fatality rate for the same period was 28.50 fatalities per million flights flown or 17.64 when expressed as per million hours flown.[1]

4.2 There was a decreasing trend in both the overall rate of fatal accidents and onboard fatalities.

4.3 On average, the fatal accident rate for turboprops was three times that for jets, based on flights flown, and nearly seven times greater when using hours flown as the rate measure.

4.4 There was a decreasing trend in both the fatal accident rate and the onboard fatality rate for jets. The fatal accident rate and onboard fatality rate for turboprops remained relatively stable, with a slight increasing trend observed in the last three years.

4.5 On average, the fatal accident rate for aircraft with MTWA below 15 tonnes was twice that for aircraft with MTWA above 27 tonnes, based on flights flown, and over four times greater when using hours flown as the rate measure.

4.6 On average, the fatal accident rate for cargo flights was six times greater than for passenger flights (applicable for both rate measures).

4.7 On average, an aircraft occupant could expect to travel on a passenger flight every day for over 6,400 years before being killed in a fatal accident.

4.8 There was a decreasing trend in both the fatal accident rate and the onboard fatality rate for passenger flights. However, the fatal accident rate and onboard fatality rate for cargo flights showed an increasing trend in the last five years.

4.9 The fatal accident rate for African operators was over seven times greater than that for all operators combined and over 30 times greater than that for North American operators, which had the lowest fatal accident rate of all the regions.

5 Primary Causal Factors

5.1 Two-thirds of all fatal accidents involved a flight crew related primary causal factor and 7% involved an aircraft related primary causal factor.

5.2 The most frequently identified primary causal factor was "Omission of action/inappropriate action", which was allocated in 22% of all fatal accidents. This generally related to flight crew continuing their descent below the decision height or minimum descent/safety heights without visual reference, failing to fly a missed approach or omitting to set the correct aircraft configuration for take-off.

6 All Causal Factors

6.1 Three-quarters of all fatal accidents involved at least one flight crew related causal factor and 42% involved at least one aircraft related causal factor.

6.2 The most frequently identified causal factors were "Omission of action/inappropriate action", "Flight handling" and "Lack of positional awareness - in air", which were allocated in 39%, 29% and 27% of all fatal accidents respectively. "Flight handling" tended to be associated with inadequate speed, pitch attitude and/or directional control, often following an engine failure, resulting in the aircraft stalling.

1. These values included jets and turboprops and passenger and cargo flights only due to lack of equivalent utilisation data for business jets and ferry/positioning flights.

6.3 These three causal factors were also the most prominent in the previous Global Fatal Accident Review. However, “Lack of positional awareness - in air” was involved in proportionally fewer fatal accidents in this study, which reflected a decrease in the proportion of CFIT accidents.

6.4 “Engine failure or malfunction” was the first non-flight crew related causal factor in the list of most frequently identified causal factors and was allocated in 17% of all fatal accidents. Over half of the fatal accidents with this causal factor involved a single engine failure on a twin-engine aeroplane.

7 Circumstantial Factors

7.1 The most frequently identified circumstantial factor was “Non-fitment of presently available aircraft safety equipment”, which was allocated in 33% of all fatal accidents. 85% of the fatal accidents with this circumstantial factor involved non-fitment of the latest TAWS equipment.

7.2 “Poor visibility or lack of external visual reference” was a circumstantial factor in 31% of all fatal accidents.

8 Consequences

8.1 “Post crash fire” and “Loss of control in flight” were the two most frequently identified consequences, each appearing in approximately 40% of all fatal accidents. “CFIT” was the third most common consequence, accounting for 25% of all fatal accidents.

8.2 Compared to the previous Global Fatal Accident Review, “Post crash fire” and “Loss of control in flight” were involved in proportionally more fatal accidents, whilst “CFIT” was involved in proportionally fewer fatal accidents.

8.3 The fatal accidents allocated with “Loss of control in flight” were evenly split between those that followed technical and non-technical failure.

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Appendix 1 The CAA Accident Analysis Group (AAG)

1 Introduction

1.1 The AAG was established by the CAA early in 1996 to systematically review worldwide fatal accidents to identify the foremost global aviation risks. The primary aim of the analysis was to extract safety related information from past accidents so that strategies could be developed to help reduce the worldwide fatal accident rate in the future.

1.2 The AAG decided to assess all worldwide fatal accidents, unlike other studies that only reviewed accidents with sufficient information. This was done to avoid any bias in the analysis towards accidents that had occurred in nations with more mature accident investigation processes.

1.3 The AAG initially comprised of seven experts each bringing to the group extensive aeronautical experience gained both inside and outside the regulatory environment. Areas of expertise included: commercial airline flying, flight testing, handling and performance, systems and structural design, human factors and flight deck design, maintenance, risk and safety analysis, cabin safety and survivability and regulatory/legal procedures.

1.4 The AAG originally analysed worldwide fatal accidents to jet and turboprop aeroplanes above 5,700 kg maximum take-off weight for the period 1980 to 1996. The original study covered public transport operations and business flights, as well commercial training and ferry/positioning flights. The main output of this analysis was "CAP 681 Global Fatal Accident Review 1980-96", which is still published on the CAA website.

1.5 Following production of CAP 681, the AAG has continued to meet on an annual basis to analyse the worldwide fatal accidents from the previous year and the output forms a key part of the CAA Safety Planning process. The AAG's membership has expanded to include representation from the UK Air Accidents Investigation Branch (AAIB), who provide invaluable insight to the accident analysis process as well as an additional source of useful information.

2 AAG Working Methodology

2.1 The AAG's assessment process consisted of three main parts: causal factors, circumstantial factors and consequences. This was accompanied by an evaluation of the level of confidence in the information available. These assessment criteria are detailed below and the complete list of factors and consequences can be found in Appendix 5.

2.1.1 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 an 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 an 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 "Flight Crew" and then divided further into specific factors such as "Lack of positional awareness – in air". An accident may have been allocated any number of causal factors from any one group, and any combination of groups. There was a total of 67 causal factors to choose from.

2.1.2 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 been involved in a Controlled Flight Into Terrain (CFIT) accident 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 GPWS could be deemed circumstantial, but not causal, in a CFIT type accident.

The circumstantial factors were listed in groups such as "Infrastructure" and then divided further into specific factors such as "Company management failure". An accident may have been allocated any number of circumstantial factors from any one group, and any combination of groups. There was a total of 22 circumstantial factors to choose from.

2.1.3 Consequences

A list of consequences was used to record the outcomes of the fatal accidents in terms of loss of control, fire, CFIT, runway excursion, structural failure 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 another day it may only result in a minor incident. In many cases, the consequence is all that is known about a particular event. An accident may have been allocated any number of consequences. There was a total of 15 consequences to choose from.

2.1.4 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 information and therefore the 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 that there was not enough substantive information, then there was a fourth level of confidence, "Insufficient Information".

The breakdown of level of confidence for the 283 fatal accidents in the study is shown below:

- High: 117 (41%)
- Medium: 98 (35%)
- Low: 37 (13%)
- Insufficient Information: 31 (11%)

3 Limitations of AAG Data

3.1 It should be noted that as only fatal accidents were included in this study, some important events, such as non-fatal hull losses (for example the Airbus A340 overrun at Toronto in 2005), have not been represented.

3.2 The information contained in the Ascend (formerly Airclaims) accident summaries was believed to be accurate but in some cases was quite brief. These summaries may not have included 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 have been an element of incomplete data. This was particularly true of flight crew related factors such as CRM and fatigue, which may have been 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.

3.3 In this report, the analysis of the data was performed on groups of accidents, rather than individual accidents. It was considered that aggregation of the data would help to lessen the effect of any random errors introduced by inaccurate factor allocation.

3.4 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.

4 Differences to CAP 681 Global Fatal Accident Review 1980-96

4.1 To align with other current CAA documents involving statistical analysis of accidents, the criteria for inclusion of fatal accident in the study dataset employed in CAP 776 was slightly different to that used in CAP 681. The differences are listed below.

4.1.1 CAP 776 only considered fatal accidents with at least one fatality to an aircraft occupant (CAP 681 also included third-party only fatalities).

4.1.2 CAP 776 only considered fatal accidents involving passenger, cargo and ferry/positioning flights (CAP 681 also included private business jet flights, executive flights, demonstration flights and commercial training flights).

4.1.3 CAP 776 only considered fatal accidents involving aeroplanes whose original certified maximum take-off weight was above 5,700 kg (CAP 681 also included some aeroplanes with maximum take-off weight below 5,700 kg).

4.1.4 The "Collision with terrain/water/obstacle" consequence was used differently in CAP 776 in that it was only allocated in cases where a more specific consequence did not apply (in CAP 681 it was used for all cases where an aircraft, or any part of an aircraft, collided with terrain/water/obstacle whilst not under full control – this included cases when the aircraft had previously broken up in mid-air).

4.1.5 The "Undershoot" consequence was used differently in CAP 776 in that it was only applied when the aircraft undershot in close proximity to the runway (in CAP 681 it was used as far out as five miles on or near the runway centreline).

4.1.6 CAP 776 included an additional three causal factors ("Inadequate or incorrect performance of ancillary equipment", "Inadequate or incorrect airport departure or arrival procedure design" and "Unsafe action by other personnel") and an additional seven circumstantial factors ("Inoperative aircraft systems", "Non-fitment of presently available ATC system or equipment (e.g. MSAW)", "Non-precision approach flown", "Aerodrome design or location", "Low fuel state", "Carriage of dangerous goods" and "Non-safety related restrictions").

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Appendix 2 Definitions

Accident (Fatal)

The ICAO Annex 13 definition for a fatal accident is used:

An occurrence associated with the operation of an aircraft, which takes place between the time any person, boards the aircraft with the intention of flight until such time as all such persons have disembarked, in which:

A person is fatally injured as a result of:

- being in the aircraft, or
- direct contact with any part of the aircraft, including parts which have become detached from the aircraft, or
- direct exposure to jet blast,

except when the injuries are from natural causes, self-inflicted or inflicted by other persons, or when the injuries are to stowaways hiding outside the areas normally available to the passengers and crew.

NOTE 1: For statistical uniformity only, an injury resulting in death within thirty days of the date of the accident is classified as a fatal injury by ICAO.

NOTE 2: An additional requirement for this particular study is that there must have been at least one fatality to an aircraft occupant (this is not an ICAO condition).

Africa

The countries included in the African region are taken from the ICAO Safety Indicators Study Group regional definitions and are as follows:

Algeria
Angola
Benin
Botswana
British Indian Ocean Territory
Burkina Faso
Burundi
Cameroon
Cape Verde Islands
Central African Republic
Chad
Comoros
Congo
Congo (Democratic Republic)
Djibouti
Egypt
Equatorial Guinea
Eritrea
Ethiopia
Gabon
Gambia
Ghana
Guinea
Guinea-Bissau
Ivory Coast
Kenya
Lesotho
Liberia
Libya
Madagascar
Malawi
Mali
Mauritania
Mauritius
Morocco
Mozambique
Namibia
Niger
Nigeria
Reunion
Rwanda
Saint Helena
Sao Tome and Principe
Senegal
Seychelles
Sierra Leone
Somalia
South Africa
Sudan
Swaziland
Tanzania
Togo
Tunisia
Uganda
Western Sahara
Zambia
Zimbabwe

Asia

The countries included in the Asian region are taken from the ICAO Safety Indicators Study Group regional definitions and are as follows:

Afghanistan
Bangladesh
Bhutan
Brunei
Cambodia
China
East Timor
Hong Kong
India
Indonesia
Japan
Kazakhstan
Kyrgyzstan
Laos
Macau
Malaysia
Maldives
Mongolia
Myanmar
Nepal
North Korea
Pakistan
Philippines
Singapore
South Korea
Sri Lanka
Taiwan
Tajikistan
Thailand
Turkmenistan
Uzbekistan
Vietnam

Causal Factor

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

Central America and Caribbean

The countries included in the Central American and Caribbean region are taken from the ICAO Safety Indicators Study Group regional definitions and are as follows:

Belize
Costa Rica
El Salvador
Guatemala
Honduras
Mexico
Nicaragua
Panama
Anguilla
Antigua and Barbuda
Aruba
Bahamas
Barbados
Bermuda
Cayman Islands
Cuba
Dominica
Dominican Republic
French Antilles
Grenada
Guadeloupe
Haiti
Jamaica
Martinique
Montserrat
Netherlands Antilles
Puerto Rico
Saint Barthelemy
Saint Kitts and Nevis
Saint Lucia
Saint Martin
Saint Vincent and the Grenadines
Trinidad and Tobago
Turks and Caicos Islands
Virgin Islands (British)
Virgin Islands (US)

Circumstantial Factor

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

Consequence

An outcome of the fatal accident.

Europe

The countries included in the European region are taken from the ICAO Safety Indicators Study Group regional definitions and are as follows (the original 15 European Union member states are shown in bold text and the additional 12 accession states in italic text):

Albania
Andorra
Armenia
Austria
Azerbaijan
Azores
Belarus
Belgium
Bosnia-Herzegovina
Bulgaria
Canary Islands
Croatia
Cyprus
Czech Republic
Denmark
Estonia
Faroe Islands
Federation of Serbia and Montenegro
Finland
France
Georgia
Germany
Gibraltar
Greece
Greenland
Hungary
Iceland
Ireland
Italy
Latvia
Liechtenstein
Lithuania
Luxembourg
Macedonia
Madeira
Malta
Moldova
Monaco
Montenegro
Netherlands
Norway
Poland
Portugal
Romania
Russia
San Marino
Serbia
Slovak Republic
Slovenia
Spain
Sweden
Switzerland
Turkey
Ukraine
United Kingdom

Level of Confidence

The level of confidence in the fatal accident summary and the consequent factors allocated by the CAA's Accident Analysis Group.

Middle East

The countries included in the Middle Eastern region are taken from the ICAO Safety Indicators Study Group regional definitions and are as follows:

Bahrain
Iran
Iraq
Israel
Jordan
Kuwait
Lebanon
Oman
Palestine
Qatar
Republic of Yemen
Saudi Arabia
Syria
United Arab Emirates
Yemen

North America

The countries included in the North American region are taken from the ICAO Safety Indicators Study Group regional definitions and are as follows:

Canada
Saint Pierre and Miquelon
USA

Oceania

The countries included in the Oceania region are taken from the ICAO Safety Indicators Study Group regional definitions and are as follows:

American Samoa
Australia
Cook Islands
Easter Island
Fiji
French Polynesia
Guam
Johnston Island
Kiribati
Line Islands
Marshall Islands
Micronesia
Midway
Nauru
New Caledonia
New Zealand
Niue
Northern Marianas Islands
Palau
Papua New Guinea
Pitcairn Island
Solomon Islands
Tonga
Tuvalu
Vanuatu
Wake Island
Wallis and Futuna Islands
Western Samoa

Operator Region

The world region from which the aircraft operator originates.

Primary Causal Factor

The dominant causal factor of the fatal accident as judged by the CAA's Accident Analysis Group.

South America

The countries included in the South American region are taken from the ICAO Safety Indicators Study Group regional definitions and are as follows:

Argentina
Bolivia
Brazil
Chile
Colombia
Ecuador
Falkland Islands
French Guiana
Guyana
Paraguay
Peru
Suriname
Uruguay
Venezuela

Appendix 3 Glossary

AAIB	Air Accidents Investigation Branch
AAG	Accident Analysis Group
ATC	Air Traffic Control
ATS	Air Traffic Service
CAA	Civil Aviation Authority
CAP	Civil Aviation Publication
CFIT	Controlled Flight Into Terrain
CRM	Crew Resource Management
DH	Decision Height
EGPWS	Enhanced Ground Proximity Warning System
EU	European Union
GPS	Global Positioning System
GPWS	Ground Proximity Warning System
ICAO	International Civil Aviation Organisation
MDH	Minimum Descent Height
MSA	Minimum Safe Altitude
MSAW	Minimum Safe Altitude Warning
MTWA	Maximum Take-off Weight Authorised
SISG	Safety Indicators Study Group
TAWS	Terrain Awareness and Warning System

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Appendix 4 Aircraft Types Included in Study

1 Tables 1, 2 and 3 show the aircraft types that were considered to be jets, turboprops and business jets, respectively. The tables also show how many times each individual aircraft type featured in a fatal accident. A zero entry, for jets and turboprops only, signifies that the aircraft was not involved in a fatal accident during the study period but it contributed to the flights and hours flown, and hence the calculation of rates.

2 One of the conditions for an aircraft to be included in the fatal accident dataset was that the MTWA must be over 5,700 kg. For the purposes of this study, the original certified MTWA determined whether an aircraft was included or not. For example, the Embraer Bandeirante was excluded, although there are individual aircraft that have MTWA above 5,700 kg.

3 Jets

Table 1 Jet aircraft that featured in the fatal accident dataset and utilisation

Aircraft Type	No. Fatal Accidents	Aircraft Type	No. Fatal Accidents
Aerospatiale Caravelle	1	Embraer ERJ-135	0
Aerospatiale Concorde	1	Embraer ERJ-140	0
Airbus A300	5	Embraer ERJ-145	0
Airbus A310	3	Embraer 170	0
Airbus A318	0	Embraer 175	0
Airbus A319	0	Embraer 190	0
Airbus A320	2	Embraer 195	0
Airbus A321	0	Fokker F28	1
Airbus A330	0	Fokker 70	0
Airbus A340	0	Fokker 100	1
Antonov An-72	0	Ilyushin IL-62	0
Antonov An-74	0	Ilyushin IL-76	11
Antonov An-124	0	Ilyushin IL-86	1
Antonov An-225	0	Ilyushin IL-96	0
Avroliner RJ	2	Lockheed L-1011 TriStar	0
BAC One-Eleven	1	McDonnell-Douglas DC-8	2
BAe 146	2	McDonnell-Douglas DC-9	5
Boeing 707	3	McDonnell-Douglas DC-10	1
Boeing 717	0	McDonnell-Douglas MD-80	5
Boeing 720	0	McDonnell-Douglas MD-90	0
Boeing 727	6	McDonnell-Douglas MD-11	3
Boeing 737	21	Tupolev Tu-134	1
Boeing 747	7	Tupolev Tu-154	8
Boeing 757	2	Tupolev Tu-204	0
Boeing 767	2	VFW 614	0
Boeing 777	0	Yakovlev Yak-40	5
Canadair Regional Jet	4	Yakovlev Yak-42	3
Dornier 328 Jet	0	**Total**	**109**

4 Turboprops

Table 2 Turboprop aircraft that featured in the fatal accident dataset and utilisation

Aircraft Type	No. Fatal Accidents	Aircraft Type	No. Fatal Accidents
Aerospatiale 262	0	Embraer EMB-120 Brasilia	5
Antonov An-12	17	Fairchild (Swearingen) Metro	11
Antonov An-8	1	Fairchild F-27	0
Antonov An-22	0	Fairchild FH-227	1
Antonov An-24	7	Fokker F27	9
Antonov An-26	5	Fokker 50	2
Antonov An-30	0	Grumman G-73T Turbo Mallard	1
Antonov An-32	6	Gulfstream Aerospace Gulfstream I	2
Antonov An-38	0	Handley Page Herald	0
Antonov An-140	2	Handley Page Jetstream	0
ATR 42	3	HS 748	4
ATR 72	2	IAI Arava	0
BAe ATP	2	Ilyushin IL-18	1
BAe Jetstream 31	4	Ilyushin IL-114	1
BAe Jetstream 41	0	Let L-410 Turbolet	19
Beech 1900	7	Lockheed Hercules	1
Bristol Britannia	0	Lockheed L-188 Electra	1
Canadair CL-44	0	NAMC YS-11	0
CASA/IPTN 212	2	Saab 340	2
CASA/IPTN CN-235	1	Saab 2000	0
Convair 580	3	Shaanxi Y-8	0
Convair 600	0	Shorts 330	1
Convair 640	0	Shorts 360	2
DHC-5 Buffalo	0	Shorts SC.5 Belfast	0
DHC Dash 7	0	Transall C-160	1
DHC Dash 8	0	Vickers Viscount	1
Dornier 228	4	WSK-PZL Mielec An-28	7
Dornier 328	1	Xian Y-7	1
		Total	**140**

5 Business Jets

Table 3 Business jet aircraft that featured in the fatal accident dataset

Aircraft Type	No. Fatal Accidents	Aircraft Type	No. Fatal Accidents
Aerospatiale Corvette	1	Learjet 24	3
Canadair CL-600 Challenger	1	Learjet 25	5
Cessna 550 Citation II	1	Learjet 35	7
Cessna 560 Citation V	1	Learjet 45	1
Dassault Aviation Falcon 20/200	2	Learjet 55	1
Gulfstream Aerospace Gulfstream III	2	M.B.B. HFB 320 Hansa	1
HS 125	3	Rockwell Sabreliner	4
IAI Westwind	2	**Total**	**35**

NOTE: Utilisation data was not available for business jet aircraft, which is why Table 3 only includes business jet aircraft types that featured in at least one fatal accident.

6 The sum, by individual aircraft type, of the number of fatal accidents was 284, one more than the total number of fatal accidents stated earlier in this document. This was due to the inclusion of both jet aircraft involved in the Uberlingen mid-air collision that occurred on 1 July 2002 (a Boeing 757 and a Tupolev TU-154). This mid-air collision was counted as one fatal accident in the overall statistics.

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Appendix 5 List of Factors and Consequences Attributed to Worldwide Fatal Accidents 1997 to 2006

The AAG taxonomy is shown below in Table 1, complete with the number of times each causal factor, circumstantial factor and consequence was allocated. These factors and consequences are not mutually exclusive[1] as each fatal accident generally involves more than one factor or consequence.

1. With the exception of primary causal factors, of which only one was allocated per fatal accident.

Table 1 AAG Taxonomy

List of Factors and Consequences Attributed to Worldwide Fatal Accidents - 1997 to 2006

(Each accident can have more than one factor or consequence)

A	Causal Factors			Primary	Other Causal	Total
A.1	Aircraft Systems	1.1	System failure - affecting controllability	3	5	**8**
		1.2	System failure - flight deck information	4	11	**15**
		1.3	System failure - other	4	8	**12**
A.2	ATC/Ground Aids	2.1	Incorrect or inadequate instruction/advice	4	7	**11**
		2.2	Misunderstood or missed communication	0	3	**3**
		2.3	Failure to provide separation - air	1	1	**2**
		2.4	Failure to provide separation - ground	0	2	**2**
		2.5	Ground aid malfunction or unavailable	1	11	**12**
A.3	Environmental	3.1	Structural overload	0	0	**0**
		3.2	Wind shear, upset or turbulence	6	8	**14**
		3.3	Icing	3	9	**12**
		3.4	Wake turbulence - aircraft spacing	0	1	**1**
		3.5	Volcanic ash, sand, precipitation, etc.	0	3	**3**
		3.6	Birds	1	2	**3**
		3.7	Lightning	1	1	**2**
		3.8	Runway condition unknown to crew	0	1	**1**
A.4	Flight Crew	4.1	Lack of positional awareness - in air	40	36	**76**
		4.2	Lack of positional awareness - on ground	0	2	**2**
		4.3	Lack of awareness of circumstances in flight	4	11	**15**
		4.4	Incorrect selection on instrument or navaid	0	1	**1**
		4.5	Action on wrong control or instrument	0	3	**3**
		4.6	Slow or delayed action	0	18	**18**
		4.7	Omission of action or inappropriate action	63	48	**111**
		4.8	"Press-on-itis"	2	33	**35**
		4.9	Failure in CRM (cross-check/co-ordinate)	0	63	**63**
		4.10	Poor professional judgement or airmanship	16	47	**63**
		4.11	Disorientation or visual illusion	4	10	**14**
		4.12	Fatigue	0	18	**18**
		4.13	State of mind	2	2	**4**
		4.14	Interaction with automation	0	8	**8**
		4.15	Fast and/or high on approach	0	17	**17**
		4.16	Slow and/or low on approach	0	34	**34**
		4.17	Loading incorrect	5	11	**16**
		4.18	Flight handling	39	43	**82**
		4.19	Lack of/inadequate qualification, training or experience	0	25	**25**
		4.20	Incapacitation, medical or other factors reducing crew performance	1	8	**9**
		4.21	Failure in look-out	2	0	**2**
		4.22	Deliberate non-adherence to procedures	5	17	**22**
A.5	Engine	5.1	Engine failure or malfunction	2	46	**48**
		5.2	Propeller failure	1	1	**2**
		5.3	Damage due to non-containment	1	0	**1**
		5.4	Fuel contamination	0	0	**0**
		5.5	Engine failure simulated	0	1	**1**
A.6	Fire	6.1	Engine fire or overheat	2	2	**4**
		6.2	Fire due to aircraft systems	2	2	**4**
		6.3	Fire - other cause	0	0	**0**
		6.4	Post crash fire	0	35	**35**
A.7	Maintenance/ Ground Handling	7.1	Failure to carry-out due maintenance	0	3	**3**
		7.2	Maintenance or repair error, oversight or inadequacy	12	13	**25**
		7.3	Ground staff or passenger(s) struck by aircraft	0	0	**0**
		7.4	Loading error	5	7	**12**
		7.5	Bogus parts	0	1	**1**
A.8	Aircraft Structure	8.1	Corrosion or fatigue	1	2	**3**
		8.2	Overload failure	0	11	**11**
		8.3	Flutter	0	0	**0**
A.9	Infrastructure	9.1	Incorrect, inadequate or misleading information to crew	0	18	**18**
		9.2	Inadequate aerodrome support	0	8	**8**
A.9	Infrastructure	9.3	Inadequate or incorrect performance of ancillary equipment	0	1	**1**
		9.4	Inadequate or incorrect airport departure or arrival procedure design	0	1	**1**
A.10	Aircraft Design	10.1	Design shortcomings	3	27	**30**
		10.2	Unapproved modification	0	0	**0**
		10.3	Manufacturing defect	0	1	**1**
A.11	Aircraft Control/ Performance	11.1	Unable to maintain speed/height or achieve scheduled performance	1	23	**24**
		11.2	Aircraft becomes uncontrollable	1	23	**24**
A.12	Other	12.1	Caused by other aircraft or vehicle	3	2	**5**
		12.2	Non-adherence to cabin safety procedures	0	5	**5**
		12.3	Unsafe action by other personnel	0	1	**1**

B	Circumstantial Factors			Total
B.1	Aircraft Systems	1.1	Non-fitment of presently available aircraft safety equipment (e.g. TAWS, TCAS, etc.)	**94**
		1.2	Failure or inadequacy of aircraft safety equipment	**7**
		1.3	Inoperative aircraft systems	**1**
B.2	ATC/Ground Aids	2.1	Lack of ATC	**2**
		2.2	Lack of ground aids	**19**
		2.3	Non-fitment of presently available ATC system or equipment (e.g. MSAW)	**25**
		2.4	Non-precision approach flown	**20**
B.3	Environmental	3.1	Poor visibility or lack of external visual reference	**89**
		3.2	Other weather	**79**
		3.3	Runway or taxiway condition (e.g. ice, slippery, standing water, debris, etc.)	**5**
		3.4	Aerodrome design or location	**12**
B.4	Flight Crew	4.1	Training inadequate	**30**
		4.2	Presented with situation beyond training or experience	**3**
		4.3	Failure in CRM (cross-check/co-ordinate)	**81**
B.5	Infrastructure	5.1	Incorrect or inadequate procedures	**31**
		5.2	Company management failure	**76**
		5.3	Inadequate regulation	**26**
		5.4	Inadequate regulatory oversight	**69**
B.6	Other	6.1	Illegal, unauthorised or drug smuggling flight	**5**
		6.2	Low fuel state	**11**
		6.3	Carriage of dangerous goods	**2**
		6.4	Non-safety related restrictions	**2**

C	Consequences	Total
C.1	Controlled Flight Into Terrain (CFIT)	**71**
C.2	Collision with terrain, water or obstacle	**32**
C.3	Mid-air collision	**5**
C.4	Ground collision with other aircraft	**2**
C.5	Ground collision with object or obstacle	**29**
C.6	Loss of control in flight (all)	**110**
C.7	Fuel exhaustion	**8**
C.8	Runway excursion or overrun	**32**
C.9	Undershoot	**5**
C.10	Structural failure	**20**
C.11	Post crash fire	**120**
C.12	Fire or smoke during operation	**10**
C.13	Emergency evacuation difficulties	**16**
C.14	Forced landing - land or water	**22**
C.15	Other cause of fatality	**7**

Level of Confidence

117	High	37	Low
98	Medium	31	Insufficient Information

Total Number of Fatal Accidents in Study 283