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Federal Aviation Administration
William J. Hughes Technical Center
Aviation Research Division
Atlantic City International Airport
New Jersey 08405

A Study Analyzing the Trends in Accidents and Fatalities in Large Transport Airplanes

October 2013

Final Report

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16. Abstract

This study was commissioned by the Federal Aviation Administration to analyze accident data to large transport airplanes registered in the United States of America and worldwide. It assessed trends in airplane safety in terms of number of accidents, accident rates, number of fatalities, fatality rates, the probability of an accident being survivable, and the probability of death in a survivable accident.

Over the study period, there has been a marked reduction in the total accident rate, both for the world fleet and the U.S. fleet. 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 increasing. These improvements are apparent in both the world fleet and the U.S. fleet.

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 is beyond the scope of this study.

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LIST OF ACRONYMS

ASN	Aviation Safety Network
CAA	Civil Aviation Authority
CSRTG	Cabin Safety Research Technical Group
FAA	Federal Aviation Administration
RITA	Research and Innovative Technology Administration
UK	United Kingdom

EXECUTIVE SUMMARY

Over the past forty years, many safety enhancements have been instituted resulting from advances in technology and by regulations derived from research aimed at improving aircraft safety by preventing accidents and enhancing occupant survivability. The Federal Aviation Administration has 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 research and possibly subsequent regulatory activity—particularly in relation to occupant survivability. The more significant findings of the study are contained within this report.

The study is based on accidents that occurred over the period 1968 to 2010, to large transport category turbojet and turboprop western-built airplanes operating in a passenger or passenger/cargo role. One thousand and eighty eight accidents were selected for analysis, of which seven hundred and six were categorized as survivable.

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

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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 is beyond the scope of this study.

1. INTRODUCTION.

This study has been carried out at the request of the Federal Aviation Administration (FAA). A previous study carried out for the FAA and Transport Canada [1] analyzed data contained within the Cabin Safety Research Technical Group (CSRTG) Accident Database [2] over the period 1968 to 2007 to determine trends in accident rates and occupant survivability. Since this earlier study, further data has been obtained and added to the database. This update has provided further detailed information on some of the accidents over the period 1968 to 2007, and data has been added for accidents occurring over the period 2008 to 2010. This updated data has been used as a basis for this current study.

1.1 OBJECTIVES.

The broad objectives of the study are to make determinations of:

- The number of accidents per year
- The accident rate per year for all accidents and survivable accidents
- The accident rate per year for turbojets and turboprops
- The number of fatalities per year in all accidents and survivable accidents
- The number of fatalities per million flights in all accidents and survivable accidents
- The probability of an accident being survivable
- The probability of death in a survivable accident
- 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 data analyzed is to be categorized and analyzed in relation to:

i. Accidents to the world fleet
ii. Accidents to U.S.-registered aircraft

Determinations of the safety trends are to be made for the western world fleet of aircraft as defined in appendix A. The rates of occurrence used in the analysis are derived on a per-million-flight, per-million-passengers, and per-100-million-revenue-passenger-mile basis.

1.2 SCOPE.

The study is based on accidents to large transport category turbojet and turboprop western-built airplanes operating in a passenger or passenger/cargo role. The analysis considers accidents to the aircraft identified in appendix A over the period 1968 to 2010.

2. METHODOLOGY.

The terms Accident, Survivable, and Nonsurvivable used throughout this report are as defined in section 2.2.

It would be possible to generate an enormous number of graphs based on the data analyzed in this study to assess 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 which are considered to be statistically significant have been reproduced in this report.

2.1 ACCIDENTS SELECTED FOR ANALYSIS.

Accidents (as defined in section 2.2.1) which met the following criteria were selected for analysis using the CSRTG Accident Database [2]:

- The Accident occurred over the period 1968 to 2010 inclusive
- 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 within 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 Database[1].

1088 accidents were selected for analysis that met the criteria specified above.

Of the accidents selected for analysis, 382 were categorized as Nonsurvivable and 706 were categorized as Survivable.

In some instances, difficulty was encountered in classifying the accident as Survivable or Nonsurvivable. For example, some accidents were 100 percent fatal but were considered Survivable, since factors could be identified which might have improved occupant survivability.

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

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

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 are 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 have been developed to minimize the use of subjective judgments. They have been agreed with the airworthiness authorities as follows:

2.2.1 Accident.

> "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"

The following definitions are used as a basis for determining whether an accident is Nonsurvivable or Survivable:

2.2.2 Nonsurvivable Accident.

> "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 which 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 airplane before having clearly identified the problem. The airplane,

[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.

with landing gear extended, struck the ground on its right side. A severe fire broke out immediately.

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.

2.2.3 Survivable Accident.

"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 Non-survivable. 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.

[3] This account of the accident is based on the NTSB Report AAR-88-5
[4] This account of the accident is based on the NTSB Report AAR-86/05

2.3 ASSESSMENT OF OCCUPANT SURVIVABILITY.

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

- The number of occupants on-board the aircraft
- The number of fatalities by cause of death

In certain instances, accidents were identified for which the data available were insufficient to determine the precise value for each of these numbers and assessments were needed to be made of their likely values. The following sections indicate 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, 15 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 on previous accidents to the aircraft type. For these 15 accidents, random selections were made of the distribution of the total number of occupants in order 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 numbers of fatalities resulting from each of the following causes were identified.

- Impact
- Fire
- Impact/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), explosive door opening due to cabin pressure on the ground.

No determination was made as to cause of death for those accidents categorized as Nonsurvivable.

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 impact with no fire, or fire with no impact, the cause of death is obvious. However, in 183 of the Survivable Accidents the occupants were subjected to both impact and fire, and in 166 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/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 2010 inclusive, the number of flights, passengers carried and revenue passenger miles were assessed for western-built aircraft and are contained 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. Research and Innovative Technology Administration (RITA) Bureau of Transportation Statistics (Passengers & Revenue Passenger Miles for the U.S.)

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 produced meaningful results. The most comprehensive data available were those relating to the number of flights for the U.S. and worldwide (taken from data source 1 above). Therefore, this source was 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. ACCIDENTS AND ACCIDENT RATES.

All data in the graphs shown in this section are based on a 9-year centered moving average.

3.1 NUMBER OF ACCIDENTS.

The number of Accidents, expressed as a 9-year centered moving average, experienced by turbojet and turboprop airplanes on the U.S. register is compared with the world fleet as illustrated in figure 1.

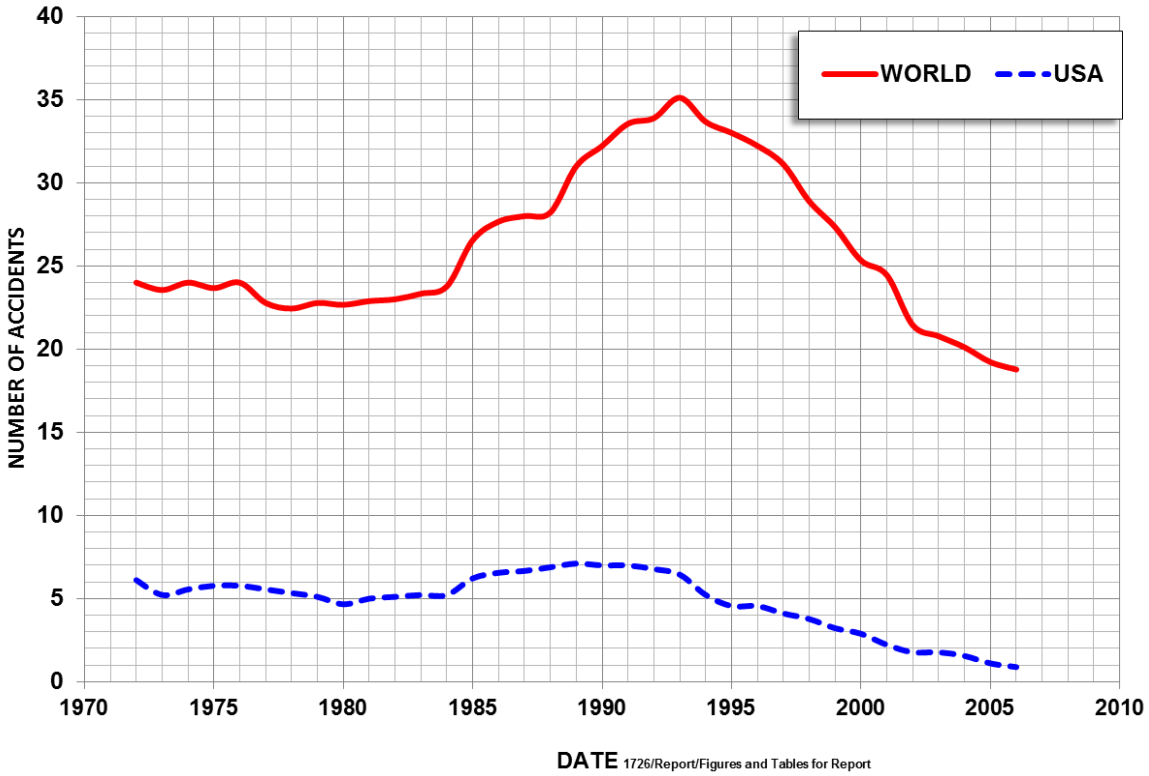

Figure 1. Number of Accidents—World Fleet Compared With U.S.-Registered Airplanes

The data in figure 1 relate to the period 1968 to 2010 inclusive. However, only the period 1970 to 2006 is illustrated in order to obtain a meaningful centered moving average.

It may be seen from the data illustrated in figure 1 that the annual number of accidents to the western built world fleet of aircraft has been decreasing since the early 1990s despite a large increase in the annual number of flights. This pattern is also apparent for U.S.-registered aircraft.

3.2 ACCIDENT RATES.

Accident Rate is a better indicator of the intrinsic safety of airplanes than the actual number of accidents experienced per year. The Accident Rate per million flights experienced by turbojet and turboprop airplanes on the U.S. register is compared with the world fleet as illustrated in figure 2.

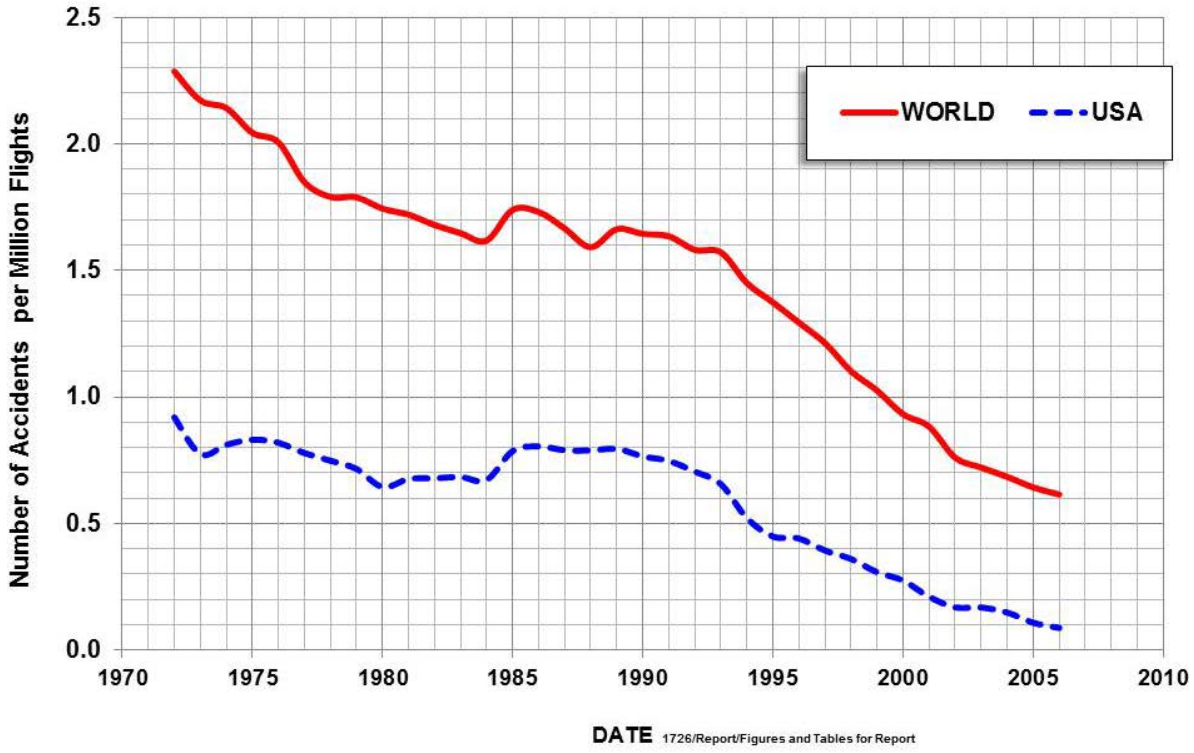

Figure 2. Accident Rate—World Fleet Compared With U.S.-Registered Airplanes

3.2.1 All Accidents and Survivable Accidents—World Fleet.

The reduction in the number of accidents to the world fleet described in section 3.1 is attributable to a marked reduction in accident rate, as expressed as a 9-year centered moving average, in figure 3.

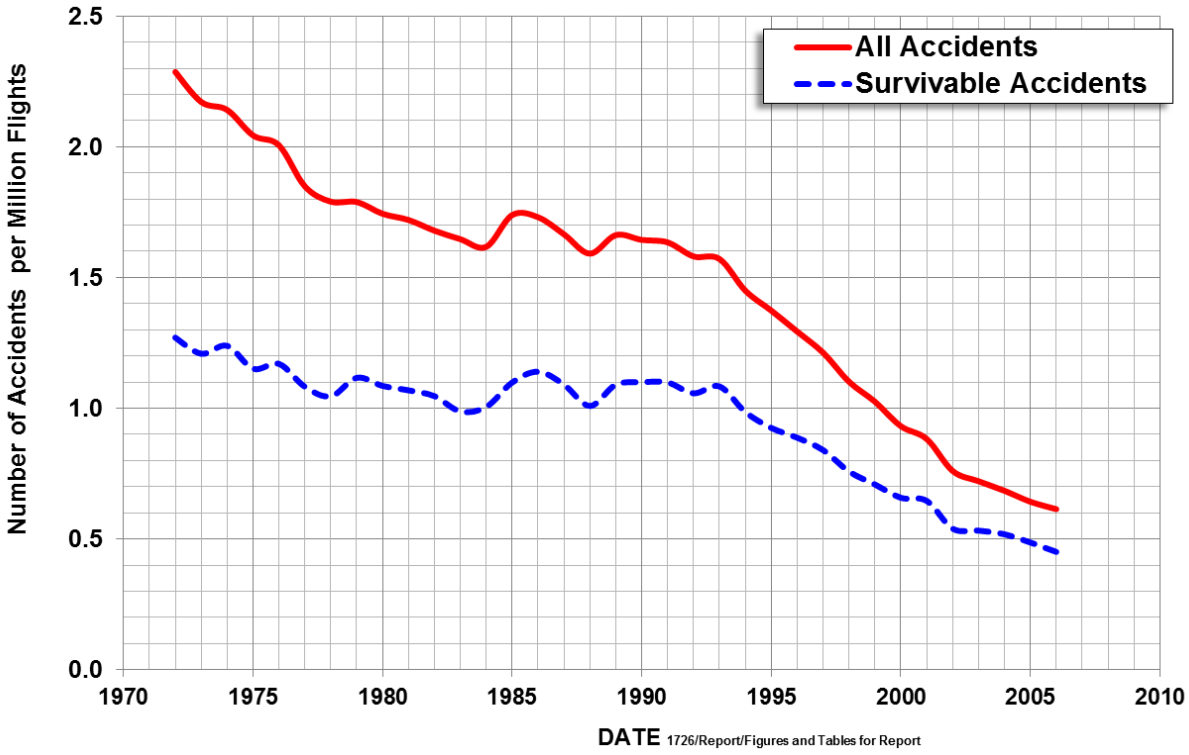

Figure 3. Accident Rate per Million Flights—World Fleet

Figure 3 also illustrates that the proportion of accidents that are Survivable has increased over the study period—this issue is discussed further in section 5.1.

As might be expected, similar trends are shown for the accident rate to the world fleet when expressed in terms of a 100 million revenue passenger miles basis as shown in figure 4.

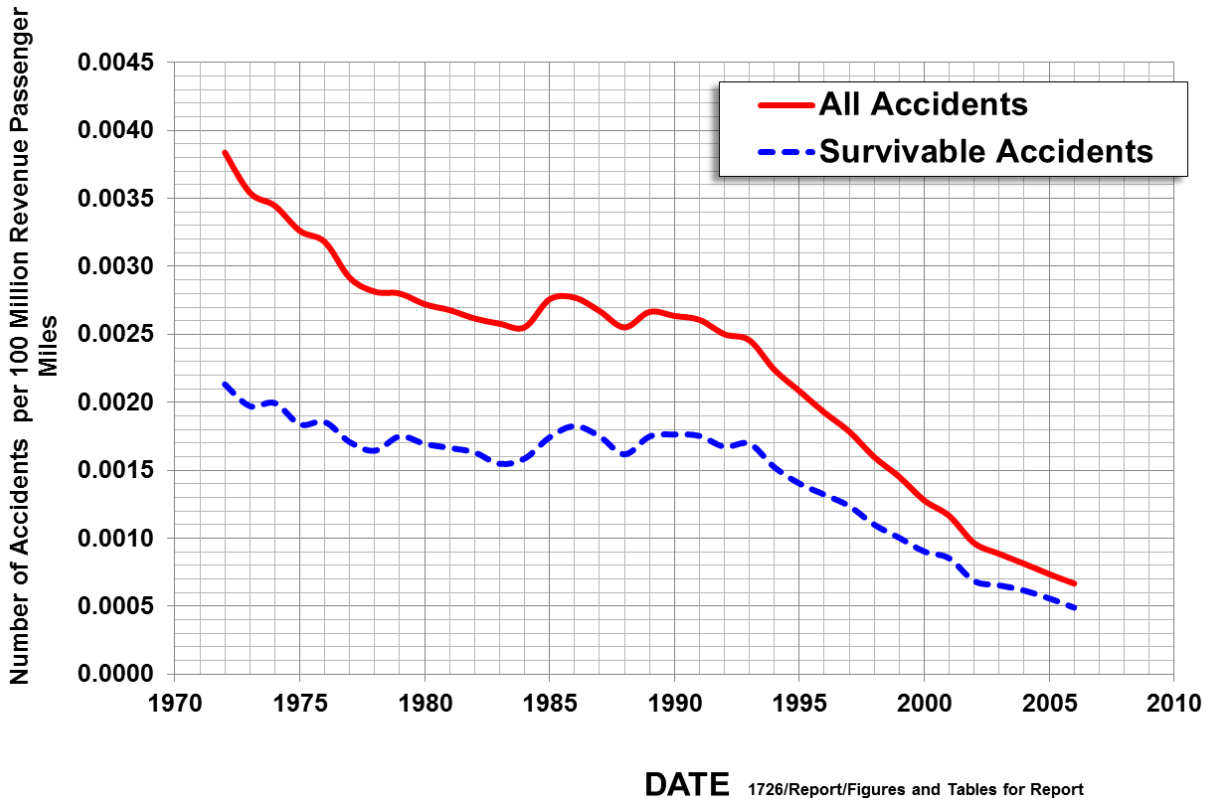

Figure 4. Accident Rate per 100 Million Revenue Passenger Miles—World Fleet

3.2.2 All Accidents and Survivable Accidents—U.S. Fleet.

The 9-year centered moving average accident rate for the U.S. fleet has also improved markedly both in terms of all Accidents and Survivable Accidents as illustrated in figure 5. Comparison between the accident rate for the world fleet, illustrated in figure 3, and the U.S. fleet, illustrated in figure 5, suggests a significantly lower accident rate for airplanes operating on the U.S. register. The rate of improvement for the U.S. fleet would also seem to be improving faster than the world fleet.

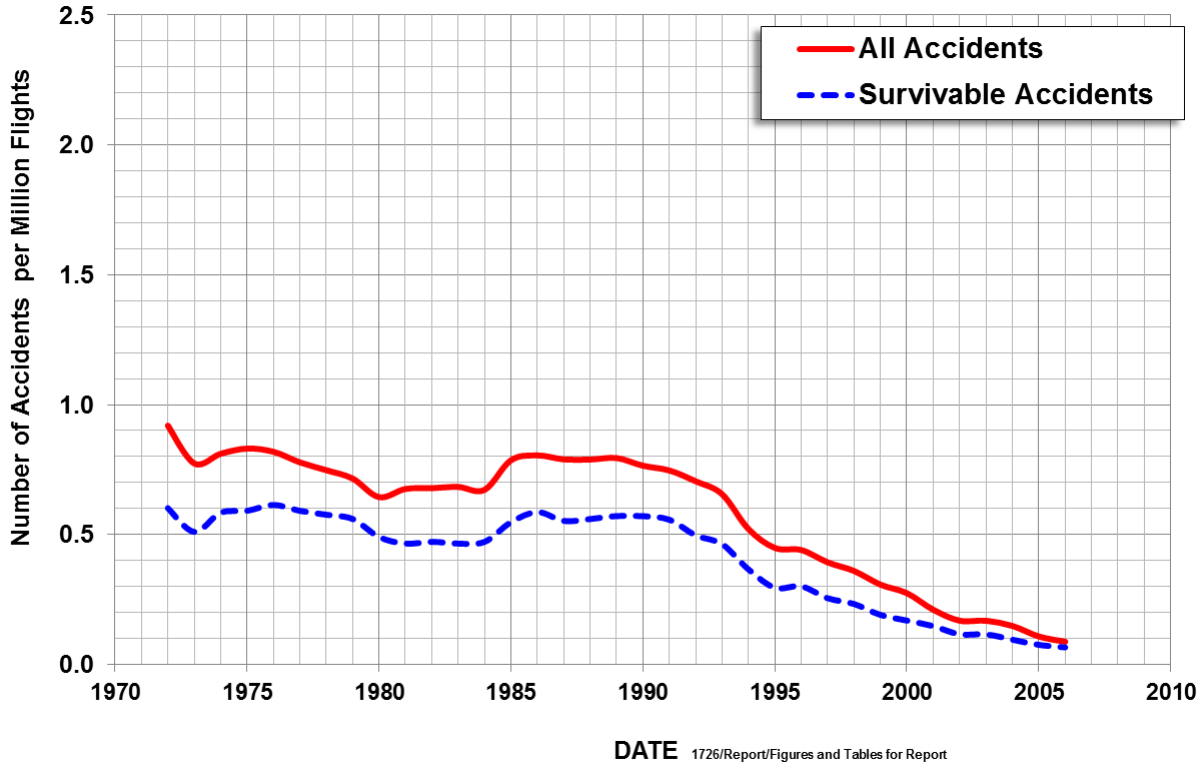

Figure 5. Accident Rate—All Accidents and Survivable Accidents—U.S. Fleet

3.2.3 All Accidents—Turbojets & Turboprops—World Fleet.

Figure 6 shows the 9-year centered moving average accident rate for both turbojets and turboprops. It may be seen that, for both turbojets and turboprops, the accident rate has improved significantly over the past thirty to forty years with perhaps turboprops showing the greater rate of improvement. However, the accident rate per flight continues to be significantly lower for turbojets than for turboprops.

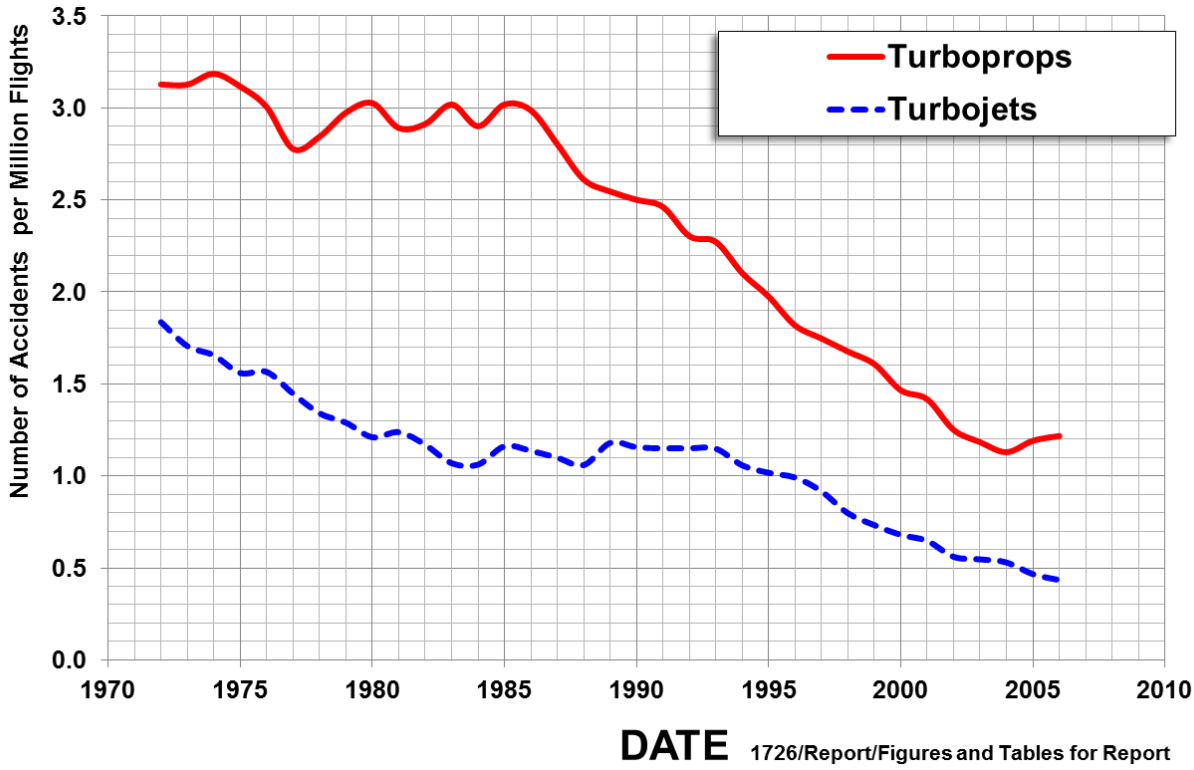

Figure 6. Accident Rate per Million Flights—All Accidents—Turbojets and Turboprops—World Fleet

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

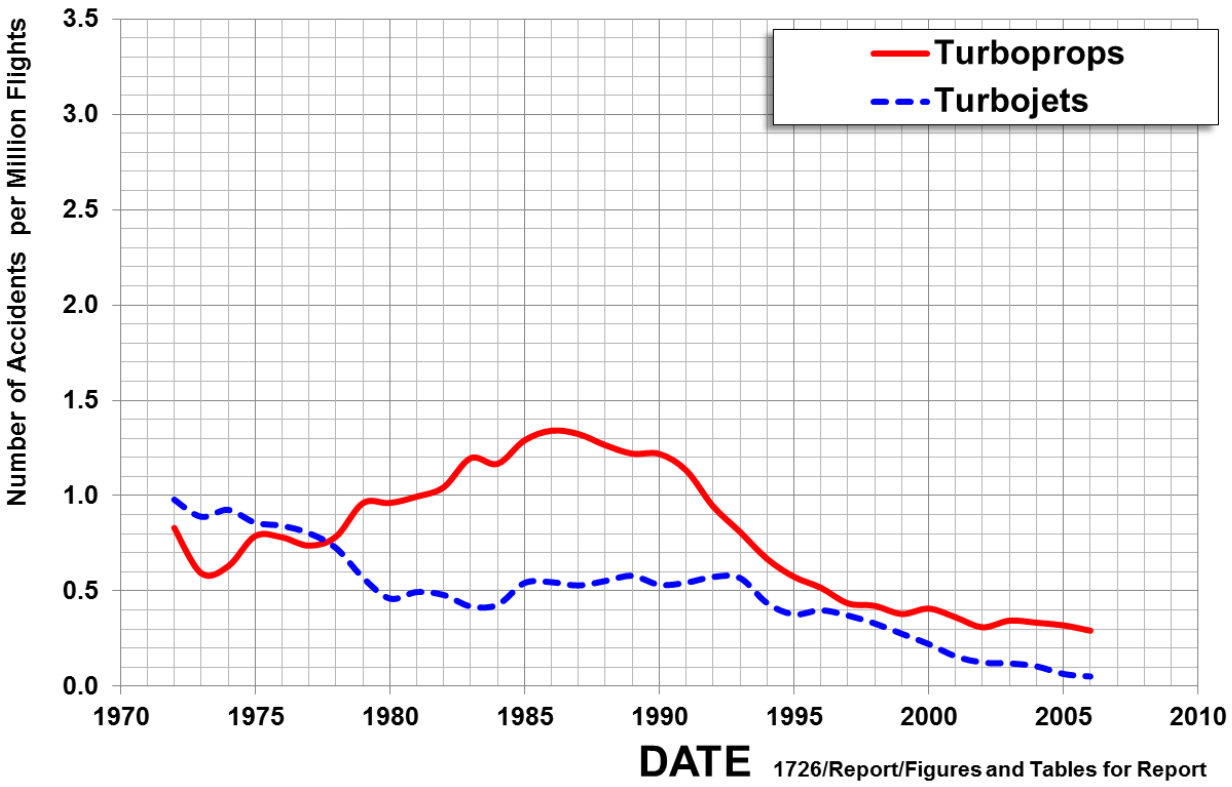

Figure 7. Accident Rate per Million Flights—All Accidents—Turbojets and Turboprops—U.S. Fleet

Comparison between figure 6 and figure 7 illustrates that the accident rate of the U.S. fleet is significantly better than the world fleet for both turbojets and turboprops.

4. TRENDS IN NUMBER OF FATALITIES AND FATALITY RATES.

All data in the graphs shown in this section are based on a 9-year centered moving average.

4.1 NUMBER OF FATALITIES.

Figure 8 shows that the number of fatalities in all accidents has diminished for the world fleet over the study period from an average value of approximately 1000 per year to less than 600. While the number of flights, passengers, and revenue passenger miles has increased over this period, the accident rate has diminished markedly as discussed in section 3.2.1. This improvement, combined with the decline in fatalities due to improvements in occupant survivability (as discussed in section 5), has resulted in the reduction in fatalities illustrated in figure 8.

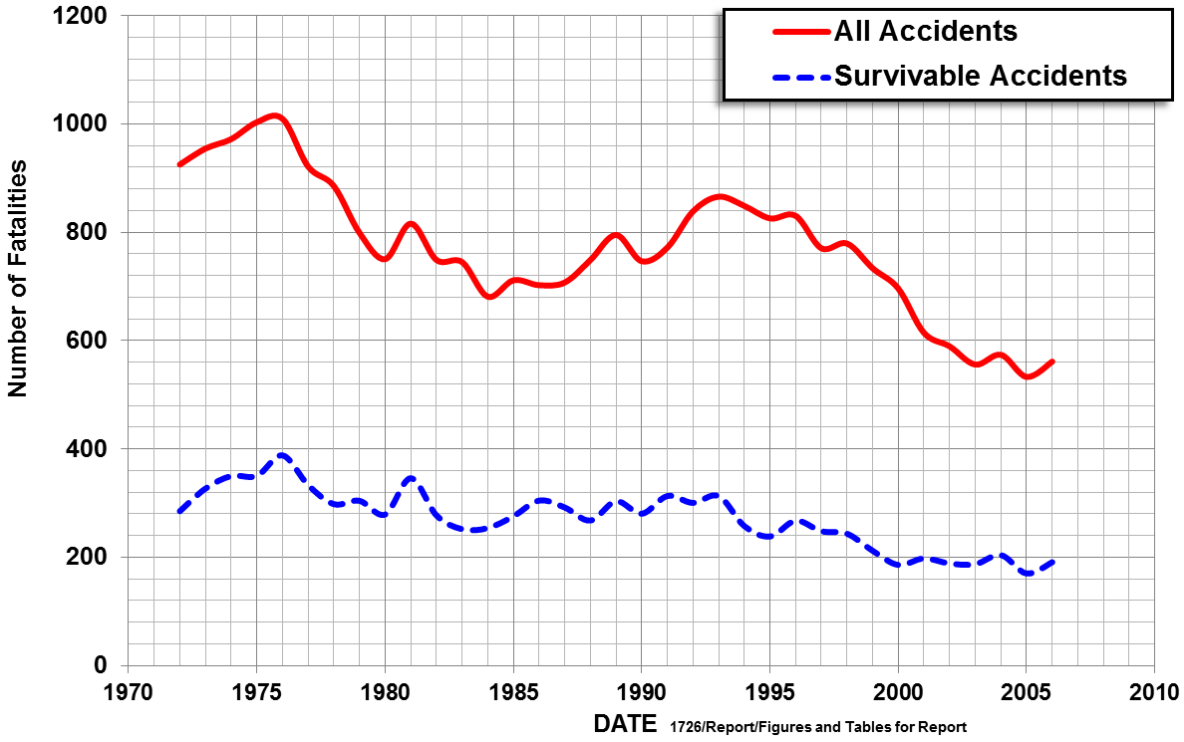

Figure 8. Number of Fatalities—All Accidents and Survivable Accidents—World Fleet

The number of fatalities attributable to the U.S. fleet has also diminished, as illustrated in figure 9. Comparison between figure 8 and figure 9 shows that the U.S. fleet accounts for a small proportion of the fatalities worldwide.

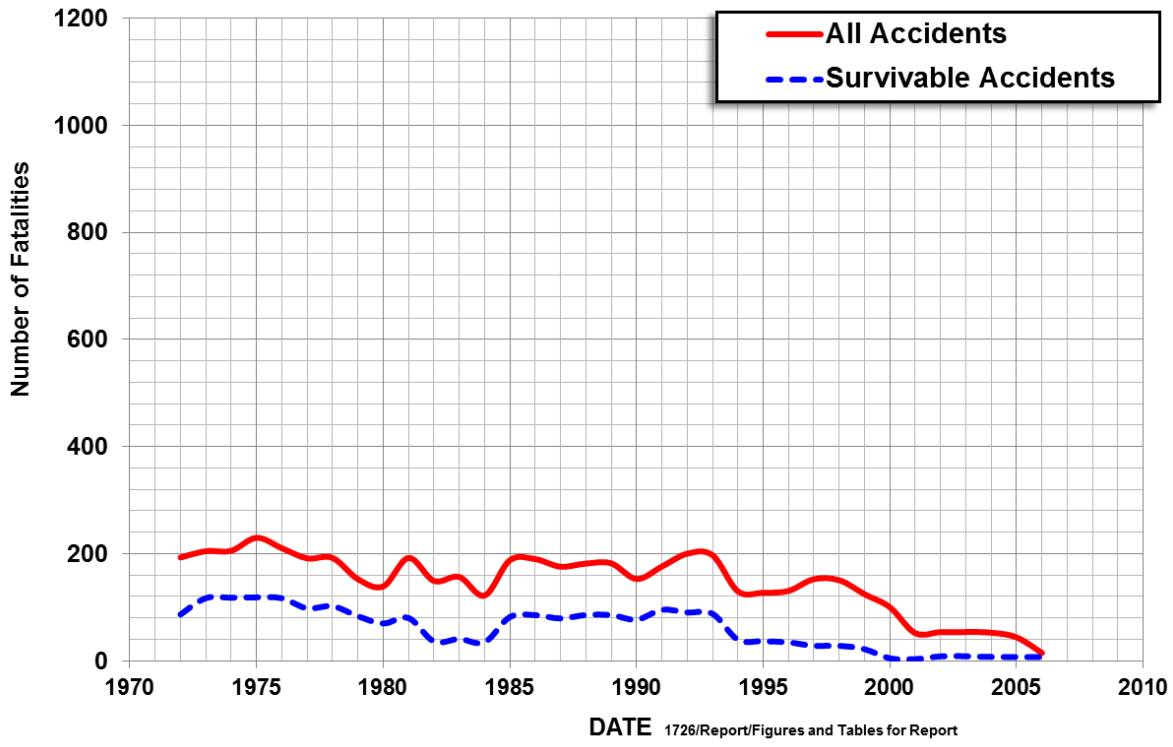

Figure 9. Number of Fatalities—All Accidents and Survivable Accidents—U.S. Fleet

4.2 FATALITY RATES.

The fatality rate for the world fleet, expressed as the number of fatalities per million flights, has shown a marked improvement over the study period decreasing by a factor of four to five for all accidents as illustrated in figure 10. The fatality rate for Survivable Accidents has also decreased markedly.

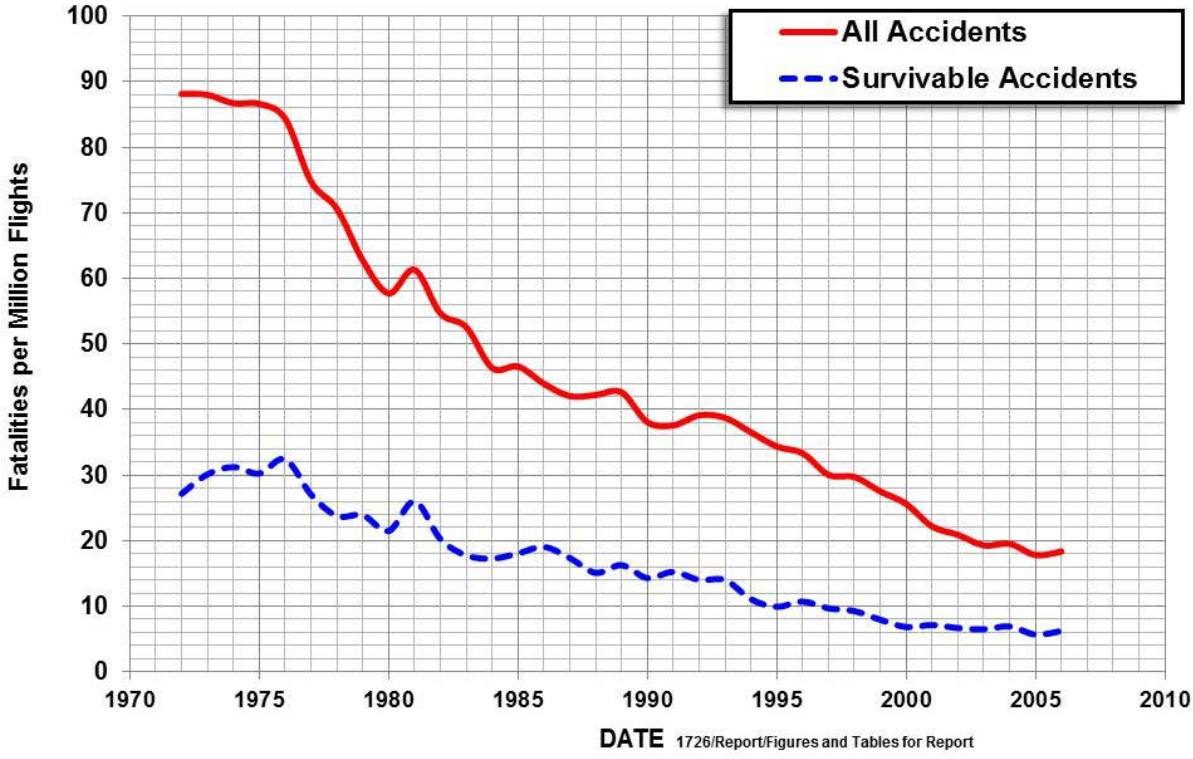

Figure 10. Fatality Rate—All Accidents and Survivable Accidents—World Fleet

The U.S. fleet has also shown a marked reduction in the fatality rate over the study period as illustrated in figure 11. By comparison between figure 10 and figure 11, it may be seen that the fatality rate for the U.S. fleet is small in comparison with the world fleet.

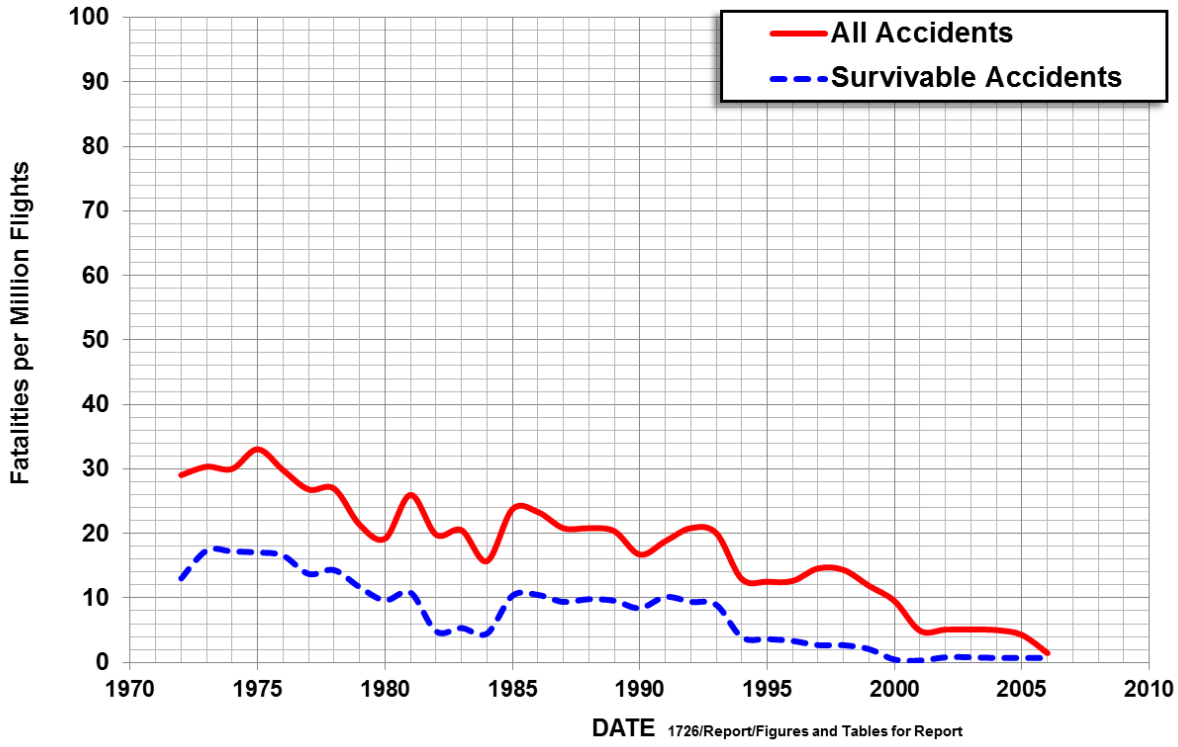

Figure 11. Fatality Rate—All Accidents and Survivable Accidents—U.S. Fleet

5. SURVIVABILITY TRENDS.

All data in the graphs shown in this section are based on a 9-year centered moving average.

5.1 PROBABILITY OF AN ACCIDENT BEING SURVIVABLE.

Figure 12 shows that over the study period, there has been an improvement for the world fleet in the probability of an accident being Survivable[5]. The U.S. fleet does not appear to exhibit such a marked steady improvement over the study period. However, it would appear that the probability of an accident being Survivable is at a similar level for both the U.S. and world fleet.

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

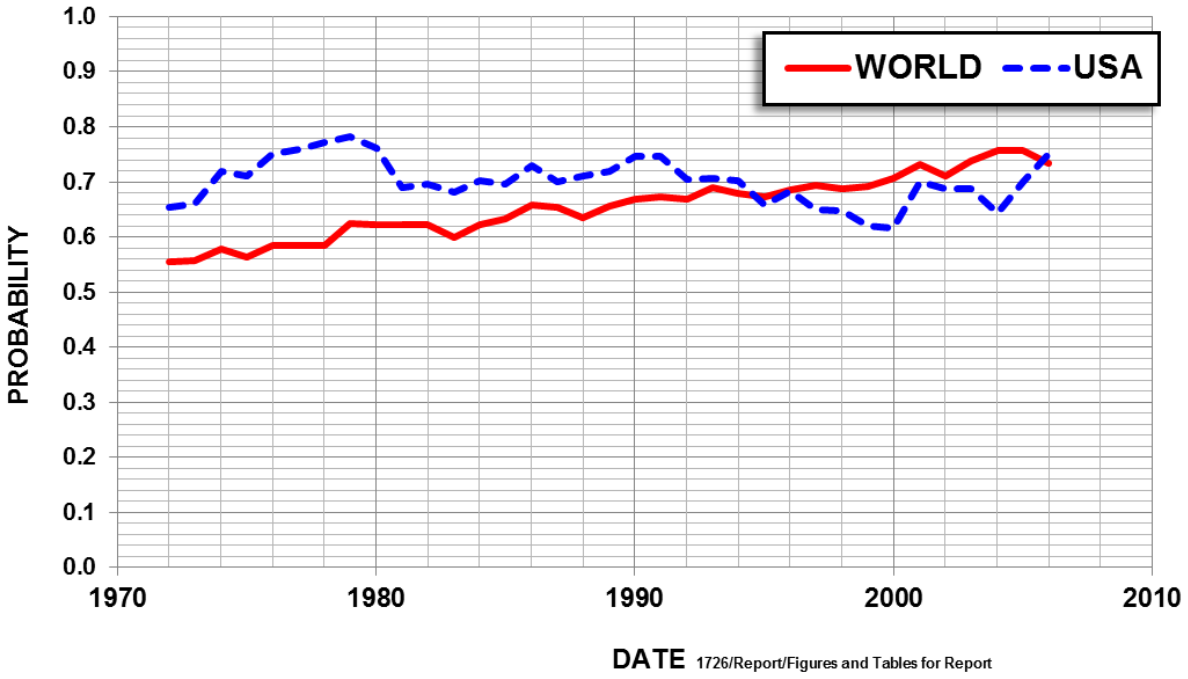

Figure 12. Probability of an Accident Being Survivable—World Fleet and U.S. Fleet

5.2 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.

This improvement in the probability of death is reflected in the U.S. fleet, which currently appears to surpass that exhibited by the average for the world fleet.

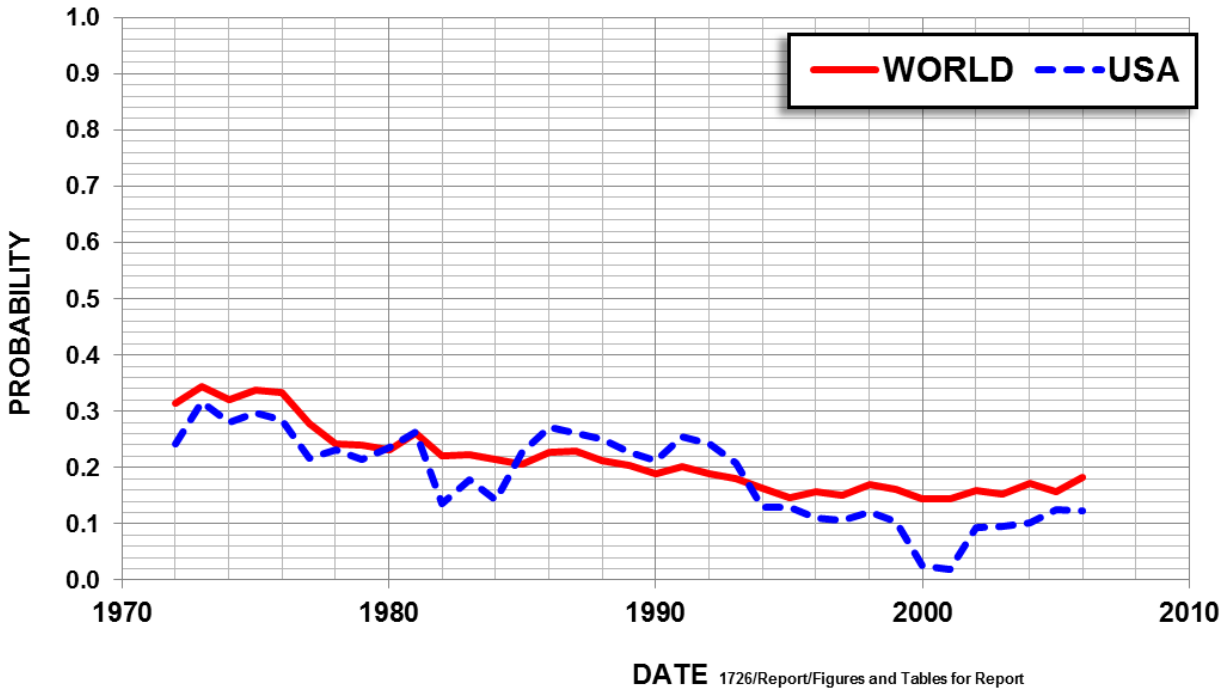

Figure 13. Probability of Death in a Survivable Accident—World Fleet and U.S. Fleet

6. TRENDS IN CAUSE OF DEATH.

All data in the graphs shown in this section are based on a 9-year centered moving average.

Figure 14 shows the reduction in the probability of death in Survivable Accidents subdivided into cause of death for the world fleet. The data are presented as a centered 9-year moving average in order to identify the underlying trend. Because of the limited data on some accidents, compensated to a degree by the use of random numbers as described in section 2.3, some of the values depicted in the graph cannot be considered as precise.

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 be seen to 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. Therefore, 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.

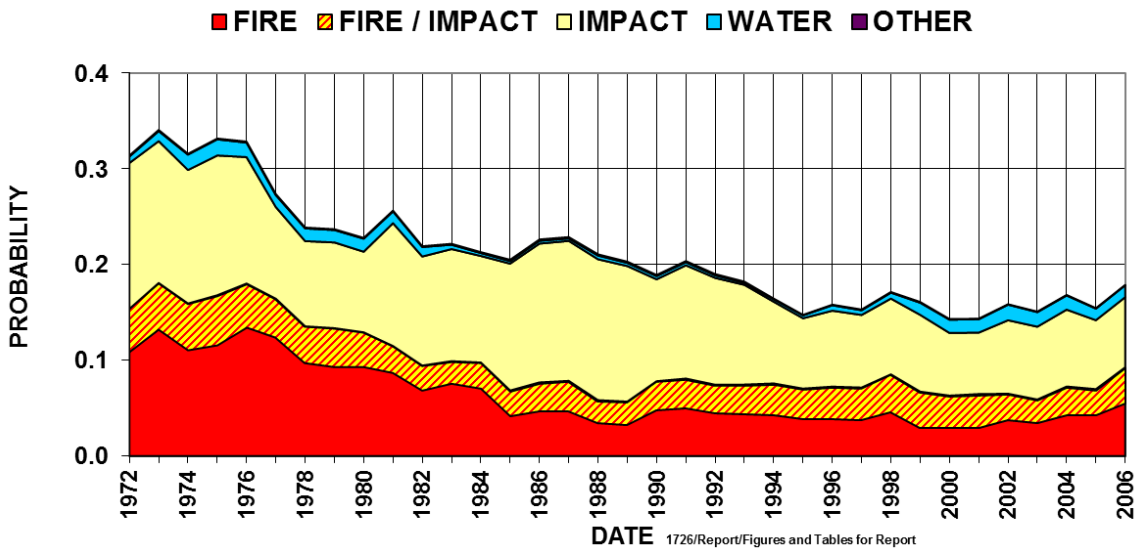

Figure 14. Cause of Death in a Survivable Accident—World Fleet

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 is beyond the scope of this study. For some accidents, improvements in impact-related survivability factors may not have prevented all of the impact-related fatalities as previously discussed.

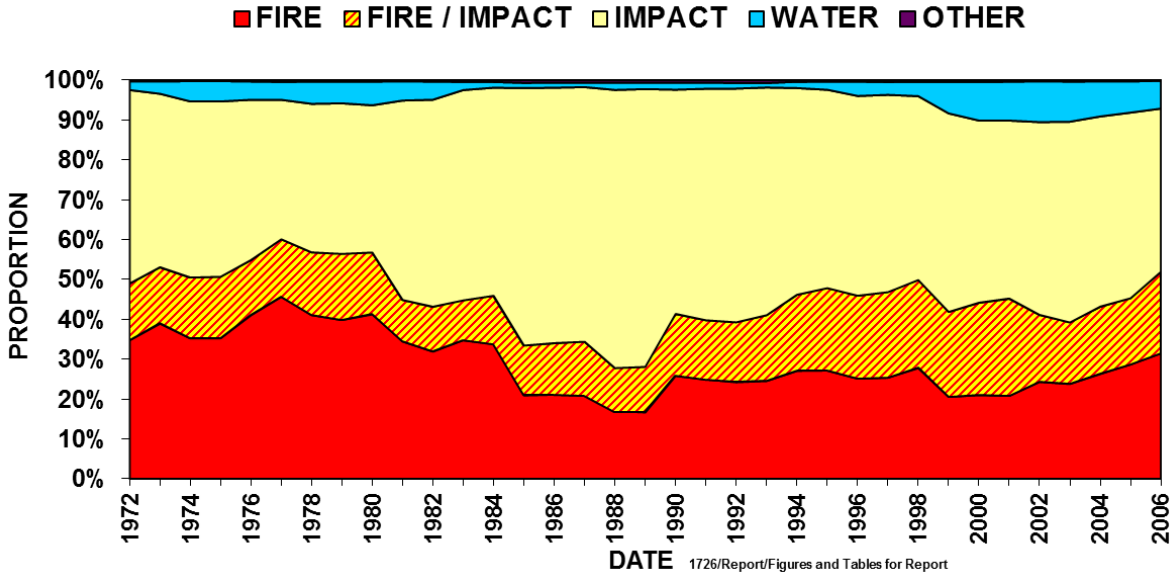

Figure 15. Proportion of Fatalities by Cause in a Survivable Accident—World Fleet

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

7. IN-FLIGHT FIRE ACCIDENTS.

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

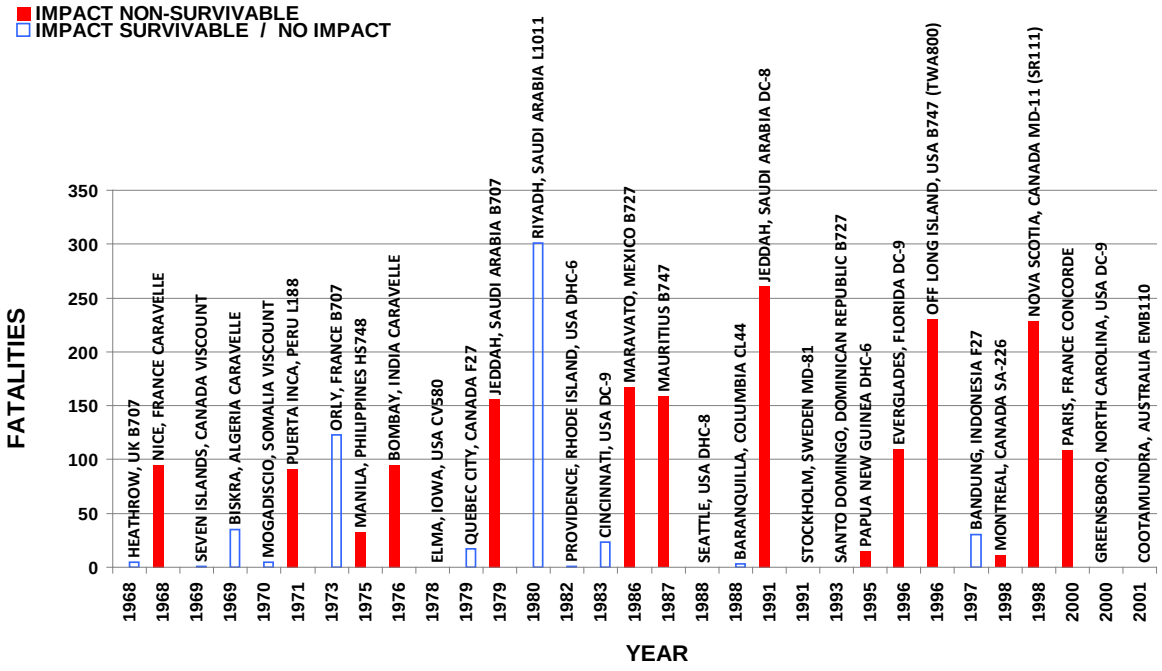

Figure 16. In-Flight Fire Accidents Over the Study Period

8. REFERENCES.

1. RGW Cherry & Associates Limited (2010), DOT/FAA/AR-10/16, "Trends in Accidents and Fatalities in Large Transport Aircraft: U.S. Department of Transportation Federal Aviation Administration." http://www.fire.tc.faa.gov/pdf/10-16.pdf (last visited June, 2013).

2. RGW Cherry & Associates Limited, (May 2013). The Cabin Safety Research Technical Group Accident Database, Prepared for Transport Canada, the Federal Aviation Administration and the UK Civil Aviation Authority. U.S. Department of Transportation Federal Aviation Administration http://www.fire.tc.faa.gov/ADB/index.html (last visited June, 2013).

APPENDIX A—AIRCRAFT TYPES ANALYZED IN THE STUDY

A.S.T.A. (GAF) Nomad
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 (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 1900
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.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 50
Fokker 70
Fokker 100
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
Gulfstream Aerospace Gulfstream I
Handley Page Herald
Handley Page Jetstream
IAI Arava
Jetstream 31
Jetstream 41
Lockheed L-1011 TriStar
Lockheed L-188 Electra

McDonnell Douglas DC-8
McDonnell Douglas DC-9
McDonnell Douglas DC-10
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	US
1968	9,166,538	6,252,882
1969	9,482,153	6,353,339
1970	9,800,866	6,450,371
1971	10,126,126	6,546,186
1972	10,462,699	6,643,908
1973	10,811,152	6,743,713
1974	11,168,753	6,843,465
1975	11,539,425	6,945,672
1976	11,923,211	7,050,124
1977	12,319,775	7,156,331
1978	12,729,622	7,264,391
1979	13,153,434	7,374,511
1980	13,589,209	7,485,013
1981	13,657,033	7,387,220
1982	12,747,061	6,671,207
1983	12,948,345	6,941,304
1984	13,915,582	7,877,801
1985	14,695,957	8,444,810
1986	15,829,862	8,332,138
1987	16,983,465	8,250,095
1988	17,932,279	8,515,805
1989	18,720,579	8,801,916
1990	20,108,178	9,471,755
1991	20,186,500	9,354,593
1992	21,221,182	9,541,649
1993	22,134,507	9,817,755
1994	23,282,551	10,247,990
1995	24,180,952	10,343,089
1996	25,151,490	10,403,859
1997	26,128,860	10,510,754
1998	26,579,462	10,469,367
1999	27,353,869	10,715,918
2000	28,181,569	10,989,317
2001	27,887,491	10,600,890
2002	27,269,580	10,207,687
2003	27,159,885	10,083,008
2004	28,991,898	10,668,166
2005	29,694,016	10,661,900
2006	30,670,435	10,444,581
2007	32,074,931	10,632,186
2008	32,459,591	10,009,428
2009	32,954,942	9,385,608
2010	33,820,680	9,163,404
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FLIGHTS		
TURBOJETS		
YEAR	WORLD	US
1968	4,433,870	2,997,940
1969	5,740,475	3,835,289
1970	6,429,284	4,108,820
1971	6,729,759	4,074,221
1972	7,051,353	4,094,261
1973	7,384,343	4,187,025
1974	7,622,376	4,100,036
1975	7,926,268	4,124,124
1976	8,232,737	4,231,896
1977	8,541,436	4,363,677
1978	8,947,506	4,527,934
1979	9,383,765	4,746,329
1980	9,658,151	4,819,687
1981	9,705,060	4,756,717
1982	9,056,265	4,295,668
1983	9,200,848	4,469,587
1984	9,892,151	5,072,608
1985	10,433,297	5,428,345
1986	10,938,998	5,719,977
1987	11,487,636	6,058,505
1988	11,939,864	6,149,615
1989	12,044,079	6,021,726
1990	12,686,193	6,224,015
1991	12,388,064	5,905,763
1992	13,013,198	5,913,858
1993	13,567,339	6,065,011
1994	14,356,272	6,385,543
1995	15,025,886	6,482,633
1996	15,810,441	6,619,674
1997	16,518,701	6,763,085
1998	17,110,461	6,900,805
1999	17,908,743	7,282,433
2000	18,948,940	7,734,029
2001	19,205,375	7,706,593
2002	19,377,600	7,808,485
2003	19,753,491	8,040,917
2004	21,607,846	8,800,947
2005	22,590,279	9,007,414
2006	23,699,018	8,963,335
2007	25,245,029	9,343,962
2008	25,776,691	8,918,505
2009	26,431,259	8,464,859
2010	27,348,157	8,199,034

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FLIGHTS		
TURBOPROPS		
YEAR	WORLD	US
1968	4,732,668	3,254,942
1969	3,741,677	2,518,049
1970	3,371,582	2,341,551
1971	3,396,368	2,471,965
1972	3,411,346	2,549,647
1973	3,426,809	2,556,689
1974	3,546,377	2,743,430
1975	3,613,157	2,821,548
1976	3,690,474	2,818,227
1977	3,778,339	2,792,654
1978	3,782,116	2,736,457
1979	3,769,669	2,628,182
1980	3,931,058	2,665,326
1981	3,951,973	2,630,503
1982	3,690,795	2,375,539
1983	3,747,497	2,471,717
1984	4,023,430	2,805,193
1985	4,262,661	3,016,465
1986	4,890,864	2,612,161
1987	5,495,829	2,191,590
1988	5,992,414	2,366,190
1989	6,676,500	2,780,190
1990	7,421,986	3,247,740
1991	7,798,437	3,448,830
1992	8,207,984	3,627,791
1993	8,567,168	3,752,744
1994	8,926,279	3,862,447
1995	9,155,066	3,860,456
1996	9,341,048	3,784,185
1997	9,610,159	3,747,669
1998	9,469,001	3,568,562
1999	9,445,126	3,433,485
2000	9,232,628	3,255,288
2001	8,682,116	2,894,297
2002	7,891,980	2,399,202
2003	7,406,393	2,042,091
2004	7,384,052	1,867,218
2005	7,103,737	1,654,485
2006	6,971,417	1,481,246
2007	6,829,902	1,288,225
2008	6,682,900	1,090,923
2009	6,523,683	920,749
2010	6,472,524	964,369

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PASSENGERS (x million)		
TURBOJETS AND TURBOPROPS		
YEAR	**WORLD**	**US**
1968	396	257
1969	478	308
1970	523	325
1971	546	324
1972	570	327
1973	595	334
1974	614	330
1975	638	333
1976	661	340
1977	685	349
1978	715	360
1979	747	375
1980	770	380
1981	773	375
1982	722	339
1983	733	353
1984	788	400
1985	832	428
1986	877	445
1987	927	510
1988	970	518
1989	1,023	526
1990	1,060	534
1991	1,114	542
1992	1,189	550
1993	1,233	559
1994	1,286	567
1995	1,362	576
1996	1,435	585
1997	1,503	603
1998	1,566	618
1999	1,632	642
2000	1,732	674
2001	1,664	629
2002	1,678	622
2003	1,829	657
2004	2,036	714
2005	2,205	747
2006	2,329	751
2007	2,505	776
2008	2,532	749
2009	2,615	709
2010	2,934	727

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PASSENGERS (x million)		
TURBOJETS		
YEAR	WORLD	US
1968	327	215
1969	423	275
1970	474	295
1971	496	292
1972	520	294
1973	544	300
1974	562	294
1975	584	296
1976	607	304
1977	630	313
1978	660	325
1979	692	340
1980	712	346
1981	716	341
1982	668	308
1983	678	321
1984	729	364
1985	769	389
1986	807	410
1987	847	435
1988	884	444
1989	925	451
1990	955	459
1991	996	467
1992	1,062	476
1993	1,101	488
1994	1,149	501
1995	1,218	515
1996	1,285	529
1997	1,347	547
1998	1,409	562
1999	1,472	588
2000	1,570	621
2001	1,515	583
2002	1,538	581
2003	1,685	619
2004	1,887	679
2005	2,049	713
2006	2,173	723
2007	2,343	748
2008	2,371	722
2009	2,453	685
2010	2,758	703

PASSENGERS (x million)		
TURBOPROPS		
YEAR	WORLD	US
1968	69	42
1969	55	33
1970	49	31
1971	50	32
1972	50	33
1973	50	33
1974	52	36
1975	53	37
1976	54	37
1977	56	36
1978	56	36
1979	55	34
1980	58	35
1981	58	34
1982	54	31
1983	55	32
1984	59	37
1985	62	39
1986	71	34
1987	80	29
1988	86	32
1989	98	38
1990	105	42
1991	118	47
1992	127	52
1993	132	54
1994	137	54
1995	143	55
1996	150	56
1997	156	56
1998	158	56
1999	160	55
2000	162	53
2001	149	47
2002	140	40
2003	144	37
2004	149	35
2005	156	35
2006	156	27
2007	162	28
2008	161	27
2009	162	24
2010	176	23

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REVENUE PASSENGER MILES (x 100 million)		
TURBOJETS AND TURBOPROPS		
YEAR	**WORLD**	**US**
1968	4,193	2,439
1969	5,287	3,012
1970	5,873	3,204
1971	6,141	3,186
1972	6,426	3,206
1973	6,720	3,276
1974	6,938	3,223
1975	7,210	3,246
1976	7,485	3,326
1977	7,762	3,422
1978	8,121	3,541
1979	8,504	3,696
1980	8,756	3,753
1981	8,798	3,704
1982	8,210	3,345
1983	8,341	3,480
1984	8,968	3,950
1985	9,459	4,226
1986	9,940	4,419
1987	10,459	4,645
1988	10,915	4,767
1989	11,563	4,891
1990	12,018	5,019
1991	12,648	5,150
1992	13,593	5,284
1993	14,066	5,422
1994	14,825	5,563
1995	15,754	5,708
1996	16,565	5,857
1997	17,596	6,124
1998	18,304	6,257
1999	19,272	6,589
2000	20,673	7,008
2001	19,914	6,585
2002	19,930	6,505
2003	21,493	6,742
2004	24,749	7,523
2005	27,146	7,951
2006	28,812	8,101
2007	29,337	8,420
2008	30,883	8,238
2009	32,827	7,800
2010	38,507	8,091

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REVENUE PASSENGER MILES (x 100 million)		
TURBOJETS		
YEAR	WORLD	US
1968	3,913	2,226
1969	5,066	2,848
1970	5,674	3,051
1971	5,939	3,025
1972	6,223	3,040
1973	6,517	3,109
1974	6,727	3,044
1975	6,995	3,062
1976	7,266	3,142
1977	7,538	3,240
1978	7,896	3,362
1979	8,281	3,524
1980	8,524	3,578
1981	8,565	3,532
1982	7,992	3,189
1983	8,120	3,318
1984	8,730	3,766
1985	9,208	4,030
1986	9,654	4,247
1987	10,138	4,498
1988	10,582	4,621
1989	11,198	4,728
1990	11,612	4,829
1991	12,196	4,937
1992	13,108	5,045
1993	13,576	5,180
1994	14,319	5,319
1995	15,225	5,458
1996	16,016	5,601
1997	17,025	5,866
1998	17,738	6,006
1999	18,700	6,342
2000	20,097	6,765
2001	19,386	6,372
2002	19,446	6,322
2003	21,003	6,574
2004	24,231	7,361
2005	26,598	7,791
2006	28,263	7,948
2007	28,800	8,309
2008	30,324	8,123
2009	32,247	7,692
2010	37,841	7,978

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REVENUE PASSENGER MILES (x 100 million)		
TURBOPROPS		
YEAR	WORLD	US
1968	279	213
1969	221	165
1970	199	153
1971	201	162
1972	203	167
1973	203	167
1974	211	179
1975	215	184
1976	219	184
1977	224	182
1978	224	179
1979	223	172
1980	232	174
1981	233	172
1982	217	155
1983	221	162
1984	238	183
1985	251	196
1986	286	172
1987	321	147
1988	333	145
1989	364	163
1990	405	190
1991	452	212
1992	485	239
1993	491	242
1994	506	244
1995	529	250
1996	549	256
1997	571	258
1998	566	252
1999	572	247
2000	576	243
2001	528	213
2002	484	183
2003	490	168
2004	518	163
2005	549	160
2006	549	153
2007	537	111
2008	559	115
2009	580	108
2010	666	113