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Trends in Accidents and Fatalities in Large Transport Aircraft

June 2010

Final Report

U.S. Department of Transportation
Federal Aviation Administration

Transport Canada Transports Canada

United Kingdom Civil Aviation Authority

NOTICE

This research was commissioned by the Federal Aviation Administration and Transport Canada by means of their respective Memorandums of Cooperation regarding Civil Aviation Research and Development with the Civil Aviation Authority of the United Kingdom. This activity has been carried out in cooperation between the Federal Aviation Administration, Transport Canada, and the UK Civil Aviation Authority under the auspices of the International Cabin Safety Research Technical Group whose goal is to enhance the effectiveness and timeliness of cabin safety research.

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16. Abstract

This study is based on 1036 accidents (of which 672 were survivable) that occurred between 1968 and 2007 involving large transport category turbojet and turboprop western-built aircraft operating in a passenger or passenger/cargo role.

Over the study period, there was a marked reduction in the total accident rate both for the world fleet and the combined U.S. and Canadian fleets. This reduction is apparent when the accident rate is measured on a per flight, per passenger, or per revenue passenger mile basis.

The survivability of accidents has also shown a marked improvement over the study period with a greater proportion of accidents being survivable and a marked increase in the proportion of occupants surviving an accident. These improvements are apparent in both the world fleet and the combined U.S. and Canadian fleets.

It would seem that fatalities attributable to impact represent a larger proportion of the total number of fatalities in survivable accidents than those that are caused by fire.

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TABLE OF CONTENTS

APPENDICES

LIST OF FIGURES

LIST OF ACRONYMS

ASN	Aviation Safety Network
CAA	Civil Aviation Authority
CSRTG	Cabin Safety Research Technical Group
FAA	Federal Aviation Administration
NTSB	National Transportation Safety Board
UK	United Kingdom

EXECUTIVE SUMMARY

Over the past 40 years, many safety enhancements have been instituted as a result of advances in technology, and by regulations derived from research, aimed at improving aircraft safety through accident prevention and occupant survivability enhancement. However, the magnitude of these improvements has not been quantified precisely. Therefore, the Federal Aviation Administration and Transport Canada have commissioned this study with the broad aim of identifying the degree of improvement in aircraft safety and occupant survivability that has been achieved. The intention is that the results of the study can help in the determination of the future direction of any regulatory activity, particularly in relation to occupant survivability. The most significant findings of the study are contained within this report.

The study is based on 1036 accidents (of which 672 were survivable) that occurred between 1968 and 2007 involving large transport category turbojet and turboprop western-built aircraft operating in a passenger or passenger/cargo role.

Over the study period, there was a marked reduction in the total accident rate both for the world fleet and the combined U.S. and Canadian fleets. This reduction is apparent when the accident rate is measured on a per flight, per passenger, or per revenue passenger mile basis.

The survivability of accidents has also shown a marked improvement over the study period with a greater proportion of accidents being survivable and the proportion of occupants surviving an accident increased markedly. These improvements are apparent in both the world fleet and the combined U.S. and Canadian fleets.

It would seem that fatalities attributable to impact represent a larger proportion of the total number of fatalities in survivable accidents than those that are caused by fire. However, the extent to which the number of fatalities attributable to each of these two areas might be reduced was beyond the scope of this study.

1. INTRODUCTION.

Over the past 40 years, many safety enhancements have been instituted as a result of advances in technology, and by regulations derived from research, aimed at improving aircraft safety through accident prevention and occupant survivability enhancement. However, the magnitude of these improvements has not been quantified precisely. Earlier studies carried out on behalf of Transport Canada [1 and 2] gave an indication of the likely direction of improvements in aircraft accident rates, albeit limited by the data available at the time. The development of the Cabin Safety Research Technical Group (CSRTG) Accident Database has resulted in improved availability of sufficient data. This has facilitated the task of analyzing the magnitude of the safety improvements that have been achieved.

The broad aim of this study was, therefore, to identify the degree of improvement in aircraft safety and occupant survivability to enable the airworthiness authorities to determine the future direction of research and regulatory activity, particularly in relation to occupant survivability.

This study has identified and analyzed all the data required to meet the objectives defined in section 1.1. However, for reasons of clarity, only the most significant results of the analysis are presented in this report. The complete data set has been made available to the Federal Aviation Administration (FAA) and Transport Canada, who commissioned this study in association with the United Kingdom (UK) Civil Aviation Authority (CAA).

1.1 OBJECTIVES.

The broad objectives of the study were to make determinations of

- The total number of fatalities in all accidents (survivable and nonsurvivable)
- The total number of occupants per year involved in survivable accidents
- The total number of fatalities per year involved in survivable accidents
- The total number of fire fatalities per year involved in survivable accidents
- The total number of impact fatalities per year involved in survivable accidents
- The proportion of the total number of fatalities that are nonsurvivable, survivable impact-related, survivable fire-related, survivable fire- and impact-related, survivable water-related and other
- The proportion of occupants in survivable accidents sustaining fatal injuries resulting from impact, fire, fire and impact, drowning, or other (e.g., caused by turbulence, violent maneuvers, etc.)
- The total number of fatalities, per in-flight fire accident

The data analyzed was categorized and analyzed in relation to:

- Accidents to the world fleet
- Accidents to U.S.-registered aircraft
- Accidents to U.S.- and Canadian-registered aircraft
- Accidents occurring on U.S. or Canadian soil or within their territorial waters

Determinations of the safety trends were made for the western-built fleet of aircraft, as defined in appendix A. Further determinations were made for the western-built fleet, which were subdivided into turbojets and turboprops. The rates of occurrence used in the analysis were derived on a per million flight, per million passengers, and per 100-million revenue passenger mile basis.

This report presents the more significant trends in safety; however, data and trend curves were prepared relevant to all the indicators, based on the variables listed above. These are contained in Microsoft® Excel® spreadsheets provided separately to the FAA, Transport Canada, and the UK CAA.

1.2 SCOPE.

The study was based on accidents to large transport category turbojet and turboprop western-built aircraft operating in a passenger or passenger/cargo role. The analysis considered accidents involving the aircraft identified in appendix A between 1968 and 2007.

2. METHODOLOGY.

2.1 ACCIDENTS SELECTED FOR ANALYSIS.

Accidents (as defined in section 2.2) that met the following criteria were selected for analysis using the CSRTG Accident Database version 33:

- The accident occurred between 1968 and 2007.
- The aircraft type is listed in appendix A.
- The aircraft was operating a passenger or combined passenger/cargo flight.
- The accident was not caused by an act of terrorism or violence.

Although the primary data source was the CSRTG Accident Database, additional information was obtained from the in-house library of accident reports produced by accident investigating authorities. In instances where official data were not available, unofficial data were used, primarily based on the Aviation Safety Network (ASN) database[1]. Thirty-two accidents were excluded from the study because there was insufficient information to make an assessment as to whether they were survivable or nonsurvivable.

There were 1036 accidents selected for analysis that met the criteria specified above.

[1]ASN Aviation Safety Database—a service of the Flight Safety Foundation http://aviation-safety.net/database/

2.2 CATEGORIZATION OF ACCIDENTS.

This study was primarily intended to provide data to assist the airworthiness authorities in their decision-making process regarding the direction of research and regulations related to occupant survivability. As part of the regulatory decision-making process, the authorities were required to undertake cost benefit analyses and regulatory impact assessments to determine the effects of any changes. As a consequence, the definitions of an Accident, a Nonsurvivable Accident, and a Survivable Accident used in this study were developed and agreed to by the FAA and Transport Canada.

2.2.1 Accident.

The FAA and Transport Canada define an accident as:

> "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) At least one person is fatally injured or
> b) The aircraft is destroyed"

2.2.2 Nonsurvivable Accident.

The following definition was used as a basis for determining if an accident was Nonsurvivable:

> "A Nonsurvivable Accident is one in which all occupants sustain fatal injuries."

However, accidents were identified where the vast majority of occupants sustained fatal injuries, although a few occupants survived (typically one or two). If in these accidents it was evident that there were no survivability factors that could be identified that might have improved occupant survivability, these accidents were classified as Nonsurvivable. Examples of accidents of this kind include the following:

> Tamanrasset B737 - 2003[2]
> "On Thursday 6 March 2003, the Boeing 737 registered 7T-VEZ, operated by Air Algérie, was taking off from Tamanrasset to undertake, with a three-hour delay, scheduled flight DAH 6289 to Ghardaia and Algiers. The accident was caused by the loss of an engine during a critical phase of flight, the non-retraction of the landing gear after the engine failure, and the Captain, the PNF [pilot not flying], taking over control of the aircraft before having clearly identified the problem. The aircraft, with landing gear extended, struck the ground on its right side. A severe fire broke out immediately.

[2]This account of the accident is based on a translation of the accident report. As accurate as the translation may be, the original text of the accident report should be considered as the work of reference.

Six crew members (two flight crew and four cabin crew) and 97 passengers were on board. All six crew were fatally injured. Of the 97 passengers on board, 96 passengers were fatally injured and one passenger was seriously injured. Only one passenger, seated in the last row and with seat belt unattached, according to his statement, was ejected from the plane by the impact and escaped from the accident."

Detroit MD-82 - 1987[3]
"On 16-Aug-1987 a Northwest DC-9-82 (MD82) registered as N312RC was taking off without the flaps and slats extended. After lift-off, the aircraft collided with obstacles northeast of the runway and broke up as it slid across the ground and post-impact fires erupted along the wreckage path. Of the persons on board, 148 passengers and six crew members were killed; the only survivor, a four year old child, was seriously injured."

Of the 1036 accidents selected for analysis, 364 were categorized as Nonsurvivable.

2.2.3 Survivable Accident.

The following definition was used as a basis for determining if an accident was survivable.

"An Accident that is not Nonsurvivable, but involves at least one Fatal Injury or the aircraft was destroyed."

Some accidents, classified as Survivable, involved areas of the aircraft that were clearly Nonsurvivable. An example of such an accident is as follows:

Dallas L1011- 1985[4]
"On 2-Aug-1985, Delta Airlines Lockheed L1011-385-1, N726DA, crashed while passing through a microburst. The aircraft struck the ground about 6300 feet north of the approach end of the runway, disintegrated during the impact sequence, and a severe fire erupted during the impact sequence. Of the 163 persons aboard, 134 passengers and crewmembers were killed; 26 passengers and 3 cabin attendants survived. The forward cabin containing the cockpit and first 12 rows of passenger seats was destroyed on impact with the water tanks, and there were no survivors from this part of the airplane."

In the above accident, for the occupants located in the cockpit and first 12 rows of passenger seats, the impact injuries were clearly not survivable, and it is evident that no survivability factors could have increased their chance of survival. However, accidents of this nature were classified as Survivable.

Of the 1036 accidents selected for analysis, 672 were categorized as Survivable.

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[3]This account of the accident is based on the National Transportation Safety Board (NTSB) Report AAR-88-5.
[4]This account of the accident is based on NTSB Report AAR-86/05.

In some instances, it was difficult to classify the accident as Survivable or Nonsurvivable. For example, some accidents were 100% fatal but, nevertheless, were considered as Survivable since factors could be identified that might have improved occupant survivability.

However, the number of accidents that are not clearly in one category or the other is small and, hence, does not significantly affect the overall conclusions that may be derived from this study.

2.3 ASSESSMENT OF OCCUPANT SURVIVABILITY.

To assess trends in occupant survivability, an evaluation was required for each Survivable Accident:

- The number of occupants onboard the aircraft
- The number of fatalities by cause of death

In certain instances, accidents were identified for which there was insufficient data to determine the precise value for each of these numbers; in these cases, their probable values had to be assessed. The following sections discuss the approaches that were used to make these assessments and the number of accidents that were involved.

2.3.1 Number of Occupants.

The number of occupants (passengers and crew) was determined from the CSRTG Accident Database. However, 17 Survivable Accidents were identified for which data were not available as to the number of occupants. Since the aircraft type was known, data was extracted from the CSRTG Accident Database to assess the average and likely range of the number of occupants in previous accidents to the aircraft type. For these 17 accidents, random selections were made of the distribution of the total number of occupants to determine values that could be used in the assessment of survivability.

2.3.2 Fatalities by Cause of Death.

For each Survivable Accident, the number of fatalities resulting from each of the following causes was identified.

- Impact

- Fire

- Impact and fire (incapacitation or immobilization by impact followed by death by fire)

- Water (drowning)

- Other—"Other" causes of death include injury from turbulence or an in-flight upset, engine blade separation resulting in cabin penetration, falling from an evacuation slide, being sucked out of an opening in the aircraft during flight, asphyxiation by seat belt (child), and explosive door opening due to cabin pressure on the ground.

No determination was made as to the cause of death of the Nonsurvivable Accidents.

For some of the Survivable Accidents, there was insufficient information available to determine the cause of some or all fatalities. This occurred if the cause of death was not determined in the course of the accident investigation, if the accident report did not document the cause, or if the official accident report was not available. For accidents that involved either impact with no fire or fire with no impact, the cause of death was obvious. However, in 224 of the Survivable Accidents, the occupants were subjected to both impact and fire, and in 157 of these accidents, the cause of death could not be determined for all occupants. In such cases, the fatalities were randomly assigned to impact, impact and fire, or fire in a proportionate manner over the known possible range.

2.4 FLIGHTS, PASSENGERS, AND REVENUE PASSENGER MILES STATISTICS.

For each year from 1968 to 2007 inclusive, the number of flights, passengers carried, and revenue passenger miles were assessed for western-built aircraft and are provided in appendix B. The following sources were used as a basis for assessing the data:

1. The UK CAA Hours and Landings Database (flight hours and flights—for the U.S. and worldwide)

2. RITA (Research and Innovative Technology Administration) Bureau of Transportation Statistics (passengers and revenue passenger miles for the U.S.)

3. Transportation in Canada—An Overview (Passengers for Canada)

In many instances, the dataset was incomplete for the period covered in this study or was not divided into turbojets and turboprops. As a consequence, estimates had to be made for much of the data contained in appendix B. Estimates were crosschecked to ensure that the assumptions made were reasonably accurate and produced meaningful results. The most comprehensive data available was that relating to the number of flights for the U.S. and worldwide (taken from data source 1 above). Hence, these data were used as a basis for assessing much of the data regarding number of passengers and revenue passenger miles. Checks were made to ensure that the number of passengers per flight and the stage length in miles that might be inferred from the interpolations and extrapolations were reasonable.

3. RESULTS.

Over 400 graphs were generated as part of this study in an attempt to determine the rate of improvement in safety indicators. However, meaningful trends can only be produced when there are sufficient data to accommodate statistical variation. Therefore, only those trends that were considered to be statistically significant have been reproduced in this report.

3.1 ACCIDENT TRENDS.

3.1.1 Accident Numbers.

The average number of Accidents and Survivable Accidents to the world fleet of western-built aircraft is shown in figure 1 for the period 1970 to 2005[5] inclusive. Figure 1 also shows the annual number of flights appropriate to the accident data set, i.e., those accumulated by the western-built aircraft contained in appendix A.

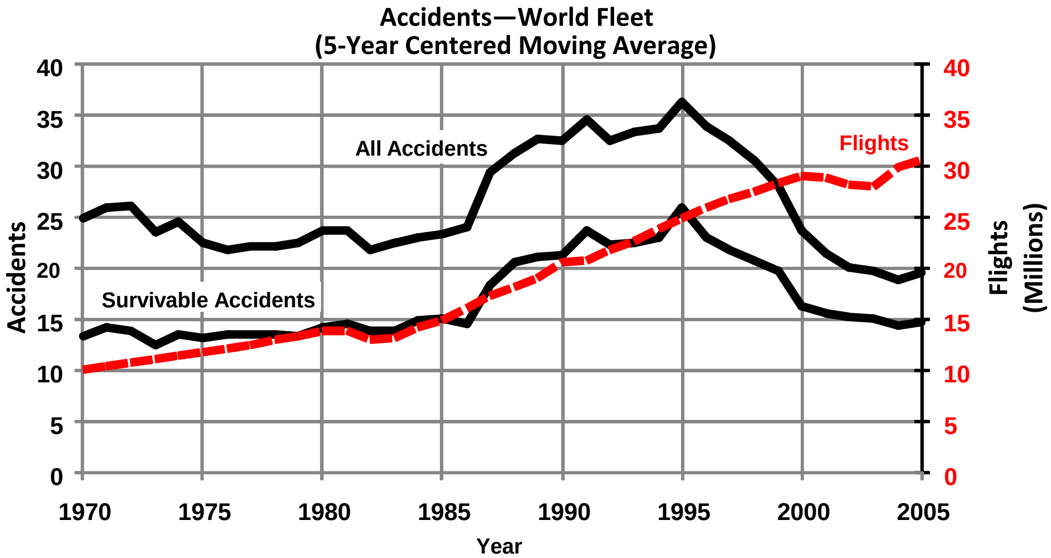

Figure 1. Annual Number of Accidents and Survivable Accidents—World Fleet

Figure 1 shows that the annual number of Accidents and Survivable Accidents to the western-built world fleet has decreased since the mid-1990s despite the large increase in the annual number of flights.

The decline in the number of Accidents and Survivable Accidents is also exhibited by U.S. and Canadian fleets, as illustrated in figure 2. Also shown in figure 2 is the annual number of flights appropriate to the accident data set, i.e., those accumulated by the western-built aircraft contained in appendix A that are U.S.- or Canadian-registered.

[5]The accidents used to obtain the data illustrated in figure 1 encompassed the period 1968 to 2007. However, only the period 1970 to 2005 is illustrated to obtain a meaningful centered moving average.

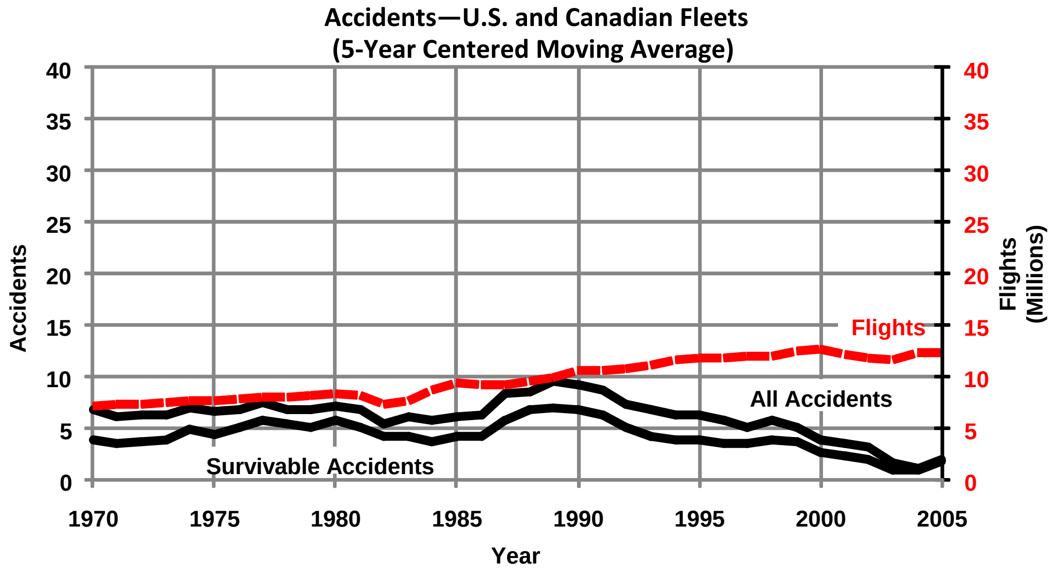

Figure 2. Annual Number of Accidents and Survivable Accidents—U.S. and Canadian Fleets

Figure 2 shows that the annual total number of Accidents and Survivable Accidents to U.S.- and Canadian-registered aircraft has decreased since the late 1980s.

3.1.2 Accident Rates.

3.1.2.1 All Accidents and Survivable Accidents—World Fleet.

The reduction in the number of accidents to the world fleet described in section 3.1.1 is attributable to a marked reduction in the accident rate, as illustrated in figure 3.

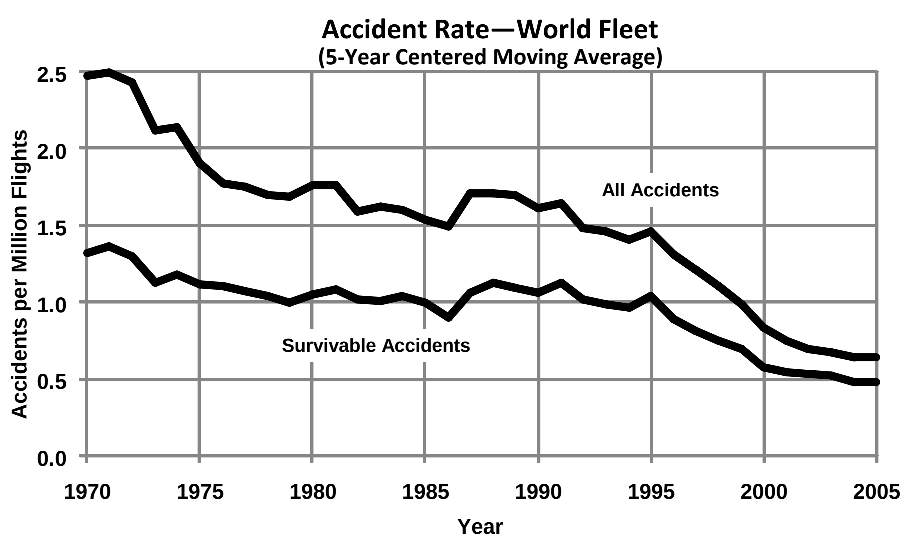

Figure 3. Accident Rate per Million Flights—All Accidents and Survivable Accidents—World Fleet

As expected, similar trends are shown for the accident rate to the world fleet when expressed in terms of millions of passengers carried or on a 100-million revenue passenger miles basis, as shown in figure 4. Figures 3 and 4 also illustrate that the proportion of accidents that are Survivable increased over the study period (this issue is discussed further in section 3.3.1).

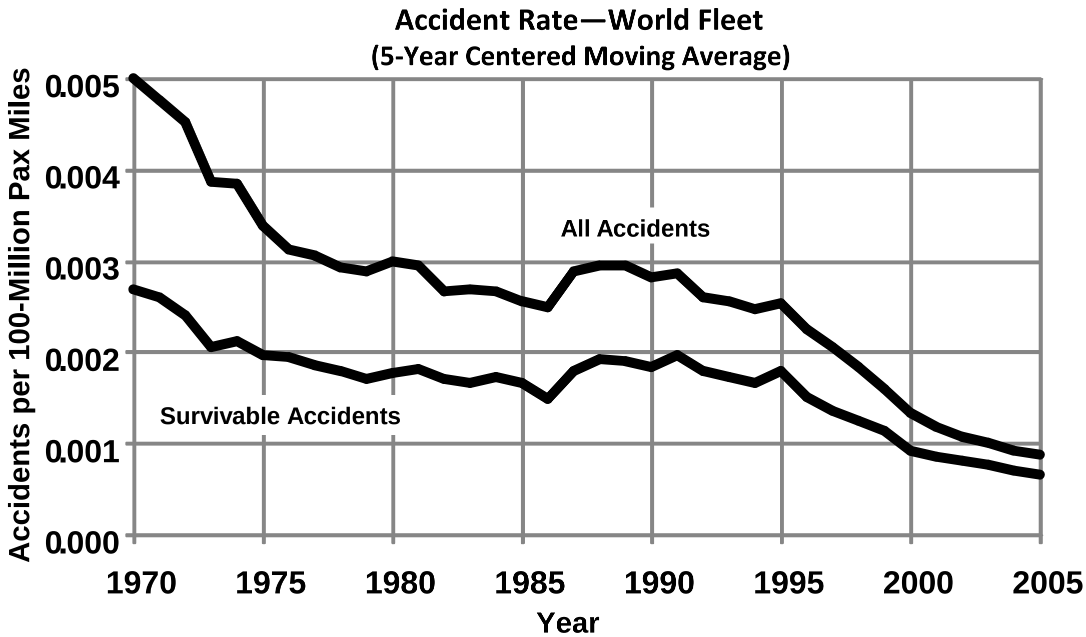

Figure 4. Accident Rate per 100-Million Revenue Passenger Miles—All Accidents and Survivable Accidents—World Fleet

3.1.2.2 All Accidents and Survivable Accidents—U.S. and Canadian Fleets.

The accident rate, for the combined U.S. and Canadian fleets, has also improved markedly both in terms of all Accidents and Survivable Accidents, as illustrated in figure 5. The U.S. and Canadian fleets are exhibiting accident rates that are less than half those experienced by the world fleet.

Once again, similar trends are shown for the Accident Rate to the U.S. and Canadian fleets when expressed in terms of millions of passengers carried or on a 100-million revenue passenger miles basis.

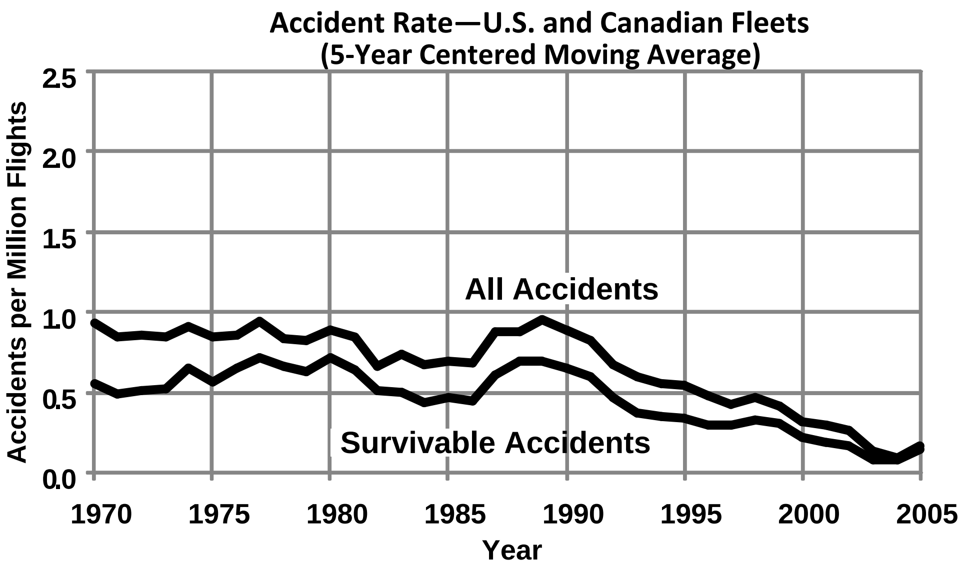

Figure 5. Accident Rate per Million Flights—All Accidents and Survivable Accidents—U.S. and Canadian Fleets

3.1.2.3 All Accidents and Survivable Accidents—Turbojets and Turboprops—World Fleet.

Figure 6 shows that for both turbojets and turboprops, the accident rate has improved significantly over the past 30 to 40 years, with turboprops showing the greater rate of improvement. However, the accident rate per flight continues to be significantly higher for turboprops than for turbojets.

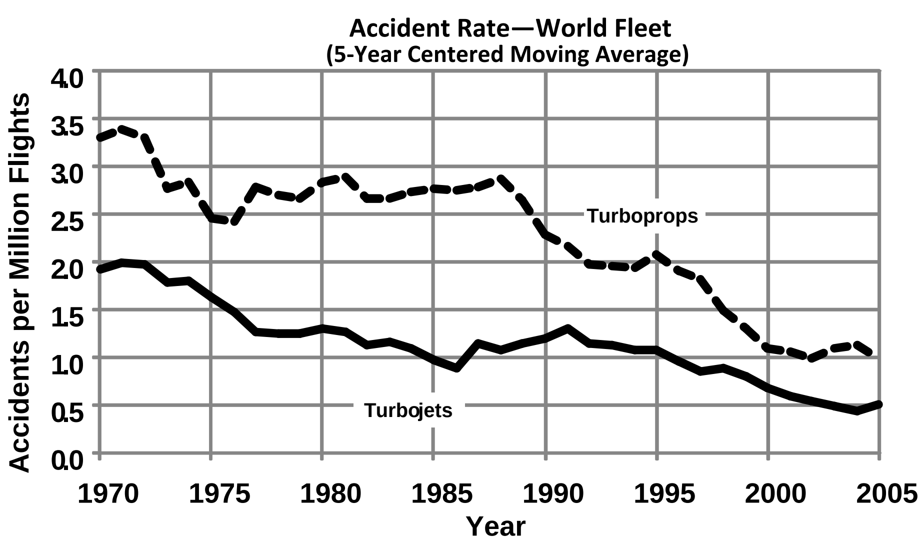

Figure 6. Accident Rate per Million Flights—All Accidents—Turbojets and Turboprops—World Fleet

3.1.2.4 All Accidents and Survivable Accidents—Turbojets and Turboprops—U.S. and Canadian Fleets.

Figure 7 shows, for the most part, the accident rate for turboprops is also higher than turbojets for the U.S. and Canadian fleets. It is unknown whether the apparent discrepancy in the 1970s is significant or simply attributable to statistical variation.

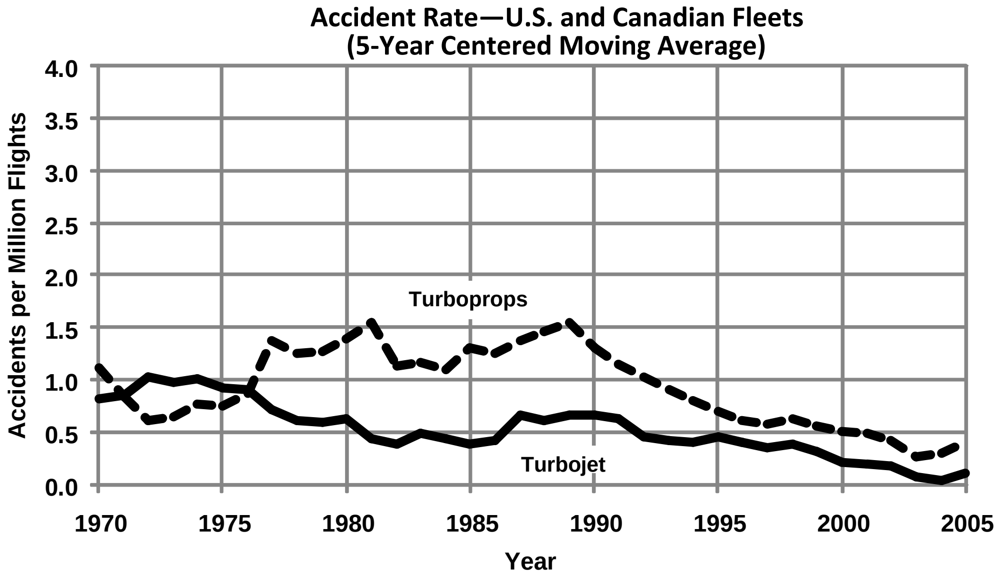

Figure 7. Accident Rate per Million Flights—All Accidents—Turbojets and Turboprops—U.S. and Canadian Fleets

The accident rate of the U.S. and Canadian fleets is significantly lower than the world fleet for both turbojets and turboprops.

3.2 FATALITY TRENDS.

3.2.1 Fatality Numbers.

Figure 8 shows that the number of fatalities in all accidents has diminished for the world fleet over the study period from an average of approximately 1000 per year to less than 600. While the number of flights, passengers, and revenue passenger miles has steadily increased over this period, the accident rate has diminished markedly, as discussed in section 3.1.2.1. This improvement, combined with the decline in fatalities due to improvements in occupant survivability (as discussed in section 3.3), has resulted in the reduction in fatalities illustrated in figure 8.

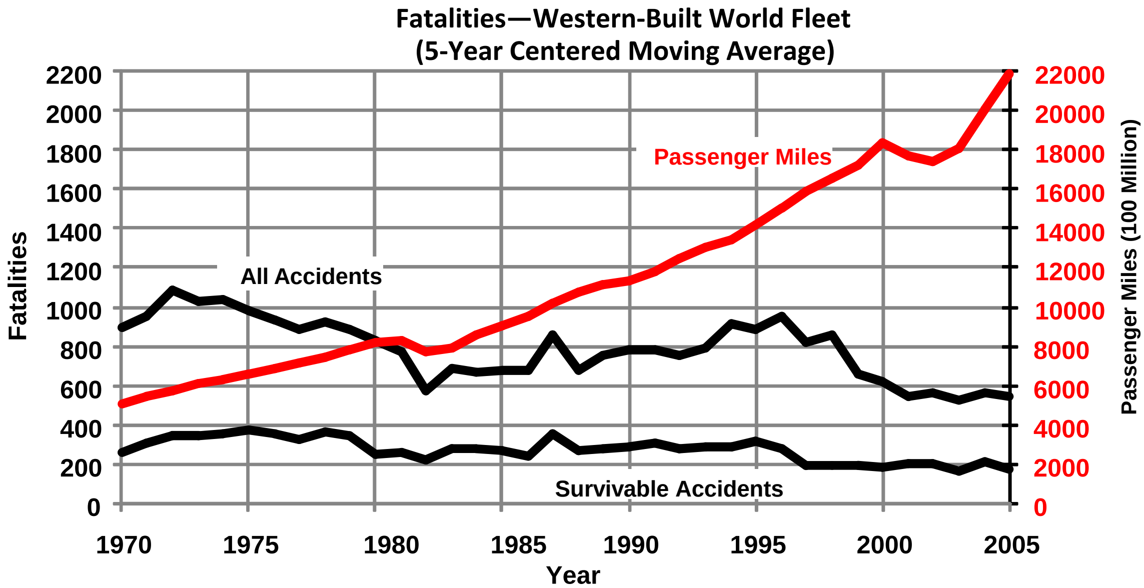

Figure 8. Number of Fatalities—All Accidents and Survivable Accidents—World Fleet

The number of fatalities attributable to the U.S. and Canadian fleets has also diminished, as illustrated in figure 9. Comparing figures 8 and 9 shows that the U.S. and Canadian fleets account for a small proportion of the fatalities worldwide.

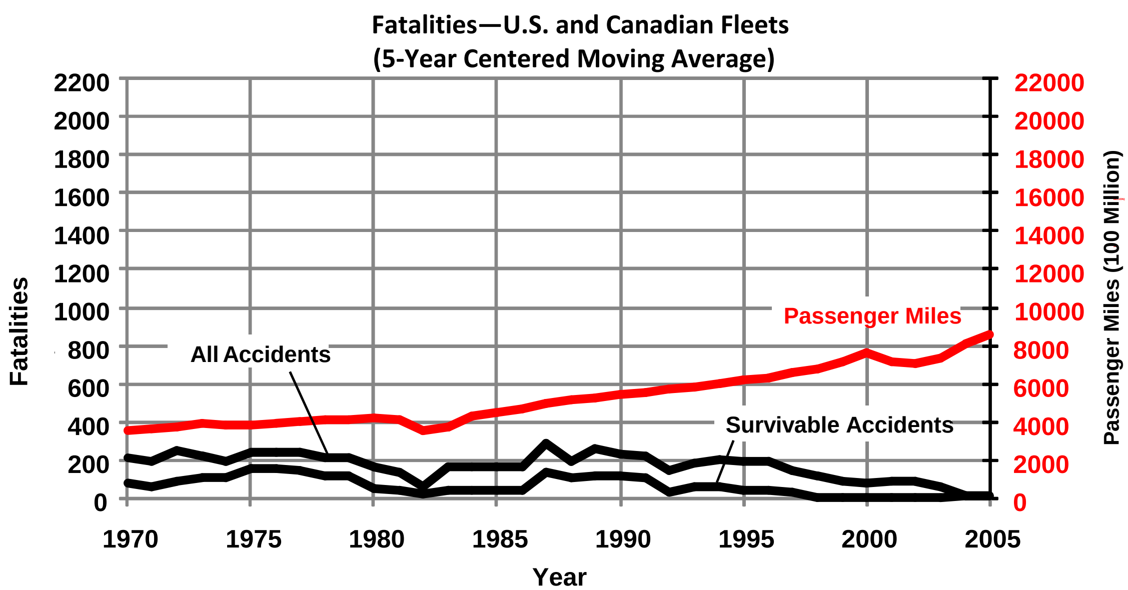

Figure 9. Number of Fatalities—All Accidents and Survivable Accidents—U.S. and Canadian Fleets

3.2.2 Fatality Rates.

The fatality rate for the world fleet, expressed as the number of fatalities per million flights, shows a marked improvement over the study period, decreasing by a factor of 4 to 5, for All

Accidents, as illustrated in figure 10. The fatality rate for Survivable Accidents has also decreased, although not as markedly as the All Accidents rate. This is primarily attributable to the greater proportion of accidents that are Survivable, as discussed in section 3.3.1.

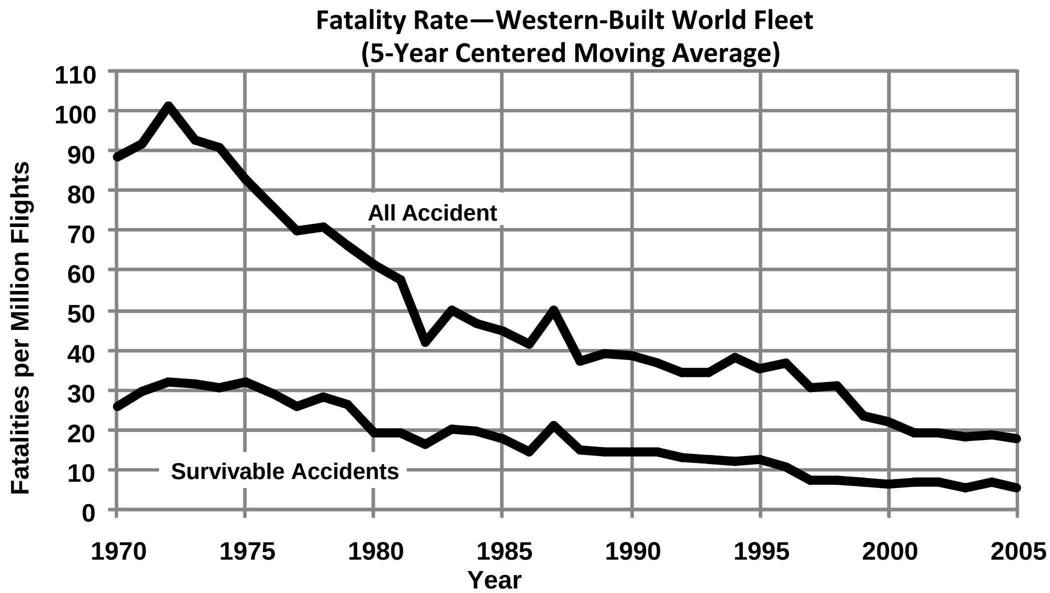

Figure 10. Fatality Rate—All Accidents and Survivable Accidents—World Fleet

The U.S. and Canadian fleets have also shown a marked reduction in the fatality rate over the study period, as illustrated in figure 11. Figures 10 and 11 show that the fatality rate for the U.S. and Canadian fleets is lower compared with the world fleet.

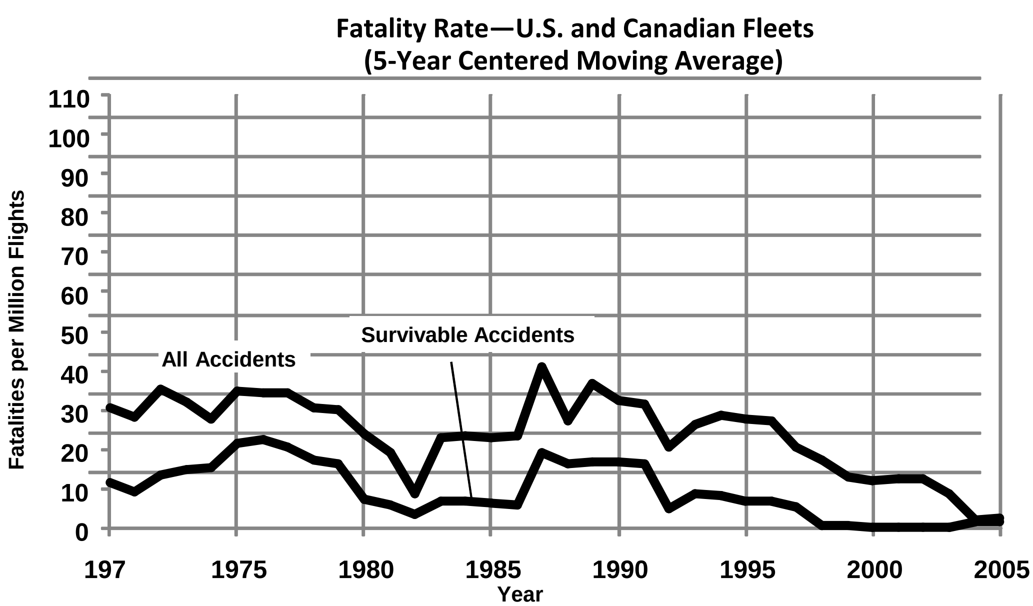

Figure 11. Fatality Rate—All Accidents and Survivable Accidents—U.S. and Canadian Fleets

3.3 SURVIVABILITY TRENDS.

3.3.1 Probability of an Accident Being Survivable.

Figure 12 shows that over the study period, there has been an improvement in the probability of an accident being Survivable for the world fleet[6]. The U.S. and Canadian fleets do not appear to exhibit such a steady improvement, although it is likely that over the study period the proportion of accidents that are Survivable has increased.

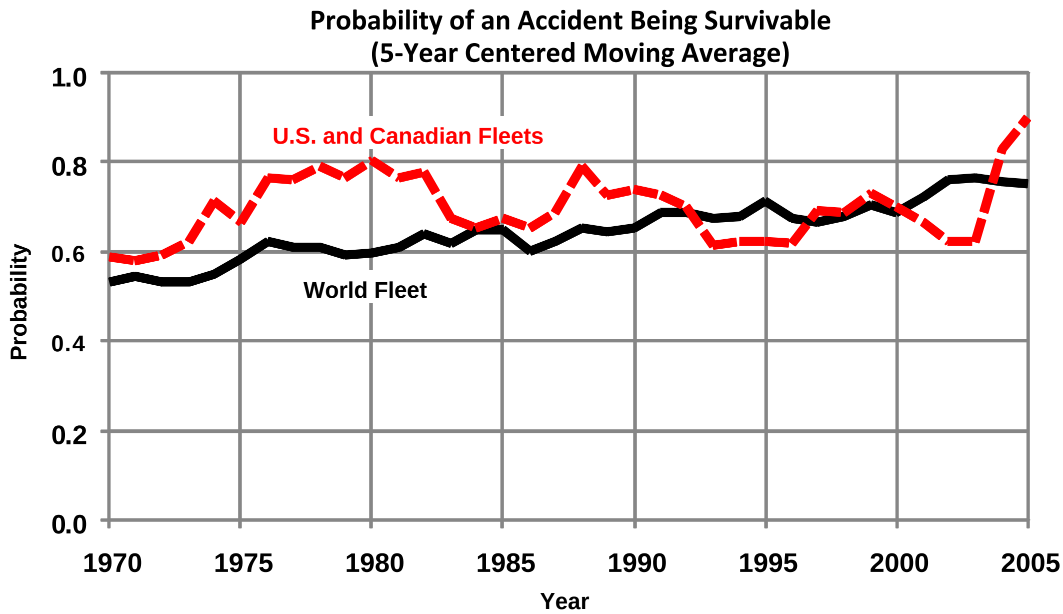

Figure 12. Probability of an Accident Being Survivable—World Fleet and U.S. and Canadian Fleets

3.3.2 Probability of Death in a Survivable Accident.

Figure 13 shows that there is a marked improvement in occupant survivability for the world fleet, as measured by the probability of death in a Survivable Accident. The improvement would seem to be in the order of a factor of 2, i.e., from approximately 0.3 to approximately 0.15. For this dataset, a 9-year moving average was used in preference to a 5-year moving average to more clearly identify the underlying trend.

This improvement is reflected in the U.S. and Canadian fleets, which appear to have shown an improvement, such that this measure of occupant survivability surpasses that exhibited by the average for the world fleet.

[6]This probability is simply the ratio of Survivable Accidents to All Accidents.

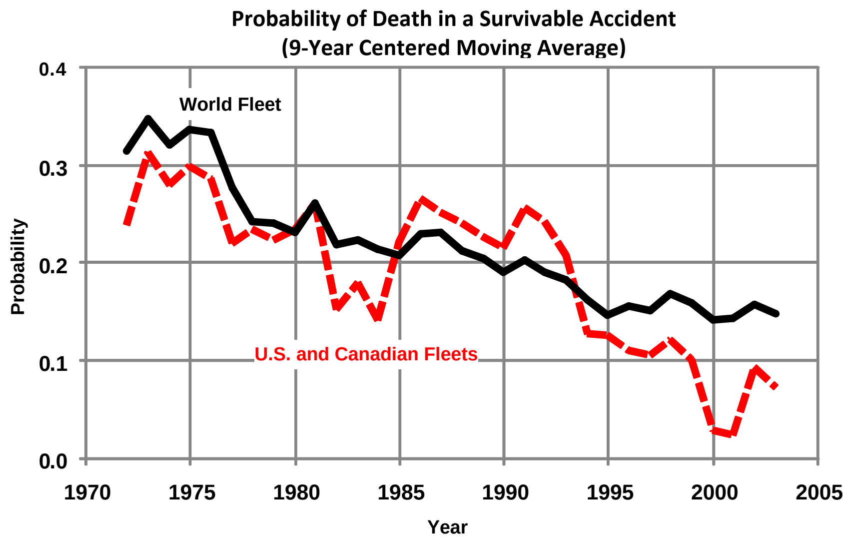

Figure 13. Probability of Death in a Survivable Accident—World Fleet and U.S. and Canadian Fleets

3.4 TRENDS IN CAUSE OF DEATH.

Figure 14 shows the reduction in fatality rate in Survivable Accidents subdivided into cause of death for the world fleet. The data are presented as a centered 9-year moving average to identify the underlying trend. Because of the limited data on some accidents, compensated to a degree by the use of random numbers described in section 2.3.2, some of the values depicted in the graph cannot be considered as precise.

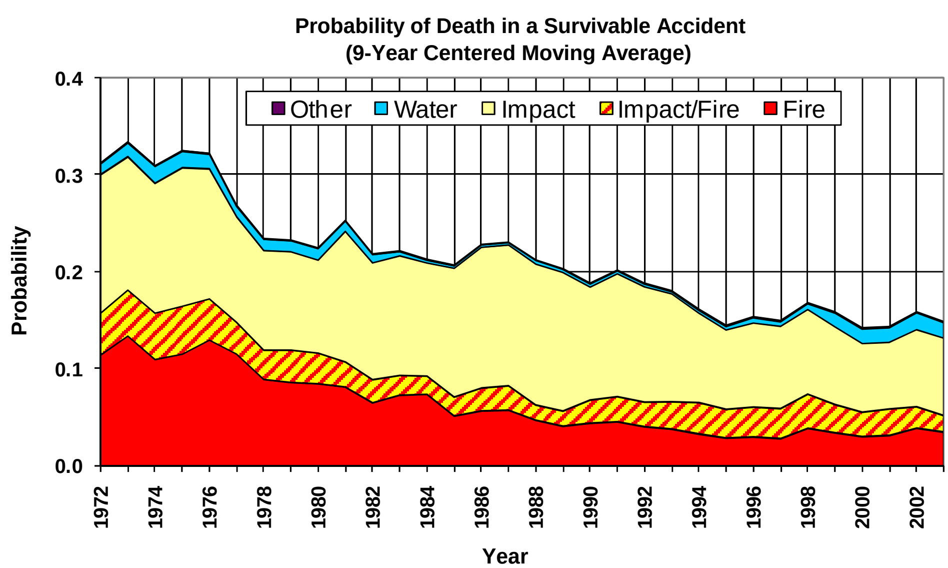

Figure 14. Cause of Death in a Survivable Accident—World Fleet

The upper bound of the curve shown in figure 14 simply reflects the data presented in figure 13. As expected, the probability of death due to water (drowning) and those in the "Other" category are small in comparison with those attributable to fire and impact, which are the primary causes of death.

The probability of death attributable to fire may have reduced markedly over the study period as have those attributable to impact, although perhaps not to the extent that fire-related deaths have diminished. Deaths attributable to impact and fire are, for the most part, caused by incapacitation or immobilization by impact followed by death by fire. Hence, further mitigation of the fire threat is likely to reduce the deaths of occupants in this category, although not the injuries due to impact. Conversely, had these occupants been uninjured by the impact, they might have survived the accident, provided they were able to evacuate the aircraft prior to being overcome by the fire.

To obtain a clearer understanding of the relative magnitude of the five causes of death, each are presented in figure 15 as a proportion of the total number of fatalities in a Survivable accident. Once again, due to the incomplete nature of some of the accident data, precise values cannot be determined from figure 15. It would seem that fatalities attributable to impact represent a larger proportion of the total number of fatalities than those that are caused by fire. However, the extent to which the number of fatalities, attributable to each of these two causes of death, might be reduced was beyond the scope of this study. For some accidents, improvements in impact-related survivability factors may not have prevented all the impact-related fatalities (see section 2.2.2).

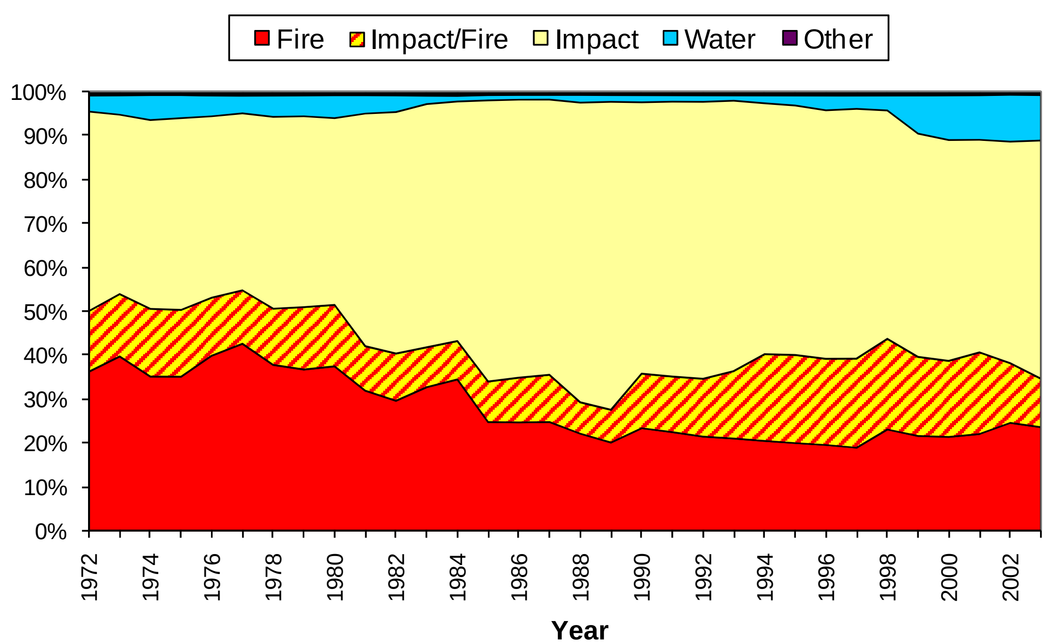

Figure 15. Proportion of Fatalities by Cause in a Survivable Accident—World Fleet

The data presented in figures 14 and 15 are based on the world fleet for which there are sufficient data to assess trends. For smaller data sets, such as the U.S. and Canadian fleets, the smaller sample sizes result in large periodical variations from which meaningful trends cannot be determined.

3.5 IN-FLIGHT FIRE ACCIDENTS.

Figure 16 shows the in-flight fires that have occurred to the world fleet over the study period. They are classified as Impact Nonsurvivable, in which the in-flight fire resulted in a nonsurvivable ground impact, and Impact Survivable/No Impact, in which the aircraft landed without resultant impact conditions that would cause death to all of the occupants.

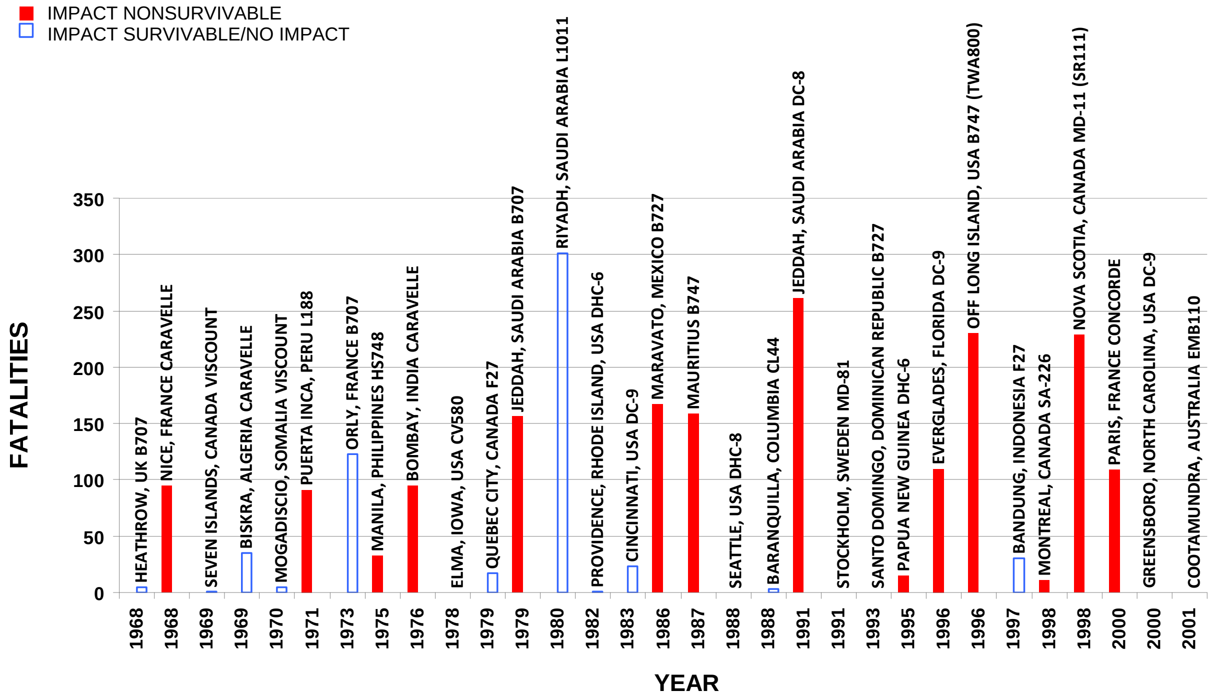

Figure 16. In-Flight Fire Accidents Over the Study Period

4. REFERENCES.

1. RGW Cherry & Associates Ltd., 0937/R/000289/KK, "The Identification of Trends in Aircraft Accident Rates," United Kingdom, 2005.

2. RGW Cherry & Associates Ltd., 0977/R/000410KK, "Safety Trends Analysis—A Comparison Between the Fatal Accident Rates for Current Production Aircraft and the In-Service World Fleet," United Kingdom, 2008.

APPENDIX A—AIRCRAFT TYPES ANALYZED IN THE STUDY

A.S.T.A. (GAF) Nomad
Aero Spacelines Guppy
Aerospatiale 262
Aerospatiale Caravelle
Airbus Industrie A300-600
Airbus Industrie A300B2/B4
Airbus Industrie A310
Airbus Industrie A318
Airbus Industrie A319
Airbus Industrie A320
Airbus Industrie A321
Airbus Industrie A330
Airbus Industrie A340
ATR ATR42
ATR ATR72
Avro RJ
BAe (AW) Argosy
BAe (BAC) One-Eleven
BAe (Bristol) Britannia
BAe (DH) Comet
BAe (HS) 748
BAe (HS) ATP
BAe (HS) Trident
BAe (Vickers) Vanguard
BAe (Vickers) VC-10
BAe (Vickers) Viscount
BAe 146
BAe/Aerospatiale Concorde
Beech 1300
Beech 1900
Beech 99
Boeing 707
Boeing 717
Boeing 720
Boeing 727
Boeing 737 (CFMI)
Boeing 737 (JT8D)
Boeing 737 (NG)
Boeing 747 "Classic"
Boeing 747-400
Boeing 757
Boeing 767
Boeing 777
Bombardier (Canadair) CL-44
Bombardier (Canadair) RJ100/200 Regional Jet
Bombardier (Canadair) RJ700 Regional Jet
Bombardier (Canadair) RJ900 Regional Jet
Bombardier (DHC) Dash 7
Bombardier (DHC) Dash 8-100/200
Bombardier (DHC) Dash 8-300
Bombardier (DHC) Dash 8-400
Bombardier (DHC) DHC-5 Buffalo
Bombardier (DHC) DHC-6 Twin Otter
Bombardier (Shorts) 330
Bombardier (Shorts) 360
Bombardier (Shorts) SC.5 Belfast
Bombardier (Shorts) SC.7 Skyvan
CASA/IPTN 212
CASA/IPTN CN-235
Dassault Aviation Mercure
Embraer 170
Embraer 175
Embraer 190
Embraer 195
Embraer EMB-110 Bandeirante
Embraer EMB-120 Brasilia
Embraer ERJ-135
Embraer ERJ-140
Embraer ERJ-145
Fairchild (Swearingen) Metro
Fairchild F-27
Fairchild FH-227
Fairchild/Dornier 228
Fairchild/Dornier 328
Fairchild/Dornier 328 Jet
Fokker 100
Fokker 50
Fokker 70
Fokker F.27
Fokker F.28
General Dynamics (Convair) 580
General Dynamics (Convair) 600
General Dynamics (Convair) 640
General Dynamics (Convair) 880
General Dynamics (Convair) 990
Grumman G-73T Turbo Mallard
Gulfstream Aerospace Gulfstream I

Handley Page Herald
Handley Page Jetstream
IAI Arava
Jetstream Jetstream 31
Jetstream Jetstream 41
Lockheed Hercules
Lockheed L-1011 TriStar
Lockheed L-188 Electra
McDonnell Douglas DC-10
McDonnell Douglas DC-8
McDonnell Douglas DC-9
McDonnell Douglas MD-11
McDonnell Douglas MD-80
McDonnell Douglas MD-90
NAMC YS-11
Saab 2000
Saab 340
Saunders ST-27
Transall C-160
VFW 614

APPENDIX B—AIRCRAFT FLIGHTS, PASSENGERS, AND REVENUE PASSENGER MILES

Flights—Turbojets and Turboprops				
Year	World	U.S.	Canada	U.S. and Canada
1968	9,510,491	6,493,649	569,126	7,062,775
1969	9,757,275	6,545,925	573,707	7,119,632
1970	10,059,937	6,631,721	581,227	7,212,947
1971	10,398,056	6,736,537	590,413	7,326,950
1972	10,742,531	6,839,790	599,463	7,439,253
1973	11,092,242	6,940,477	608,287	7,548,764
1974	11,468,033	7,052,961	618,146	7,671,106
1975	11,846,674	7,160,747	627,592	7,788,339
1976	12,230,770	7,265,415	636,766	7,902,180
1977	12,625,557	7,370,379	645,965	8,016,344
1978	13,030,754	7,475,183	655,151	8,130,334
1979	13,445,021	7,578,622	664,216	8,242,838
1980	13,884,954	7,692,035	674,156	8,366,191
1981	13,948,914	7,591,537	665,348	8,256,885
1982	13,010,651	6,855,721	600,859	7,456,579
1983	13,222,608	7,133,288	625,186	7,758,473
1984	14,226,847	8,095,686	709,534	8,805,220
1985	15,008,271	8,663,429	759,293	9,422,721
1986	16,149,587	8,555,946	749,872	9,305,819
1987	17,334,121	8,495,555	744,580	9,240,134
1988	18,308,537	8,779,186	769,438	9,548,624
1989	19,155,493	9,106,355	798,112	9,904,467
1990	20,611,401	9,824,010	861,010	10,685,020
1991	20,794,533	9,780,216	857,172	10,637,387
1992	21,855,054	9,985,359	875,151	10,860,511
1993	22,789,206	10,276,044	900,628	11,176,672
1994	23,959,130	10,721,596	939,677	11,661,273
1995	24,910,110	10,853,500	951,238	11,804,737
1996	25,940,246	10,955,988	960,220	11,916,209
1997	26,934,881	11,074,968	970,648	12,045,616
1998	27,485,269	11,103,432	973,143	12,076,574
1999	28,438,600	11,475,230	1,005,728	12,480,958
2000	29,195,008	11,698,724	1,025,316	12,724,040
2001	28,873,006	11,290,751	989,560	12,280,311
2002	28,261,535	10,902,055	955,493	11,857,548
2003	28,072,358	10,721,739	939,690	11,661,429
2004	29,917,939	11,316,394	991,808	12,308,202
2005	30,665,596	11,342,006	994,052	12,336,058
2006	31,667,184	11,142,305	976,550	12,118,855
2007	33,046,547	11,312,317	991,450	12,303,767

Passengers—Turbojets and Turboprops (million)				
Year	World	U.S.	Canada	U.S. and Canada
1968	387	257	23	280
1969	457	301	26	328
1970	499	319	28	347
1971	523	323	28	351
1972	550	329	29	358
1973	578	340	30	369
1974	598	336	29	366
1975	623	340	30	370
1976	647	347	30	378
1977	673	356	31	387
1978	702	366	32	398
1979	734	377	33	410
1980	762	384	34	417
1981	770	377	33	410
1982	723	341	30	371
1983	738	356	31	387
1984	797	403	35	439
1985	840	428	37	465
1986	889	443	39	482
1987	947	464	41	505
1988	993	476	42	518
1989	1,027	488	43	531
1990	1,052	501	44	545
1991	1,093	514	45	559
1992	1,155	528	46	574
1993	1,201	541	47	589
1994	1,242	556	49	604
1995	1,308	570	50	620
1996	1,385	585	51	636
1997	1,467	603	53	656
1998	1,530	618	54	672
1999	1,592	642	56	699
2000	1,696	674	60	734
2001	1,632	629	57	686
2002	1,610	622	54	676
2003	1,666	657	54	711
2004	1,855	714	60	774
2005	2,020	747	65	813
2006	2,192	751	69	820
2007	2,400	776	72	848

Passengers—Turbojets (million)				
Year	World	U.S.	Canada	U.S. and Canada
1968	303	206	18	224
1969	390	261	23	284
1970	439	282	25	307
1971	462	283	25	308
1972	489	289	25	314
1973	517	299	26	325
1974	534	293	26	318
1975	558	295	26	321
1976	581	303	27	329
1977	605	312	27	339
1978	634	323	28	351
1979	666	335	29	365
1980	692	341	30	371
1981	699	335	29	365
1982	657	303	27	330
1983	671	317	28	345
1984	725	359	31	390
1985	764	380	33	414
1986	803	401	35	436
1987	849	428	38	466
1988	887	438	38	476
1989	910	443	39	482
1990	927	450	39	490
1991	955	458	40	498
1992	1,008	466	41	506
1993	1,047	477	42	519
1994	1,085	491	43	534
1995	1,145	504	44	549
1996	1,213	518	45	564
1997	1,286	536	47	583
1998	1,347	552	48	600
1999	1,406	577	51	627
2000	1,506	610	54	664
2001	1,457	573	52	624
2002	1,448	572	50	622
2003	1,507	611	50	661
2004	1,691	670	57	727
2005	1,846	704	62	766
2006	2,013	710	66	776
2007	2,217	737	68	806

Passengers—Turboprops (million)				
Year	World	U.S.	Canada	U.S. and Canada
1968	85	52	5	56
1969	67	40	3	43
1970	60	37	3	40
1971	61	39	3	43
1972	61	40	4	44
1973	62	41	4	44
1974	64	43	4	47
1975	65	45	4	49
1976	66	45	4	49
1977	68	44	4	48
1978	68	43	4	47
1979	67	42	4	45
1980	70	42	4	46
1981	71	42	4	45
1982	66	38	3	41
1983	67	39	3	43
1984	72	44	4	48
1985	76	48	4	52
1986	87	42	4	45
1987	97	36	3	39
1988	105	38	3	42
1989	117	45	4	49
1990	125	51	4	55
1991	138	57	5	62
1992	147	62	5	67
1993	153	64	6	70
1994	157	65	6	71
1995	164	66	6	71
1996	172	67	6	73
1997	181	67	6	73
1998	183	67	6	73
1999	186	66	6	71
2000	189	64	6	70
2001	176	56	5	62
2002	162	49	4	54
2003	159	46	4	50
2004	165	44	4	47
2005	173	43	4	46
2006	179	41	4	44
2007	183	39	4	42

Revenue Passenger Miles—Turbojets and Turboprops (100 million)				
Year	World	U.S.	Canada	U.S. and Canada
1968	3,890	2,625	230	2,855
1969	4,630	3,101	272	3,373
1970	5,123	3,330	292	3,622
1971	5,449	3,389	297	3,686
1972	5,812	3,475	305	3,780
1973	6,162	3,604	316	3,920
1974	6,371	3,525	309	3,834
1975	6,646	3,554	311	3,865
1976	6,911	3,613	317	3,929
1977	7,206	3,688	323	4,011
1978	7,510	3,776	331	4,107
1979	7,861	3,856	338	4,194
1980	8,221	3,926	344	4,270
1981	8,326	3,808	334	4,141
1982	7,733	3,337	292	3,629
1983	7,923	3,495	306	3,802
1984	8,626	3,963	347	4,310
1985	9,105	4,152	364	4,516
1986	9,583	4,318	378	4,696
1987	10,271	4,645	407	5,053
1988	10,772	4,767	418	5,184
1989	11,149	4,891	429	5,320
1990	11,410	5,019	440	5,459
1991	11,864	5,150	451	5,601
1992	12,532	5,284	463	5,747
1993	13,029	5,422	475	5,897
1994	13,472	5,563	488	6,051
1995	14,197	5,708	500	6,209
1996	15,028	5,857	513	6,371
1997	15,915	6,124	537	6,661
1998	16,606	6,257	548	6,806
1999	17,275	6,589	577	7,167
2000	18,398	7,008	614	7,622
2001	17,713	6,585	577	7,162
2002	17,465	6,505	570	7,075
2003	18,076	6,742	591	7,333
2004	20,131	7,523	659	8,183
2005	21,916	7,951	697	8,648
2006	23,781	8,101	710	8,811
2007	26,044	8,420	738	9,158

Turbojets—Revenue Passenger Miles (100 million)				
Year	World	U.S.	Canada	U.S. and Canada
1968	3,545	2,412	211	2,623
1969	4,358	2,936	257	3,194
1970	4,877	3,177	278	3,456
1971	5,201	3,228	283	3,511
1972	5,561	3,309	290	3,599
1973	5,910	3,437	301	3,739
1974	6,110	3,346	293	3,639
1975	6,380	3,370	295	3,665
1976	6,640	3,428	300	3,729
1977	6,929	3,505	307	3,812
1978	7,233	3,598	315	3,913
1979	7,585	3,684	323	4,007
1980	7,934	3,752	329	4,081
1981	8,038	3,636	319	3,954
1982	7,465	3,181	279	3,460
1983	7,651	3,334	292	3,626
1984	8,332	3,780	331	4,111
1985	8,795	3,956	347	4,302
1986	9,230	4,146	363	4,509
1987	9,874	4,498	394	4,892
1988	10,358	4,621	405	5,026
1989	10,707	4,728	414	5,143
1990	10,924	4,829	423	5,252
1991	11,330	4,937	433	5,370
1992	11,971	5,045	442	5,488
1993	12,458	5,180	454	5,634
1994	12,893	5,319	466	5,785
1995	13,597	5,458	478	5,936
1996	14,401	5,601	491	6,092
1997	15,265	5,866	514	6,380
1998	15,959	6,006	526	6,532
1999	16,629	6,342	556	6,898
2000	17,750	6,765	593	7,358
2001	17,118	6,372	558	6,930
2002	16,927	6,322	554	6,876
2003	17,552	6,574	576	7,150
2004	19,595	7,361	645	8,006
2005	21,353	7,791	683	8,474
2006	23,205	7,948	697	8,645
2007	25,477	8,277	725	9,002

Turboprops—Revenue Passenger Miles (100 million)				
Year	World	U.S.	Canada	U.S. and Canada
1968	345	213	19	231
1969	273	165	14	179
1970	246	153	13	166
1971	249	162	14	176
1972	250	167	15	181
1973	251	167	15	182
1974	261	179	16	195
1975	266	184	16	201
1976	271	184	16	200
1977	277	182	16	198
1978	277	179	16	194
1979	275	172	15	187
1980	287	174	15	189
1981	288	172	15	187
1982	268	155	14	169
1983	273	162	14	176
1984	294	183	16	199
1985	310	196	17	213
1986	353	172	15	187
1987	397	147	13	160
1988	413	145	13	158
1989	442	163	14	177
1990	486	190	17	207
1991	535	212	19	231
1992	561	239	21	260
1993	571	242	21	264
1994	578	244	21	266
1995	600	250	22	272
1996	627	256	22	279
1997	650	258	23	281
1998	647	252	22	274
1999	646	247	22	269
2000	648	243	21	264
2001	595	213	19	232
2002	539	183	16	199
2003	524	168	15	182
2004	536	163	14	177
2005	563	160	14	174
2006	576	153	13	166
2007	567	143	13	156