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Survivability of Accidents Involving U.S. Air Carrier Operations, 1983–2000

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In This Issue

Cover photo: An uncontained failure of the no. 1 engine of this Delta Air Lines McDonnell Douglas MD-88 occurred during takeoff at Pensacola, Florida, U.S., on July 6, 1996. A flight attendant inflated the evacuation slide, but because of the fire in the damaged engine, passengers were directed to another exit. Of the 149 people in the airplane, 147 survived. The two fatalities occurred when debris from the failure of the no. 1 engine penetrated the cabin; one passenger was seriously injured by the debris, and another was seriously injured during evacuation. (Source: U.S. National Transportation Safety Board)

Survivability of Accidents Involving U.S. Air Carrier Operations, 1983–2000

A study revealed that in U.S. Federal Aviation Regulations Part 121 air carrier accidents from 1983 through 2000, more than 95 percent of the airplane occupants survived and that in the most serious accidents, more than 55 percent of the occupants survived.

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U.S. National Transportation Safety Board

Executive Summary

Passenger enplanements in the United States more than doubled in the 16 years following 1983. According to recent U.S. Federal Aviation Administration (FAA) forecasts, this growth is expected to continue, approaching 1 billion enplanements by the year 2010 (an additional 53 percent increase). Despite the growing demands on the U.S. aviation system, the system continues to maintain its high level of safety. The accident rate for commercial aircraft has remained about the same for the past two decades. If the accident rate continues, however, increased traffic projected over the next 10 years will be accompanied by a commensurate increase in the number of aircraft accidents. To prevent this from occurring, government agencies are working with industry to reduce the rate of accidents.

There are two ways to prevent fatalities in air travel: by preventing accidents, and by protecting aircraft occupants in the accidents that occur. A reduction in accident rates provides an indication of the success of accident prevention; examining occupant survivability can indicate the positive results from occupant protection. The importance of examining occupant survivability in aviation accidents is twofold: It can help to dispel a public perception that most air carrier accidents are not survivable, and it can identify things that can be done to increase survivability in the accidents that occur.

The U.S. National Transportation Safety Board (NTSB) frequently receives inquiries from the general public and from government agencies concerning the survivability of airplane accidents. Although NTSB's *Annual Review of Aircraft Accident Data for U.S. Air Carrier Operations* summarizes the degree of occupant injury by aircraft damage, the annual publication has not, in the past, analyzed the issue of survivability in detail. Therefore, the purpose of this safety report is to examine aircraft occupant survivability for air carrier operations in the United States. NTSB examined only

air carrier operations performed under U.S. Federal Aviation Regulations (FARs) Part 121 because the majority of NTSB survival-factors investigations are conducted in connection with accidents involving Part 121 carriers. Therefore, more survivability data are available for Part 121 operations than are available for Part 135 (commuter and on-demand) and Part 91 (general aviation) operations. This report also examines cause-of-death information for the most serious of the Part 121 accidents; that is, those accidents involving fire, at least one serious injury or fatality, and either substantial aircraft damage or aircraft destruction.

Introduction

Passenger enplanements in the United States more than doubled in the 16 years following 1983. This growth is expected to continue, approaching 1 billion enplanements by the year 2010 (an additional 53 percent increase).[1] Commensurate with the increase in the number of people traveling will be an increase in the miles that air carriers fly. In 1999, U.S. air carriers flew 6.8 billion miles, a 50 percent increase from 10 years prior. Despite the growing demands on the U.S. aviation system, the system continues to maintain a high level of safety. The accident rate for commercial aircraft has remained about the same for the past two decades. If the accident rate continues, however, increased traffic projected over the next 10 years will be accompanied by a commensurate increase in the number of aircraft accidents.[2] To prevent this from occurring, government agencies are working with industry to reduce the rate of accidents.

In 2000, there were 54 accidents involving U.S. air carrier flights operating under Part 121; 92 fatalities occurred aboard the accident aircraft. When the accident rate for 2000 is adjusted for operating hours (0.299 accidents per 100,000 flight hours), the rate is the same as that for 1999 (0.299), when there were 52 accidents and 11 fatalities aboard accident aircraft, essentially the same as that for 1998 (0.297), when there were 50 accidents and zero fatalities aboard accident aircraft, and slightly lower than that for 1997 (0.309), when there were 49 accidents and six fatalities aboard accident aircraft (Table 1, page 3).

In 1996, Part 121 carriers experienced 37 accidents that resulted in 350 fatalities. Although the 1996 accident rate (0.269 accidents per 100,000 flight hours) was lower than in 2000 (0.299), 1999 (0.299), 1998 (0.297), or 1997 (0.309), the total number of fatalities was substantially greater because of two severe accidents (Trans World Airlines Flight 800[3] and ValuJet Flight 592[4]) in which 340 occupants were killed.

Fatal accidents such as TWA Flight 800, ValuJet Flight 592 and EgyptAir Flight 990[5] receive extensive media coverage. Nonfatal accidents, however, receive little coverage. As a result, the public may perceive that most air carrier accidents are not survivable. In 1992, for example, the Civil Aviation Authority (CAA) of the United Kingdom found that people rated aircraft accidents as the least survivable type of transportation accident. Further, 32.7 percent of the people the CAA surveyed about the likelihood of accident survival believed that they would be unlikely to survive an aircraft accident.[6]

There are two ways to prevent fatalities in air travel: by preventing accidents, and by protecting aircraft occupants in the accidents that do occur. A reduction in accident rates provides an indication of the success of accident prevention; examining occupant survivability can indicate the positive results from occupant protection. The importance of examining occupant survivability in aviation accidents is twofold: It can help to dispel a public perception that most air carrier accidents are not survivable, and it can identify things that can be done to increase survivability in the accidents that do occur.

NTSB frequently receives inquiries from the general public and government agencies concerning the survivability of airplane accidents. Although NTSB's *Annual Review of Aircraft Accident Data for U.S. Air Carrier Operations* summarizes the degree of occupant injury by aircraft damage, the annual publication has not, in the past, analyzed the issue of survivability in detail. Therefore, the purpose of this safety report is to examine aircraft occupant survivability for air carrier operations in the United States. NTSB examined only air carrier operations performed under Part 121 because the majority of NTSB survival-factors investigations are conducted in connection with accidents involving Part 121 carriers. Therefore, more survivability data are available for Part 121 operations than are available for Part 135 and Part 91 operations. This report also examines cause-of-death information for the most serious of the Part 121 accidents.[7]

Aviation Accident Survivability

Several organizations have attempted to develop general statistics on aviation accident survivability. The European Transport Safety Council (ETSC) examined the survivability of accidents worldwide and estimated that 90 percent of aircraft accidents are "survivable" (no passengers are killed) or "technically survivable" (at least one occupant survives).[8] On the basis of these definitions, the ETSC estimated that of the 1,500 people who die annually in air transport accidents, 600 people who should survive die in survivable accidents. Of these 600, the ETSC further estimated that 330 fatalities result from impact and 270 fatalities result from fire-related factors (including smoke) that occur after impact. However, the ETSC said that "these figures are best estimates, since insufficient detailed accident information is available."

Researchers at FAA examined, in the mid-1990s, a selected set of survivable accidents that occurred from 1970 to 1995 in the United States. Their report was described in the agency's employee newsletter, the *FAA Intercom*.[9] The researchers found that 68 percent of occupants involved in aircraft accidents died as a result of injuries sustained during post-crash fires. This number of fire-related fatalities was

Table 1
Accidents, Fatalities and Accident Rates for U.S. Federal Aviation Regulations Part 121 Air Carriers, 1983–2000

	Accidents		Fatalities					Accidents per 100,000 Flight Hours		Accidents per 1 Million Miles Flown		Accidents per 100,000 Departures	
Year	All	Fatal	Total	Aboard	Flight Hours[1]	Miles Flown[1]	Departures[1]	All	Fatal	All	Fatal	All	Fatal
1983	23	4	15	14	7,298,799	3,069,318,000	5,444,374	0.315	0.055	0.0075	0.0013	0.422	0.073
1984	16	1	4	4	8,165,124	3,428,063,000	5,898,852	0.196	0.012	0.0047	0.0003	0.271	0.017
1985	21	7	526	525	8,709,894	3,631,017,000	6,306,759	0.241	0.080	0.0058	0.0019	0.333	0.111
1986[2]	24	3	8	7	9,976,104	4,017,626,000	7,202,027	0.231	0.020	0.0057	0.0005	0.319	0.028
1987[2]	34	5	232	230	10,645,192	4,360,521,000	7,601,373	0.310	0.038	0.0076	0.0009	0.434	0.053
1988[2]	30	3	285	274	11,140,548	4,503,426,000	7,716,061	0.260	0.018	0.0064	0.0004	0.376	0.026
1989	28	11	278	276	11,274,543	4,605,083,000	7,645,494	0.248	0.098	0.0061	0.0024	0.366	0.144
1990	24	6	39	12	12,150,116	4,947,832,000	8,092,306	0.198	0.049	0.0049	0.0012	0.297	0.074
1991	26	4	62[3]	49	11,780,610	4,824,824,000	7,814,875	0.221	0.034	0.0054	0.0008	0.333	0.051
1992	18	4	33	31	12,359,715	5,039,435,000	7,880,707	0.146	0.032	0.0036	0.0008	0.228	0.051
1993	23	1	1	0	12,706,206	5,249,469,000	8,073,173	0.181	0.008	0.0044	0.0002	0.285	0.012
1994[2]	23	4	239	237	13,124,315	5,478,118,000	8,238,306	0.168	0.030	0.0040	0.0007	0.267	0.049
1995	36	3	168	162	13,505,257	5,654,069,000	8,457,465	0.267	0.022	0.0064	0.0005	0.426	0.035
1996	37	5	380	350	13,746,112	5,873,108,000	8,228,810	0.269	0.036	0.0063	0.0009	0.450	0.061
1997[4]	49	4	8	6	15,838,109	6,691,693,342	10,313,826	0.309	0.025	0.0073	0.0006	0.475	0.039
1998	50	1	1	0	16,821,641	6,741,690,357	10,985,345	0.297	0.006	0.0074	0.0001	0.455	0.009
1999	52	2	12	11	17,381,999	7,032,971,162	11,092,839	0.299	0.012	0.0074	0.0003	0.469	0.018
2000[5]	54	3	92	92	18,040,000	7,134,600,000	11,587,000	0.299	0.017	0.0076	0.0004	0.466	0.026

[1]Flight hours, miles and departures are compiled by the U.S. Federal Aviation Administration.

[2] Accidents and fatalities for this year include a case of suicide/sabotage, but the case is excluded from accident rates for the year. (1986: An accident near Athens, Greece, involving an aircraft operated by Trans World Airlines resulted in four fatalities, all of which occurred aboard. 1987: An accident in San Luis Obispo, California, U.S., involving an aircraft operated by Pacific Southwest Airlines resulted in 43 fatalities, all of which occurred aboard. 1988: An accident in Lockerbie, Scotland, involving an aircraft operated by Pan American World Airways resulted in 270 fatalities, 259 of which occurred aboard. 1994: An accident in Memphis, Tennessee, U.S., involving Federal Express resulted in no fatalities.)

[3]The 62 total fatalities in 1991 include 12 people killed aboard a Skywest commuter aircraft (operating under U.S. Federal Aviation Regulations Part 135) and 22 people killed aboard a USAir transport category airplane (operating under Part 121) when the two aircraft collided.

[4]Effective March 20, 1997, the data include aircraft with 10 or more passenger seats that formerly conducted scheduled passenger operations under Part 135.

[5]Data for 2000 are preliminary.

Source: U.S. National Transportation Safety Board

substantially higher than the ETSC estimates with respect to the proportion of fatalities from fire. However, not all accidents that occurred during the study period were included in the FAA analysis.

Congress charges NTSB with investigating every civil aviation accident in the United States. An accident is defined as an "occurrence associated with the operation of an aircraft … in which any person suffers death or serious injury, or in which the aircraft receives substantial damage" (FARs Part 830.2). NTSB also is responsible for maintaining a database on civil aviation accidents. The database contains a record for, among others, every accident involving Part 121 air carriers. At the end of each calendar year, NTSB releases the data and analysis of the accident rates for that year.

For this report, NTSB conducted a review of its aviation accident/incident database to examine several aspects of occupant survival in aircraft accidents that occurred during Part 121 operations. The review examined each Part 121 accident from 1983 (the first year of NTSB's current aviation accident database) through 2000 (the last full year in the database). The numbers of accidents, fatalities and survivors for these years are given in Table 2 (page 4).

Table 2
Fatalities and Survivors in Accidents Involving U.S. Federal Aviation Regulations Part 121 Cargo and Passenger Flights, 1983–2000

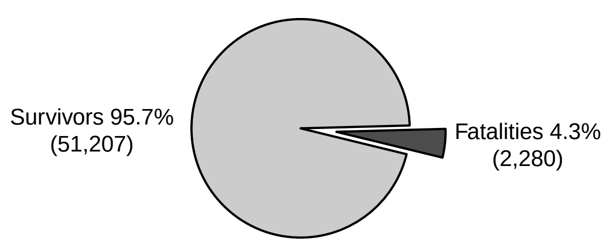
	Number of Accidents		Number of Occupants		
Year	**Total**	**Fatal**	**Total**	**Survivors**	**Fatalities**
1983	23	4	1,603	1,589	14
1984	16	1	1,530	1,526	4
1985	21	7	1,524	999	525
1986	24	3	2,599	2,592	7
1987	34	5	3,204	2,974	230
1988	30	3	3,516	3,242	274
1989	28	11	2,679	2,403	276
1990	24	6	2,264	2,252	12
1991	26	4	1,811	1,762	49
1992	18	4	1,904	1,873	31
1993	23	1	2,246	2,246	0
1994	23	4	2,305	2,068	237
1995	36	3	4,083	3,921	162
1996	37	5	3,902	3,552	350
1997	49	4	5,270	5,264	6
1998	50	1	4,550	4,550	0
1999	52	2	4,297	4,286	11
2000	54	3	4,200	4,108	92
Total	**568**	**71**	**53,487**	**51,207**	**2,280**
Percentage[1]		**12.5**		**95.7**	**4.3**

[1]Percentages have been rounded to the nearest tenth.

Source: U.S. National Transportation Safety Board

There were 568 accidents involving Part 121 air carriers from 1983 through 2000; 71 of the 568 accidents (12.5 percent) resulted in at least one occupant fatality. As Figure 1 shows, 51,207 occupants survived, whereas 2,280 occupants died in these 568 accidents. Overall for the review period, 95.7 percent of the occupants involved in a Part 121 air carrier accident survived the accident.

Percentages and Total Numbers of Survivors and Fatalities in Accidents Involving U.S. Federal Aviation Regulations Part 121 Air Carriers, 1983–2000



Source: U.S. National Transportation Safety Board

Figure 1

The number of aircraft occupant survivors and fatalities varied widely over the 18-year period (Figure 2, page 5). The percentage of fatalities was highest for 1985: Thirty-four percent of the occupants in accidents involving Part 121 operations were fatally injured. Each of the seven fatal accidents in 1985 resulted in fatal injuries to the majority of occupants. The next highest percentage (10 percent) of occupant fatalities occurred in 1989, in which each of two accidents resulted in more than 100 fatalities, and in 1994, in which three accidents resulted in fatal injuries to most of the occupants.

Because a public perception is that aviation accidents are not survivable, NTSB also examined the proportion of occupants who survived in each accident for the period 1983 through 2000. Contrary to public perception, the most likely outcome of an accident is that most people survive. In 528 of the 568 accidents (93.0 percent), more than 80 percent of the occupants survived (Figure 3, page 5). Accidents that result in complete

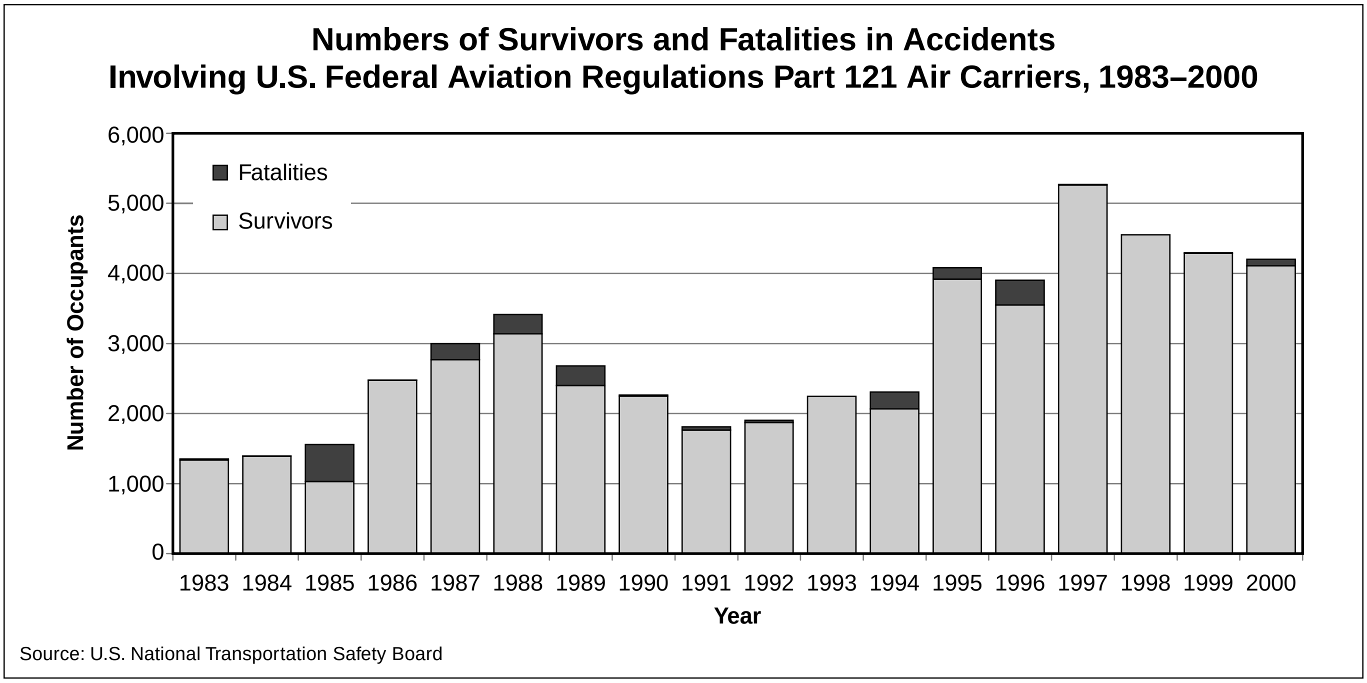


Figure 2

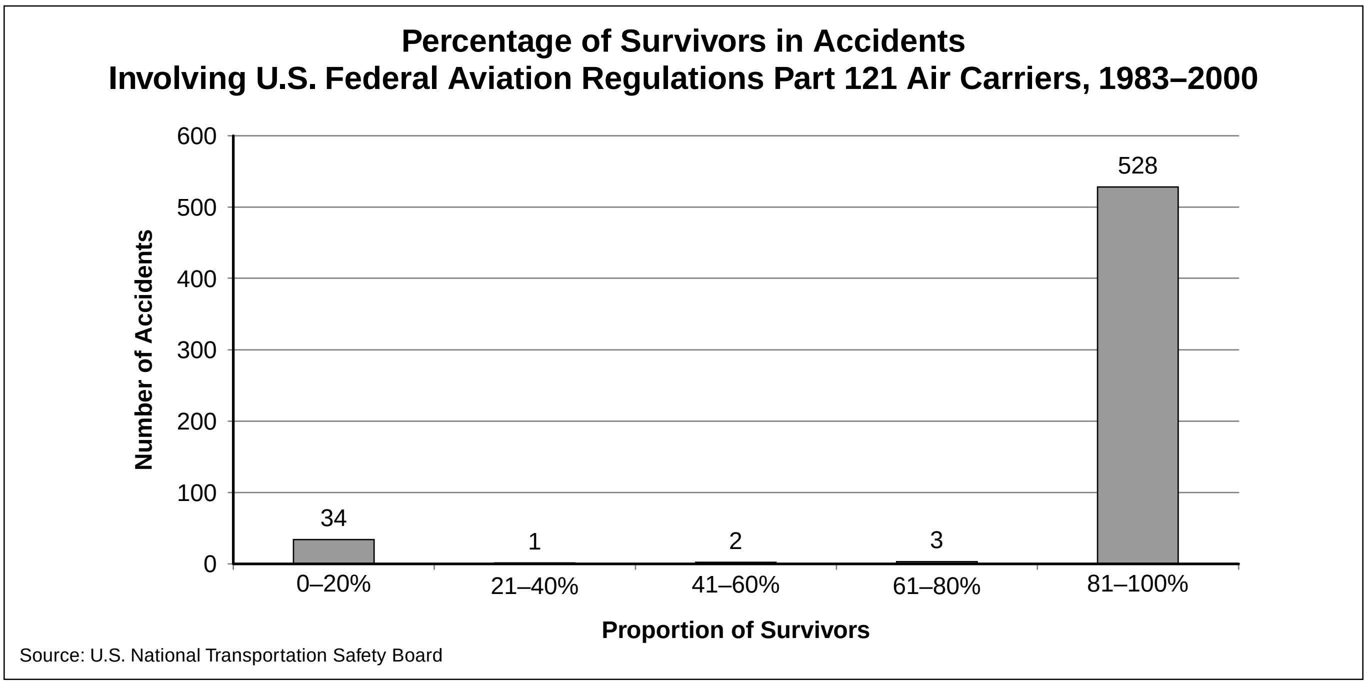


Figure 3

or near complete loss of life, such as TWA Flight 800, account for a small percentage of all accidents. Only 34 of the 568 accidents (5.9 percent) resulted in less than 20 percent of the occupants surviving.

Because in the majority of Part 121 accidents the occupants' survival was never threatened, NTSB focused on survivability in serious accidents. For the purpose of examining this subset of all Part 121 accidents, NTSB defined a serious accident as one that involved fire (pre-crash or post-crash), at least one serious injury or fatality, and either substantial aircraft damage[10] or aircraft destruction. NTSB reviewed its accident database, accident reports, public dockets and investigation files for information pertinent to determining the percentage of occupants surviving these serious accidents.[11] The cause of death, obtained from autopsy reports, represents the opinion of a pathologist or coroner authorized by the state or territory to make that determination.

From 1983 through 2000, NTSB investigated 26 accidents involving fire, serious injury and either substantial aircraft damage or aircraft destruction (Table 3). There were 2,739 occupants involved in these serious accidents; 1,524 (55.6 percent) of the occupants survived the accident, 716 (26.1 percent) of the occupants died from impact, 340 (12.4 percent) died from unknown causes,[12] 131 (4.8 percent) died from fire/smoke, and 28 (1.0 percent) died from other causes.[13] The lowest survivability rates occurred in 1985, when 11.3 percent of the occupants (30 of 265) in three accidents survived, and in 1994, when 7.8 percent of the occupants (20 of 257) in three accidents survived (Figure 4, page 7). In 1984, 1986, 1995 and 2000, there were no on-board fatalities; thus, the survivability rate was 100 percent.

NTSB also examined how many occupants survived for each of the serious accidents. The most likely outcome for these serious accidents is that most people survive the accident. In 12 of the 26 serious accidents (46.2 percent), more than 80 percent of the occupants survived (Figure 5, page 7). In nine of the 26 serious accidents (35 percent), less than 20 percent of the occupants survived.

Table 3
Fatalities and Survivors in Serious Accidents[1]
Involving U.S. Federal Aviation Regulations Part 121 Passenger Flights, 1983–2000

	Number of [2]			Number of Fatalities by Cause[3]			
Year	**Accidents**	**Occupants**	**Survivors**	**Impact**	**Fire**	**Other[4]**	**Unknown[5]**
1983	2	175	174	0	0	1	0
1984	1	39	39	0	0	0	0
1985	3	265	30	191	44	0	0
1986	1	23	23	0	0	0	0
1987	2	237	55	173	0	9	0
1988	2	148	134	0	14	0	0
1989	1	296	185	76	35	0	0
1990	1	44	36	3	5	0	0
1991	3	216	169	26	21	0	0
1992	2	343	316	9	2	16	0
1993	0	0	0	0	0	0	0
1994	3	257	20	232	5	0	0
1995	1	62	62	0	0	0	0
1996	3	489	147	0	0	2	340
1997	0	0	0	0	0	0	0
1998	0	0	0	0	0	0	0
1999	1	145	134	6	5	0	0
2000	0	0	0	0	0	0	0
Total	**26**	**2,739**	**1,524**	**716**	**131**	**28**	**340**
Percentage[6]			**55.6**	**26.1**	**4.8**	**1.0**	**12.4**

[1]A serious accident is defined as one involving a fire, at least one serious injury or fatality and either substantial aircraft damage or aircraft destruction.

[2]The number of accidents, occupants and survivors was determined from information in the aviation accident database of the U.S. National Transportation Safety Board.

[3]The number of fatalities by cause was obtained from autopsy reports. The cause of death was determined by a pathologist or coroner authorized by the state or territory to make that determination.

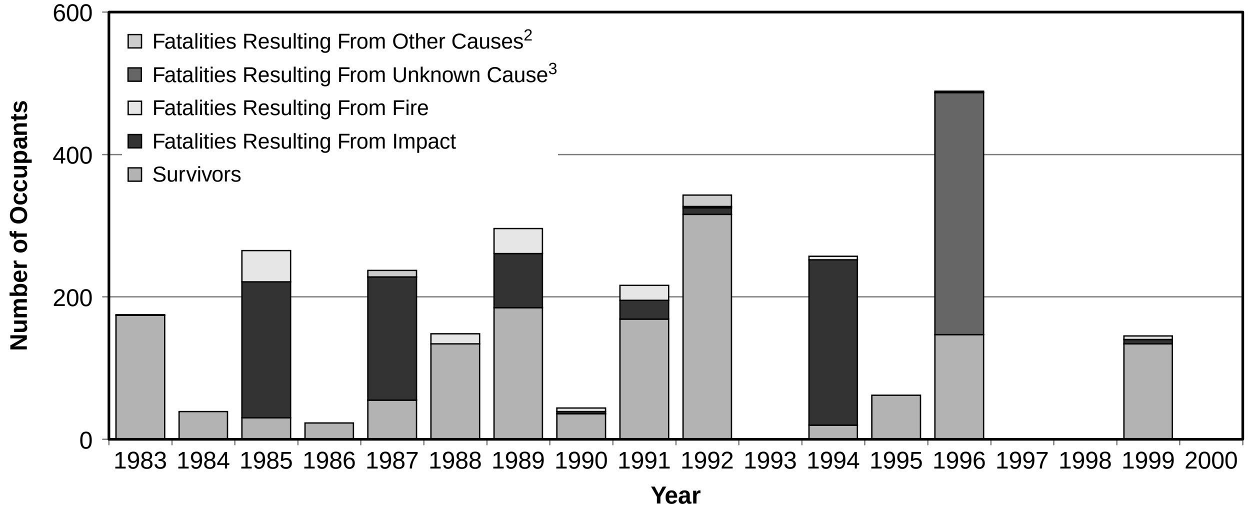
[4]Fatalities in the “other” category were reported by a pathologist or coroner to have been caused by drowning, mechanical asphyxia or trauma as a result of intrusion by engine parts or propeller parts.

[5]“Unknown cause” includes the fatalities for which a determination of the cause of death was not reported by a pathologist or coroner with sufficient specificity to classify the fatalities as impact-related, fire-related or a result of some other cause.

[6]Percentages have been rounded to the nearest tenth.

Source: U.S. National Transportation Safety Board

Causes of Fatalities Among Occupants of U.S. Federal Aviation Regulations Part 121 Passenger Flights Involved in Serious Accidents,[1] 1983–2000



[1]A serious accident is defined as one involving a fire, at least one serious injury or fatality and either substantial aircraft damage or aircraft destruction.

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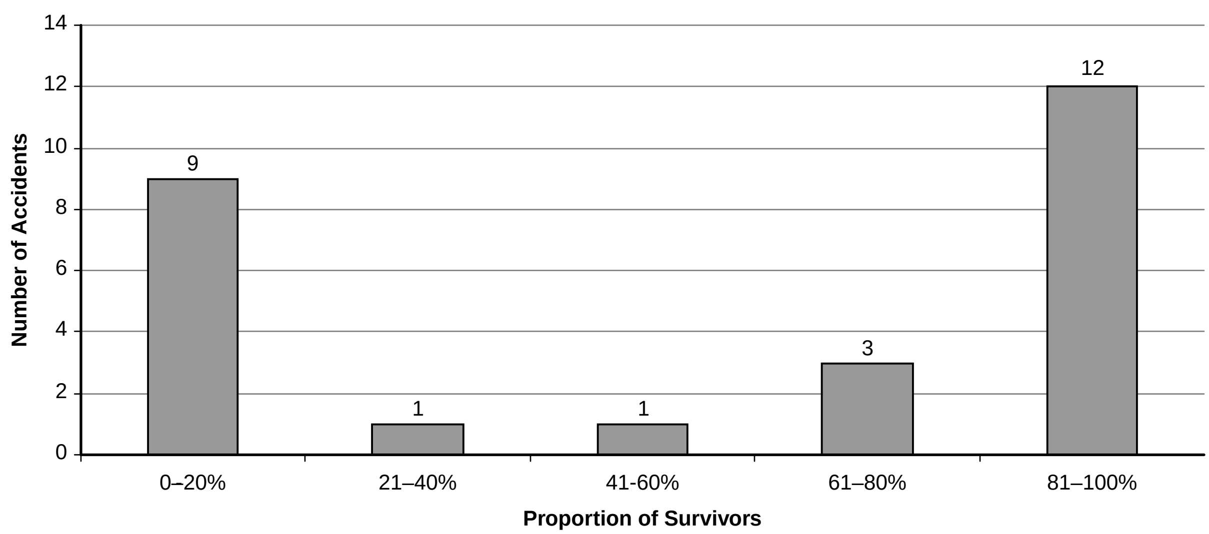
[3]"Unknown cause" includes the fatalities for which a determination of the cause of death was not reported by a pathologist or coroner with sufficient specificity to classify the fatalities as impact-related, fire-related or a result of some other cause.

Source: U.S. National Transportation Safety Board

Figure 4

Proportion of Survivors of Serious Accidents[1] Involving U.S. Federal Aviation Regulations Part 121 Passenger Flights, 1983–2000



[1]A serious accident is defined as one involving a fire, at least one serious injury or fatality and either substantial aircraft damage or aircraft destruction.

Source: U.S. National Transportation Safety Board

Figure 5

An important distinction between deaths from impact and deaths from fire is that impact deaths typically occur as a result of aircraft impact forces, whereas fire deaths typically occur after impact. In the serious accidents, there were nearly five times more impact fatalities than fire-related fatalities. The high proportion of impact-to-fire fatalities is the result of the inclusion of a number of unsurvivable accidents in the subset. For an accident to be deemed survivable, the forces transmitted to occupants through their seat and restraint system cannot exceed the limits of human tolerance to abrupt accelerations, and the structure in the occupants' immediate environment must remain substantially intact to the extent that a livable volume is provided for the occupants throughout the crash. Using this definition of a survivable accident, NTSB examined accident reports and determined that seven of the 26 serious accidents were not survivable because of the impact forces (see the shaded rows in Table 4, page 9).

Nineteen of the 26 serious accidents involving Part 121 air carriers were at least partially survivable, as indicated in accident reports; 1,523 (76.6 percent) of the 1,988 occupants in these accidents survived, 306 (15.4 percent) of the occupants died from impact, 131 (6.6 percent) died from fire, and 28 (1.4 percent) died from other causes (Table 5, page 10). In the survivable serious accidents, more than twice as many occupants died as a result of impact forces than as a result of fire. Figure 6 (page 11) shows the cause-of-death data by year for the survivable serious accidents.

As is the case with all Part 121 accidents, the most likely outcome for the serious survivable accidents is that most occupants survive. In 12 of the 19 serious accidents that were survivable (63.2 percent), more than 80 percent of the occupants survived (Figure 7, page 11). In two of the 19 serious accidents that were survivable (10.5 percent), less than 20 percent of the occupants survived.

Discussion

Nearly 96 percent of the occupants involved in a Part 121 aviation accident over the past 18 years survived the accident, and in more than 46 percent of the most serious of these accidents (accidents involving fire, serious injury and either substantial aircraft damage or aircraft destruction), more than 80 percent of the occupants survived. Although catastrophic accidents such as TWA Flight 800 result in fatalities to all occupants, such accidents are the exception. The large number of people who survive even the most serious accidents emphasizes the importance of work aimed at ensuring that accident survivors can safely remove themselves from the accident aircraft.

Even in the 19 survivable Part 121 accidents involving fire, occupants were much more likely to die from impact forces than from the effects of fire. These results indicate lower fire-related fatalities than both the ETSC estimates and the FAA research. The difference between the ETSC estimates and the NTSB findings may reflect differences in the aviation system in the United States, compared with worldwide aviation systems examined for the ETSC estimates. Further, these differences could be the result of differences in the criteria for selecting accidents by which to examine survivability data.

Surviving an accident is the result of many factors. The large number of survivors reflects the efforts of industry and government to ensure passenger safety. Cabin structural integrity, seat belts, seat design, child restraint systems and brace positions can increase a person's likelihood of surviving an impact. Fire retardancy, exit design, aircraft configuration and evacuation procedures can assist a person in escaping from an airplane after an accident. Over the last decade, air travelers have been provided improvements in many of these areas.

NTSB recommendations have been the impetus for many of these improvements in occupant protection, including fire detection and suppression systems in lavatories and cargo compartments, modifications in cargo compartments to delay fires from spreading, and fire blocking of cabin and seat materials that prevents fires from spreading.[14] NTSB also recommended floor-level escape lighting systems and heat-resistant slides to improve occupant escape paths and recommended improvements for the crashworthiness of passenger seats.

In addition to aircraft design, passenger education plays a crucial role in increasing occupant survival. The FAA requires that passengers receive a preflight briefing and safety card regarding aircraft safety systems. However, many airplane occupants do not pay attention to the preflight briefing, and more than two-thirds never examine the safety briefing card.[15] The FAA emphasizes the importance of these safety briefings directly to the public through documents such as "Fly Smart: An Air Traveler's Guide."[16]

One reason passengers do not pay attention to the briefing may be their belief that accidents are not survivable.[17] Public perceptions of survivability may be substantially lower than the actual rate of 95.7 percent for all Part 121 accidents. Empowered with the knowledge of aircraft accident survivability rates, passengers may take additional steps to improve their chances of survival, including planning exit routes, paying attention to safety briefings and reading safety cards.

Findings

- In all accidents involving Part 121 operations from 1983 through 2000, 51,207 occupants (95.7 percent) survived, whereas 2,280 occupants died;

Table 4
Fatalities and Survivors in All Serious Accidents[1] Involving U.S. Federal Aviation Regulations Part 121 Passenger Flights, 1983–2000

			Number of[2]			Number of Fatalities by Cause[3]			
Date of Accident	Location of Accident	Airplane Type	Occupants	Survivors	Fatalities	Impact	Fire	Other[4]	Unknown[5]
01/09/83	Brainerd, Minnesota	Convair 580-11-A	33	32	1	0	0	1	0
06/11/83	Chicago, Illinois	Boeing 727-222A	142	142	0	0	0	0	0
12/16/84	Jasper, Alabama	Convair 440	39	39	0	0	0	0	0
01/21/85	Reno, Nevada	Lockheed 188C	71	1	70	26	44	0	0
08/02/85	Dallas-Fort Worth, Texas	Lockheed L-1011-385-1	163	29	134	134	0	0	0
09/06/85	Milwaukee, Wisconsin	McDonnell Douglas DC-9-14	31	0	31	31	0	0	0
11/06/86	Tampa, Florida	Boeing 727-235	23	23	0	0	0	0	0
08/16/87	Romulus, Michigan	McDonnell Douglas DC-9-82	155	1	154	154	0	0	0
11/15/87	Denver, Colorado	McDonnell Douglas DC-9-14	82	54	28	19	0	9	0
04/15/88	Seattle, Washington	De Havilland DHC Dash 8	40	40	0	0	0	0	0
08/31/88	Dallas-Fort Worth, Texas	Boeing 727-232	108	94	14	0	14	0	0
07/19/89	Sioux City, Iowa	McDonnell Douglas DC-10-10	296	185	111	76	35	0	0
12/03/90	Romulus, Michigan	McDonnell Douglas DC-9-14	44	36	8	3	5	0	0
02/01/91	Los Angeles, California	Boeing 737-300	89	67	22	1	21	0	0
03/03/91	Colorado Springs, Colorado	Boeing 737-291	25	0	25	25	0	0	0
05/05/91	Atlanta, Georgia	McDonnell Douglas MD-88	102	102	0	0	0	0	0
03/22/92	La Guardia Airport, Flushing, New York	Fokker 28-4000	51	24	27	9	2	16	0
07/30/92	John F. Kennedy International Airport, Jamaica, New York	Lockheed L-1011-385-1	292	292	0	0	0	0	0
07/02/94	Charlotte, North Carolina	McDonnell Douglas DC-9-31	57	20	37	32	5	0	0
09/08/94	Aliquippa, Pennsylvania	Boeing 737-300	132	0	132	132	0	0	0
10/31/94	Roselawn, Indiana	Avions de Transport Regional (ATR) 72-212	68	0	68	68	0	0	0
06/08/95	Atlanta, Georgia	McDonnell Douglas DC-9-32	62	62	0	0	0	0	0
05/11/96	Everglades, Miami, Florida	McDonnell Douglas DC-9-32	110	0	110	0	0	0	110
07/06/96	Pensacola, Florida	McDonnell Douglas MD-88	149	147	2	0	0	2	0
07/17/96	East Moriches, New York	Boeing 747-131	230	0	230	0	0	0	230
06/01/99	Little Rock, Arkansas	McDonnell Douglas MD-82	145	134	11	6	5	0	0
Total			**2,739**	**1,524**	**1,147**	**716**	**131**	**28**	**340**

Note: An unshaded row indicates that the accident was survivable. A shaded row indicates that the accident was not survivable.

[1]A serious accident is defined as one involving a fire, at least one serious injury or fatality and either substantial aircraft damage or aircraft destruction.

[2]The number of occupants, survivors and fatalities was determined from information in the aviation accident database of the U.S. National Transportation Safety Board.

[3]The number of fatalities by cause was obtained from autopsy reports. The cause of death was determined by a pathologist or coroner authorized by the state or territory to make that determination.

[4]Fatalities in the "other" category were reported by a pathologist or coroner to have been caused by drowning, mechanical asphyxia or trauma as a result of intrusion by engine parts or propeller parts.

[5]"Unknown cause" includes the fatalities for which a determination of the cause of death was not reported by a pathologist or coroner with sufficient specificity to classify the fatalities as impact-related, fire-related or a result of some other cause.

Source: U.S. National Transportation Safety Board

Table 5
Fatalities and Survivors in Serious[1] but Survivable[2] Accidents Involving U.S. Federal Aviation Regulations Part 121 Passenger Flights

	Number of[3]			Number of Fatalities by Cause[4]			
Year	**Accidents**	**Occupants**	**Survivors**	**Impact**	**Fire**	**Other[5]**	**Unknown[6]**
1983	2	175	174	0	0	1	0
1984	1	39	39	0	0	0	0
1985	2	234	30	160	44	0	0
1986	1	23	23	0	0	0	0
1987	1	82	54	19	0	0	9
1988	2	148	134	0	14	0	0
1989	1	296	185	76	35	0	0
1990	1	44	36	3	5	0	0
1991	2	191	169	1	21	0	0
1992	2	343	316	9	2	16	0
1993	0	0	0	0	0	0	0
1994	1	57	20	32	5	0	0
1995	1	62	62	0	0	0	0
1996	1	149	147	0	0	2	0
1997	0	0	0	0	0	0	0
1998	0	0	0	0	0	0	0
1999	1	145	134	6	5	0	0
2000	0	0	0	0	0	0	0
Total	**19**	**1,988**	**1,523**	**306**	**131**	**28**	**0**
Percentage[7]			**76.6**	**15.4**	**6.6**	**1.4**	**0**

[1]A serious accident is defined as one involving a fire, at least one serious injury or fatality and either substantial aircraft damage or aircraft destruction.

[2]A survivable accident is defined as one in which the forces transmitted to occupants through their seat and restraint system do not exceed the limits of human tolerance to abrupt acceleration and in which the structure in the occupants' immediate environment remains substantially intact to the extent that a livable volume is provided for the occupants throughout the accident.

[3]The number of accidents, occupants and survivors was determined from information in the aviation accident database of the U.S. National Transportation Safety Board.

[4]The number of fatalities by cause was obtained from autopsy reports. The cause of death was determined by a pathologist or coroner authorized by the state or territory to make that determination.

[5]Fatalities in the "other" category were reported by a pathologist or coroner to have been caused by drowning, mechanical asphyxia or trauma as a result of intrusion by engine parts or propeller parts.

[6]"Unknown cause" includes the fatalities for which a determination of the cause of death was not reported by a pathologist or coroner with sufficient specificity to classify the fatalities as impact-related, fire-related or a result of some other cause.

[7]Percentages have been rounded to the nearest tenth.

Source: U.S. National Transportation Safety Board

- In 528 (93.0 percent) of the 568 accidents involving Part 121 operations from 1983 to 2000, more than 80 percent of the occupants survived;

- In serious Part 121 accidents (those involving fire, serious injury and either substantial aircraft damage or aircraft destruction), there were 2,739 occupants; 1,524 (55.6 percent) of those occupants survived;

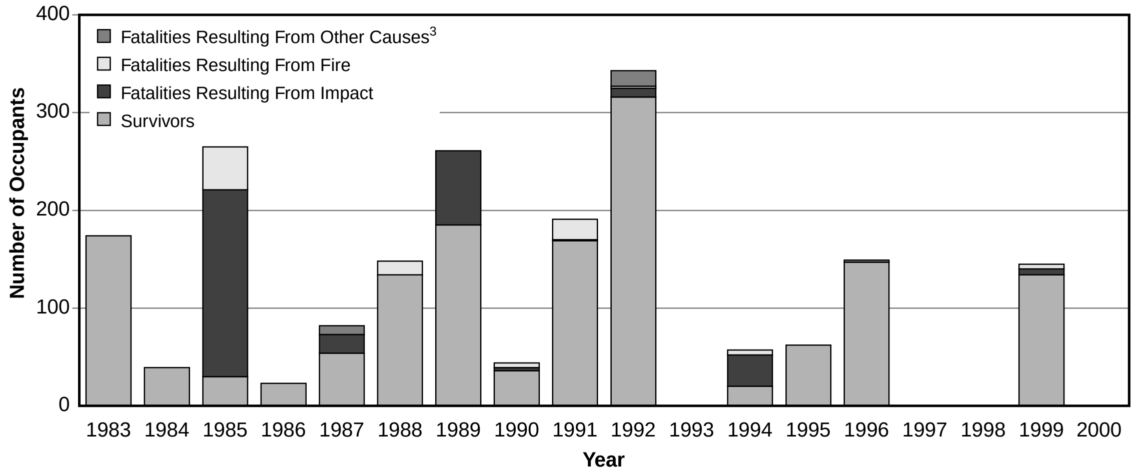
- In 12 (46.2 percent) of the 26 serious Part 121 accidents from 1983 through 2000, more than 80 percent of the occupants survived;

- In serious Part 121 accidents from 1983 through 2000, there were nearly five times more impact fatalities than fire-related fatalities;

- In serious Part 121 accidents from 1983 through 2000 that were categorized as survivable, 1,523 of the 1,988 occupants (76.6 percent) survived;

- In serious Part 121 accidents from 1983 through 2000 that were categorized as survivable, more than twice as many occupants died as a result of impact forces than as a result of fire;

Causes of Fatalities Among Occupants of U.S. Federal Aviation Regulations Part 121 Passenger Flights Involved in Serious[1] but Survivable[2] Accidents, 1983–2000



[1]A serious accident is defined as one involving a fire, at least one serious injury or fatality and either substantial aircraft damage or aircraft destruction.

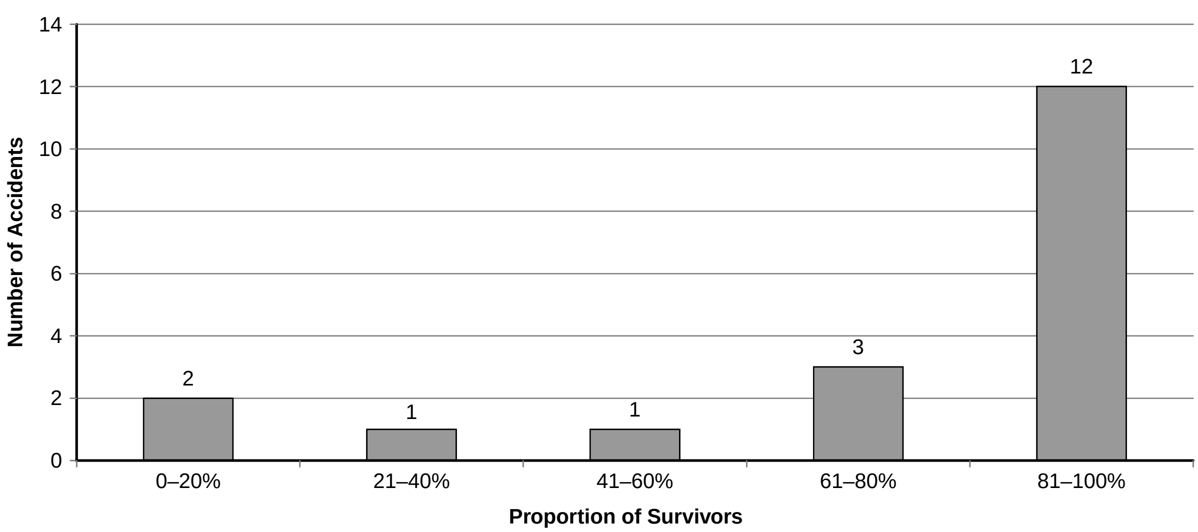
[2]A survivable accident is defined as one in which the forces transmitted to occupants through their seat and restraint system do not exceed the limits of human tolerance to abrupt acceleration and in which the structure in the occupants' immediate environment remains substantially intact to the extent that a livable volume is provided for the occupants throughout the accident.

[3]Fatalities in the "other" category were reported by a pathologist or coroner to have been caused by drowning, mechanical asphyxia or trauma as a result of intrusion by engine parts or propeller parts.

Source: U.S. National Transportation Safety Board

Figure 6

Proportion of Survivors of Serious[1] but Survivable[2] Accidents Involving U.S. Federal Aviation Regulations Part 121 Air Carriers, 1983–2000



[1]A serious accident is defined as one involving a fire, at least one serious injury or fatality and either substantial aircraft damage or aircraft destruction.

[2]A survivable accident is defined as one in which the forces transmitted to occupants through their seat and restraint system do not exceed the limits of human tolerance to abrupt acceleration and in which the structure in the occupants' immediate environment remains substantially intact to the extent that a livable volume is provided for the occupants throughout the accident.

Source: U.S. National Transportation Safety Board

Figure 7

- In 12 (63.2 percent) of the 19 serious Part 121 accidents from 1983 through 2000 that were categorized as survivable, more than 80 percent of the occupants survived; and,

- Public perception of survivability may be substantially lower than the actual rate of 95.7 percent for all Part 121 accidents.♦

[FSF editorial note: To ensure wider distribution in the interest of aviation safety, this report has been reprinted from the U.S. National Transportation Safety Board's *Survivability of Accidents Involving Part 121 U.S. Air Carrier Operations, 1983 Through 2000*, NTSB/SR-01/01, March 5, 2001. Some editorial changes were made by FSF staff for clarity and for style.]

Notes and References

1. U.S. Department of Transportation, Federal Aviation Administration. *FAA Aerospace Forecasts*, FAA-APO-00-1 (Washington, D.C.: FAA, 2000) X-13.

2. For example, the U.S. Federal Aviation Administration's (FAA's) Safer Skies initiative with industry, which seeks to reduce the fatal accident rate by 80 percent by the year 2007.

3. U.S. National Transportation Safety Board (NTSB). *In-flight Breakup Over the Atlantic Ocean, Trans World Airlines (TWA) Flight 800, Boeing 747-141, N93119, Near East Moriches, New York, July 17, 1996*, Aviation Accident Report NTSB/AAR-00/03 (Washington, D.C.: NTSB, 2001).

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5. On Oct. 31, 1999, EgyptAir flight 990, a scheduled international flight from New York, New York, U.S., to Cairo, Egypt, struck the Atlantic Ocean about 60 miles south of Nantucket Island, Massachusetts, U.S. All 217 occupants were killed. The accident occurred in international waters; thus Egypt, under Annex 13 to the Convention on International Civil Aviation, had authority to conduct or delegate the investigation. In accordance with the standards of the Convention, Egypt requested that the United States conduct the investigation of the accident; NTSB, on behalf of the United States, accepted responsibility to conduct the investigation.

6. P.J. Fennell; H.C. Muir. *Passenger Attitudes Towards Airline Safety Information and Comprehension of Safety Briefings and Cards*, CAA Paper 92015 (London: Civil Aviation Authority, 1992).

7. In June 1980, NTSB produced a similar report for testimony to the U.S. House subcommittee on oversight and review of the Public Works and Transportation Committee of the 96th Congress.

8. European Transport Safety Council (ETSC). *Increasing the Survival Rate in Aircraft Accidents: Impact Protection, Fire Survivability, and Evacuation* (Brussels, Belgium: ETSC, 1996).

9. "CAMI [Civil Aeromedical Institute] Helps Flyers Survive Aircraft Accidents," *Headquarters Intercom* March 17 (1998): 1–2 (Washington, D.C.: Federal Aviation Administration). The FAA's results were also reported by the following publication: *Surviving the Crash: The Need to Improve Lifesaving Measures at Our Nation's Airports* (Washington, D.C.: Coalition for Airport and Airplane Passenger Safety [CAAPS], 1999). The CAAPS report incorrectly attributes the research to NTSB.

10. Substantial damage is defined in U.S. Federal Aviation Regulations (FARs) Part 830.2 as damage or failure which adversely affects the structural strength, performance, or flight characteristics of the aircraft, and would normally require major repair or replacement of the affected equipment.

11. NTSB's analysis of occupant survivability excluded accidents that had not been investigated by NTSB. Part 121 fatal accidents not investigated by NTSB but documented in the NTSB database include the Dec. 20, 1995, crash of an American Airlines Boeing 757 in Cali, Colombia, and the Dec. 12, 1985, crash of an Arrow Airways DC-8 in Gander, Newfoundland, Canada.

12. Autopsy reports did not specify cause of death for the occupants in the 1996 accidents involving TWA Flight 800 and ValuJet Flight 592.

13. Fatalities in the "other" category were caused either by drowning, mechanical asphyxia or trauma as a result of intrusion by engine parts or propeller parts.

14. NTSB. *We Are All Safer* (Washington, D.C.: NTSB, 1998).

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16. Online posting accessed Oct. 13, 2000 <http://www.asy.faa.gov/asy-internet/flysmart>.

17. ETSC. *Increasing the Survival Rate in Aircraft Accidents: Impact Protection, Fire Survivability, and Evacuation* (Brussels, Belgium: ETSC, 1996).

Further Reading From FSF Publications

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FSF Editorial Staff. "Timely Detection, Response Improve Outcomes of In-flight Fire Fighting." *Cabin Crew Safety* Volume 36 (March–April 2001).

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Barnett, Arnold; Wang, Alexander. "Passenger-mortality Risk Estimates Provide Perspectives About Airline Safety." *Flight Safety Digest* Volume 19 (April 2000).

Waldock, William D. "Uniform Materials Affect Flight Attendant Safety and Ability to Help Passengers Evacuate Burning Aircraft." *Cabin Crew Safety* Volume 33 (March–April 1999).

FSF Editorial Staff. "Analysis of Training for Emergency Water Landings Questions Assumptions, Inconsistencies." *Cabin Crew Safety* Volume 33 (November–December 1998).

FSF Editorial Staff. "European Report Recommends Smoke Hoods for Passengers." *Cabin Crew Safety* Volume 33 (January–February 1998).

Koenig, Robert L. "Exit-locating Devices, Aircraft Structural Strengthening and Improved Crew Drills Called 'Most Practicable' Accident-survivability Factors." *Cabin Crew Safety* Volume 32 (January–February 1997).

Sarkos, C.P. "FAA Proposes New Rules on Cargo Compartment Fire Detection and Suppression." *Cabin Crew Safety* Volume 31 (November–December 1996).

Koenig, Robert L. "U.S. Reports Examine New Tools Aimed at Improving Survival Rates in Aircraft Fires." *Cabin Crew Safety* Volume 30 (September–October 1995).

FSF Editorial Staff. "Getting Out Alive — Would Smoke Hoods Save Airline Passengers or Put Them at Risk?" *Cabin Crew Safety* Volume 28 (November–December 1993) and Volume 29 (January–February 1994).

Data Show 391 Accidents Among Western-built Large Commercial Jets From 1991 Through 2000

More than 70 percent of the accidents involved passenger operations; 60 percent of the accidents were hull-loss accidents and/or fatal accidents in which 7,078 people were killed.

FSF Editorial Staff

Data compiled by The Boeing Co. show that 391 accidents occurred among Western-built large commercial jets from 1991 through 2000 and that 1,276 accidents occurred from 1959 through 2000 (Table 1, page 15).

Of the accidents during the 1991–2000 period, 235 were hull loss and/or fatal accidents involving 7,078 fatalities. (Boeing defines a "hull-loss" accident as an accident that involves damage to an airplane that is substantial and beyond economic repair. Boeing also classifies an accident as a hull-loss accident if the airplane is missing, if the wreckage has not been found and the search has been terminated, or if the airplane is substantially damaged and is inaccessible.) For the 1959–2000 period, 735 accidents were hull-loss/fatal accidents involving 24,396 fatalities.

The Boeing data include Western-built large commercial jet airplanes with maximum gross weights of more than 60,000 pounds/27,000 kilograms. The data exclude airplanes manufactured in the Commonwealth of Independent States because of a lack of operational data. Commercial airplanes in military service also are excluded.

Of the 235 hull-loss/fatal accidents that occurred during the 1991–2000 period, 171 (nearly 73 percent) involved passenger airplanes; 54 accidents (23 percent) involved cargo airplanes, and 10 accidents (4 percent) involved airplanes on ferry flights or test flights or those being used in training or in demonstration flights. For the period from 1959 through 2000, 564 of the 735 hull-loss/fatal accidents (nearly 77 percent) involved passenger airplanes; 111 accidents (15 percent) involved cargo airplanes, and 60 accidents (8 percent) involved airplanes on ferry flights or test flights or those being used in training or in demonstration flights.

Figure 1 (page 15) shows that, of the 1,276 accidents from 1959 through 2000, 661 accidents, including 413 fatal accidents, were hull-loss accidents, and 526 accidents, including 18 fatal accidents, were substantial damage accidents. Boeing defines substantial damage as "damage or structural failure that adversely affects the structural strength, performance or flight characteristics of the airplane and would normally require major repair or replacement of the affected component." The data also show that 89 accidents, including 56 fatal accidents, were personal-injury accidents with less than substantial damage.

Table 1
Accident Summary by Type of Operation,

Western-built Large Commercial Jet Airplanes*

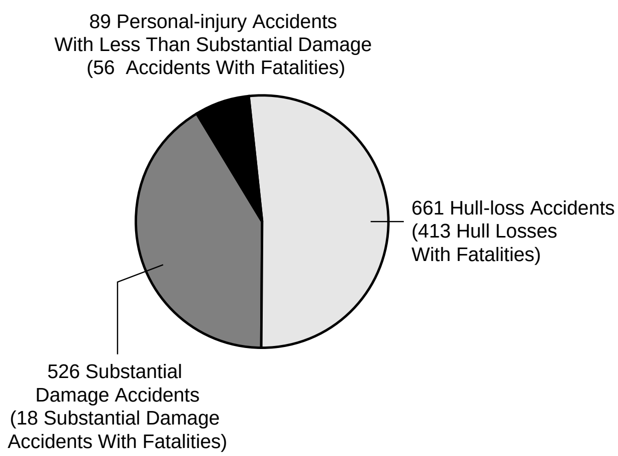
Type of Operation	All Accidents 1959–2000	All Accidents 1991–2000	Hull-loss and/or Fatal Accidents 1959–2000	Hull-loss and/or Fatal Accidents 1991–2000	On-board Fatalities 1959–2000	On-board Fatalities 1991–2000
Passenger	1,015	302	564	171	23,995	6,981
Cargo	159	74	111	54	212	63
Ferry, test, training and demonstration	102	15	60	10	189	34
Total	**1,276**	**391**	**735**	**235**	**24,396**	**7,078**

*Heavier than 60,000 pounds/27,000 kilograms maximum gross weight; excludes airplanes manufactured in the Commonwealth of Independent States and commercial airplanes in military service.

Source: The Boeing Co.

Accident Summary By Damage and Injury

All Accidents
Western-built Large Commercial Jet Airplanes*
1959–2000



Excludes:

- Fatal injuries from natural causes or suicide;
- Experimental test flights;
- Military airplanes;
- Sabotage, hijacking, terrorism or military actions; and,
- Nonfatal injuries involving:
  - Atmospheric turbulence, maneuvering or loose objects;
  - Boarding, disembarking or evacuation;
  - Maintenance and servicing; and,
  - Persons not on board the airplane.

*Heavier than 60,000 pounds/27,000 kilograms maximum gross weight; excludes airplanes manufactured in the Commonwealth of Independent States and commercial airplanes in military service.

Source: The Boeing Co.

Figure 1

Table 2 shows the primary causes found by investigative authorities in 146 hull-loss accidents in 1991–2000. In 66 percent of the 146 accidents, the primary cause involved the flight crew.

The Boeing data showed that the accident rate was 0.71 accidents per 1 million departures for hull-loss/fatal accidents from 1991 through 2000 for scheduled passenger operations. The rate of hull-loss/fatal accidents was 5.82 accidents per 1 million departures for other operations, including unscheduled passenger flights and cargo flights, ferry flights, test flights, training flights and demonstration flights.♦

Table 2
Hull-loss Accidents by Primary Cause[1]

Western-built Large Commercial Jet Airplanes[2]
1991–2000

Primary Cause	Number of Accidents	Percentage of Accidents
Flight crew	96	66%
Airplane	19	13%
Weather	12	8%
Maintenance	7	5%
Miscellaneous/other	7	5%
Airport/air traffic control	5	3%
Total with known causes	**146**	**100%**
Unknown or awaiting reports	65	
Total	**211**	

[1]As determined by investigative authority.

[2]Heavier than 60,000 pounds/27,000 kilograms maximum gross weight; excludes airplanes manufactured in the Commonwealth of Independent States and commercial airplanes in military service.

Source: The Boeing. Co.

Publications Received at FSF Jerry Lederer Aviation Safety Library

ATSB Report Describes Investigation of Contaminated Avgas in Eastern Australia

Investigators believed that deficiencies identified in their review of the contamination of aviation gasoline had the potential to affect the quality of other aviation fuels, including Jet A-1, typically used in operations of turbine aircraft.

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Reports

Systemic Investigation into Fuel Contamination. Australian Department of Transport and Regional Services, Australian Transport Safety Bureau (ATSB). March 2001. 90 pp. Figures, appendixes. Available from ATSB.*

ATSB is responsible for investigating accidents, serious incidents and safety deficiencies involving civil aircraft operations in Australia and Australian-registered aircraft operating outside Australia. ATSB's primary focus is the safety of commercial air transport operations and commercial air passenger operations. ATSB also conducts studies and investigations of factors that could affect aviation safety.

This report provides the background and conclusions of an ATSB investigation that was an expansion of an earlier investigation of contaminated aviation-grade gasoline (avgas) used by piston-engine aircraft in eastern Australia. The investigation team believed that deficiencies identified in the avgas-contamination investigation had the potential to affect the quality of other aviation fuels, such as Jet A-1, typically used in turbine aircraft. Deficiencies in engine reliability resulting from the use of contaminated fuel have the potential for causing accidents.

The final report describes manufacturing practices, fuel standards and oversight of fuel quality in Australia and includes recommendations for change. One group of recommendations addresses the development and management of manufacturing processes and procedures to produce avgas. The second group of recommendations relates to the development and use of international standards for avgas. ATSB issued several recommendations about regulatory oversight of fuel quality, appropriate lines of communication among regulatory bodies and clarification of the responsibilities of governing organizations.

Assessment of Head-Injured Aircrew: Comparison of FAA and USAF Procedures. Fiedler, E.; Orme, D.; Mills, W.; Patterson, J. U.S. Federal Aviation Administration (FAA) Office of Aerospace Medicine. DOT/FAA/AM-01/11. July 2001. 10 pp. Tables. Available through NTIS.**

Head injury or traumatic brain injury (TBI) frequently results in symptoms that are of aeromedical concern. Head injuries can be disqualifying for civilian pilots and military pilots.

Symptoms typically associated with TBI affect three major neuropsychiatric areas. Cognitive difficulties may appear as slowed information processing, reduced concentration and memory problems. Emotional changes include anxiety, depression and exaggerated emotional responsiveness. TBI patients may have reduced executive functioning, such as deficiencies in self-awareness, planning skills and impulse control. Other symptoms are focal problems and post-traumatic epilepsy.

The FAA (civil aviation) and the U.S. Air Force (military aviation) have similar responsibilities for determining whether pilots who have sustained head injuries are medically qualified to return to flying. This report explains major differences and similarities of responsibilities, procedures and rules of the two organizations. For example, one major difference is organizational mission. FAA makes decisions about medical qualifications for licenses that will remain in effect for specific periods of time. The Air Force makes decisions based upon military readiness and unexpected deployment. FAA depends upon community physicians designated by FAA to complete the medical examination of civilian pilots; when an examination by a medical specialist is required, civilian pilots may select the specialists. Medical management of military pilots is the responsibility of military flight surgeons.

Books

The Pilot's Guide to the Modern Airline Cockpit. Casner, Stephen M. Ames, Iowa, U.S.: Iowa State University Press, 2001. 153 pp.

The pilot's guide provides an introduction to cockpit automation and is written for pilots preparing to enter company-sponsored airline training programs. The author focuses on the fundamentals of cockpit automation and describes how commercial multi-engine instrument pilots should integrate technology with their experiences. Readers are introduced to automation in terms of duties performed during each phase of flight. The text is supported with illustrations and is designed to be used alone or with simulator programs developed for personal computers.

Practical Aviation Law. Hamilton, J. Scott. 3rd edition. Ames, Iowa, U.S.: Iowa State University Press, 2001. 290 pp.

The author wrote this book as a reference guide for aviation managers, pilots, air traffic controllers, aviation safety inspectors, mechanics, aircraft owners and others involved in aviation as a vocation or avocation. The scope of the book is limited to U.S. aviation law, except for some treaties that have worldwide implications or international implications. The author, a pilot and lawyer, provides readers with the basic legal knowledge and perspective to understand how the aviation legal system works, to recognize and avoid common legal pitfalls and to know when to engage legal counsel. Chapters cover administrative law (regulatory, enforcement and medical); aircraft accidents (liability, insurance, investigation and reporting); aircraft transactions (buying, selling and leasing); airports and airspace (terminal and en route airspace); and labor and employment law (in general and specifically as related to airlines). In its third edition, the book highlights changes that have occurred in statutory and regulatory law since publication of the previous edition.

The World's Most Significant and Magnificent Aircraft: Evolution of the Modern Airplane. Thurston, David B. Warrendale, Pennsylvania, U.S.: Society of Automotive Engineers, 2000. 262 pp.

The author reviews principal aircraft that "represent a significant contribution to the development and evolution of the airplane as we know it today." The author, with more than 60 years of design and manufacturing experience in the aircraft industry, limited his selection to 136 airplanes that "contributed to the advancement of design in either important retail refinement, power plant, major production or flight concept." The book is divided into seven parts representing specific stages of airplane development, and the order of presentation approximates initial flight dates. Also included are a glossary of aviation terms, photographs, drawings, figures and tables of performance and comparative data.

World Air Transport Statistics. International Air Transport Association (IATA). 45th edition. Montreal, Canada: IATA Aviation Information and Research Department, 2001. 154 pp.

World Air Transport Statistics (WATS) is an annual compilation of IATA airline member data. The book includes global airline traffic trend data and financial results from the International Civil Aviation Organization, World Tourism Organization and Airports Council International, along with summary analysis of air transport industry trends. Both domestic and international operational information on individual member airlines is provided; the information includes fleet descriptions and fleet utilization, numbers of passengers and amount of freight carried, number of aircraft departures and number of kilometers and hours flown.

Winged Life: A Biography of David Beaty. Beaty, Betty Campbell. Shrewsbury, England: Airlife Publishing, 2001. 256 pp.

David Beaty's biographer (his widow) tells his life story from birth through his many professional accomplishments to his death from cancer. David Beaty was a decorated pilot in the Royal Air Force. Later, he investigated civil air-to-air refueling and helped develop postwar trans-Atlantic aviation service. Beaty was a pioneer in examining the significance of human factors in aircraft accidents. His efforts led to significant improvements in accident investigation and in airline safety. He also wrote 24 novels, most of which involved aviation.

Regulatory Materials

Guidance to Examiners: Multi-Pilot Aeroplanes (MPA), Type Rating Skill Tests and Proficiency Checks. United Kingdom (U.K.) Civil Aviation Authority (CAA), Flight Operations Department, Operator Training Standards. Standards document 24, version 3.1. June 6, 2001. Appendixes. 22 pp. Available from SRG.***

The U.K. CAA issues flight crew licenses and ratings in accordance with the Joint Aviation Requirements for Flight Crew Licensing (JAR-FCL). CAA authorizes "suitably experienced and qualified pilots as examiners" to conduct skill tests and proficiency checks to ensure that pilots are qualified "by reason of knowledge, competence and skill to hold the appropriate license or rating." This document provides guidance to examiners conducting skills tests and proficiency checks of applicants who are members of flight crews in multi-pilot airplanes flying under U.K. and JAR-FCL licensing rules. Appendixes discuss testing standards and performance criteria for pilots. Future amendments will appear on the SRG Web site at http://www.srg.caa.co.uk.

Change 13 to Standards for Specifying Construction of Airports. U.S. Federal Aviation Administration (FAA) Advisory Circular (AC) 150/5370-10A. Jan. 30, 2001. Table. 14 pp. Available through GPO.****

This AC provides standards for construction of U.S. airports. The standards address materials and methods used in the construction of airports, including earthwork, drainage, paving, turfing, lighting and incidental construction. Compliance with these standards is recommended by FAA, but is mandatory for federally funded projects. Change 13 updates material specifications for pipe for storm drains and culverts. It updates material specifications for pipe underdrains for airports and adds standards for filter fabric.

Hydraulic System Certification Tests and Analysis. U.S. Federal Aviation Administration (FAA) Advisory Circular (AC) 25.1435-1. May 21, 2001. 7 pp. Available through GPO.****

The AC provides guidance material for complying with airworthiness standards for transport category airplanes with hydraulic system requirements. The advisory material in this AC was developed by the Hydraulic Systems Harmonization Working Group to ensure consistent application of revised standards by FAA and the Joint Aviation Authorities. [This working group comprised industry hydraulic systems specialists and government hydraulic systems specialists from Canada, Europe and the United States.]

Shock Absorption Tests. U.S. Federal Aviation Administration Advisory Circular (AC) 25.723-1. May 25, 2001. 4 pp. Available through GPO.****

This AC describes an acceptable means for demonstrating compliance with U.S. Federal Aviation Regulations Part 25, related to the use of landing gear shock absorption tests and analyses to determine landing loads for transport category airplanes. The AC provides guidance on shock absorption tests, limit-free drop tests and reserve-energy drop tests.

Part 121, 125, and 135 Flightcrew Procedures During Taxi Operations. U.S. Federal Aviation Administration (FAA) Advisory Circular (AC) 120-74. June 18, 2001. 12 pp. Available through GPO.****

Recent increases in complexity of runway and taxiway design and traffic volume have made airport surface operations more difficult and potentially more hazardous. To increase safety and efficiency, flight crews should be prepared to focus solely on essential tasks while the aircraft is in motion. With this AC, the FAA recommends developing and implementing procedures for conducting safe aircraft operations during taxiing. FAA recommends that the guidelines presented in the AC become part of standard operating procedures, flight operations manuals and formal flight crewmember training programs. Because taxi operations present distinct challenges and requirements not found in other phases of flight, guidance is directed toward activities occurring within the cockpit, such as planning, communication and task coordination, rather than actual control of the aircraft.♦

Sources

* Australian Transport Safety Bureau (ATSB)
P.O. Box 967
Civic Square ACT 2608
Australia

** National Technical Information Service (NTIS)
5285 Port Royal Road
Springfield, VA 22161 U.S.
Internet: http://www.ntis.org

*** Safety Regulation Group (SRG)
Aviation House
Gatwick Airport South
West Sussex, England RH6 OYR
Internet: http://www.srg.caa.co.uk

**** Superintendent of Documents
U.S. Government Printing Office (GPO)
Washington, DC 20402 U.S.
Internet: http://www.access.gpo.gov

Boeing 757 Hydraulic System, Indicator-light Assembly Fail During Go-around

Investigations revealed a hydraulic leak in the nose-landing-gear-operated sequence valve, which had cracked because of fatigue, and a light cap that was out of position.

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The following information provides an awareness of problems through which such occurrences may be prevented in the future. Accident/incident briefs are based on preliminary information from government agencies, aviation organizations, press information and other sources. This information may not be entirely accurate.

Flight Crew Conducts Normal Landing After Report From Controllers

Boeing 757-200. No damage. No injuries.

The airplane was being flown on an approach to an airport in Scotland when the landing gear was extended and the three green landing-gear "down-and-locked" lights illuminated. During the approach, at about 500 feet, the flight crew initiated a go-around because another aircraft was on the runway. The crew selected 20 degrees of flaps and retracted the landing gear.

The left hydraulic system fluid-quantity indication decreased to zero, "followed by a left hydraulic system low-pressure warning and flap and landing-gear position-disagree warnings," the incident report said. The landing-gear lever again was selected down, and green lights illuminated for the nose landing gear and the left-main landing gear; the green light for the right-main landing gear did not illuminate, even after the landing-gear-selector lever was cycled several times and after the flight crew conducted quick-reference-handbook procedures for left hydraulic system failure and alternate landing-gear extension.

The flap and landing-gear position-disagree warning lights extinguished, but the green light for the right-main landing gear did not illuminate. After the flight crew flew the airplane over the runway at 3,000 feet, and air traffic control told the crew that the right-main landing gear appeared to be extended fully, the crew conducted an approach with 20 degrees of flaps and landed the airplane.

Because of the failure of the left hydraulic system, nose-wheel steering was inoperative. The airplane was stopped on the runway, the engines were shut down, and the passengers deplaned. Maintenance personnel confirmed that the right-main landing gear was locked in the down position.

The left hydraulic system on a Boeing 757 supplies hydraulic power to operate the landing gear and the landing-gear doors. If the left hydraulic system fails, the landing gear may be extended with the alternate landing-gear-extension system, but there is no alternate source of hydraulic power to raise the landing gear or close the landing-gear doors.

The investigation revealed a hydraulic leak in the nose-landing-gear-operated sequence valve, which had cracked because of fatigue. The report said that the crack extended "through the valve body across the 'UP' port," which is pressurized only when the landing-gear lever is selected up. The failure probably occurred when the landing gear was retracted for the go-around. The valve had accumulated 25,985 flight hours and 28,234 cycles in service without an overhaul.

Boeing Service Bulletin 757-32-0046 was issued in 1988 to introduce a thicker valve body casting because of fatigue failures of the valve body. The operator had not installed the new valve because its aircraft had experienced no significant problems with the original valves.

Maintenance personnel said that the light cap on the green-indicator-light assembly for the right-main landing gear was protruding from its normal position in the panel and that neither of its two filaments was illuminated. When they pressed the light cap into its holder, one filament illuminated. They said that the light cap had separated from the main body of the indicator-light assembly because of a failure of hinge lugs.

"Blue Haze" in Cabin Prompts Return to Airport

Jetstream 41. No damage. No injuries.

The airplane was being flown through Flight Level 240 (24,000 feet) after departure from an airport in Scotland for a flight to Wales when a central annunciator panel warning indicated that there was "toilet smoke." The incident report said that the flight attendant had found no one smoking in the lavatory; nevertheless, the flight attendant told the flight crew that there was a "blue haze" in the cabin that was not present on the flight deck. The flight crew declared an emergency, conducted the emergency checklist and descended to the departure airport; while en route, they modified their emergency status and declared an urgency. They conducted a normal landing.

The investigation revealed that another "blue haze" incident had occurred the previous day but without the "toilet smoke" warning. The left air cycle machine (ACM) was examined after the first incident, was found to be "slightly stiff" and was repaired. After the incident the next day, the ACM was replaced. (The aircraft environmental control system uses two ACMs; air from the left ACM is delivered to the cabin; air from the right ACM is delivered to the flight deck. Each ACM has a heat exchanger that requires periodic cleaning.)

Ten days after the second incident, smoke was reported in the cabin during landing and taxi, and the right ACM was replaced. Two months later, a flight crew observed a "toilet smoke" warning and said that there was a "hot" odor in the airplane, but while they conducted the checklist, the warning and the odor ceased. The airplane was landed normally.

An investigation after the last incident revealed traces of oily contamination from the ACM and its heat exchanger, which then were replaced. No further incidents occurred, but the investigation revealed that the environmental control system probably was not the source of the smoke. There was no alternative explanation, but the report said that the left engine was being examined because "it appears the reason for the oil contamination must lie within the engine."

Engine Fire Prompts Unscheduled Landing

Boeing 737. Minor damage. No injuries.

The airplane was being flown from an airport in Cuba when the oil-quantity indication for the no. 2 engine (Pratt & Whitney JT8D-9A) began decreasing, the oil pressure began to fluctuate and the oil temperature increased.

The flight crew shut down the engine and decided to divert to an airport in the United States. They asked for and received clearance from air traffic control to hold for 45 minutes at 6,000 feet to use fuel before landing. After completing four turns in the holding pattern, the crew observed the no. 2 engine-fire lights. The crew discharged two fire bottles, but the fire could not be extinguished. The airplane was landed and was stopped on the runway, where an evacuation was conducted.

An investigation revealed damage in the no. 2 engine constant-speed drive. The engine cowling received heat damage.

Smoke From Coffee Maker Blamed for Diverting Flight

Airbus A320-200. No damage. No injuries.

The airplane was being flown to an airport in Spain when a flight attendant smelled smoke at the rear of the cabin and disconnected the aft galley circuit breakers. The odor persisted, and the flight crew diverted the flight to an airport in France.

Inspection revealed that the odor had resulted from a water leak from the coffee maker. After the coffee maker was replaced, the airplane was returned to service.

Air Taxi Commuter

Electrical Fire Melts Cabin-roof Panel

De Havilland DHC-6 Twin Otter. Minor damage. No injuries.

The airplane was being flown on a domestic flight in Australia when — during descent to the destination airport — the flight crew smelled smoke in the cockpit and observed a maximum-discharge indication on the battery loadmeter and that the right generator light was illuminated.

The flight crew moved the left generator switch to the "OFF" position, but the generator remained on line.

The flight crew observed that smoke was coming from behind the right-cabin-roof panel and that the panel was melting. They told air traffic control (ATC) about the fire and received clearance to fly direct to the destination airport. The first officer used the cabin fire extinguisher to extinguish the fire, then told ATC that the flames had been extinguished.

An investigation revealed that the left reverse-current relay and nearby components and wiring had been damaged by heat; maintenance personnel were unable to determine the cause of the fire.

Loose Bolt, Electrical Arcing Blamed for Cockpit Smoke

Embraer EMB-120ER Brasilia. No damage. No injuries.

Night visual meteorological conditions prevailed for the departure from an airport in Sweden. About 17 minutes after takeoff, as the airplane was flown through Flight Level 150 (15,000 feet), the pilots smelled something burning. As the odor intensified and a haze was observed on the flight deck, the flight crew switched both air-conditioning packs to "OFF."

They declared an emergency and were given vectors to the departure airport; the flight was conducted in a depressurized cabin, and the crew hand-flew the airplane.

The accident report said that during the flight, the captain donned his oxygen mask periodically, "when he felt a sticking sensation in his throat" because of the smoke, but removed the mask to communicate with the first officer or to use the radio; the first officer, who felt no irritation from the smoke, did not use an oxygen mask.

The flight crew conducted a normal landing at the departure airport and taxied to the terminal, where the passengers deplaned.

An investigation revealed that a bolt on the connection terminal board in front of the instrument panel was loose and that electrical arcing across the bolt caused overheating and the odor of smoke. The electrical cable and the terminal board were burned.

The report said that the event initially was dealt with as a minor incident and that accident investigators were notified of the event five days after the event occurred. After the incident, the investigative authority recommended that regulators act to ensure that operators, their employees and others "are made more aware of the instances when it is their duty … to file reports" with regulators about the incidents.

During the flight, the captain told passengers that they were returning to the departure airport because of a "technical problem" and told the flight attendant how much time remained before landing. Nevertheless, the report said, the flight attendant "was not informed of the fact that the pilots had declared an emergency" and was not given a detailed account of the incident for several days.

The report also said that operators should understand "the need to install easy-to-use, quick-donning … oxygen equipment on their pressurized aircraft" and the need to "train their personnel on the proper use of the equipment."

The report said, "Smoke or fire … can be poisonous and rapidly affect the crew's ability to function normally. It was, therefore, important for both pilots to immediately don their oxygen masks as a precautionary measure, as dictated in the emergency checklist."

Nose Landing Gear Collapses After Touchdown

Piper PA-23-250 Aztec. Substantial damage. No injuries.

Visual meteorological conditions prevailed for the evening flight to an airport in New Zealand.

During the approach to the airport, the pilot observed that the three green landing-gear "down-and-locked" lights illuminated. The airplane was flown through turbulence and wind shear on short final, then was landed "more firmly than normal" on the centerline near the runway threshold, the accident report said.

"About 10 seconds after landing, as the aircraft was slowing but still with a reasonable amount of forward speed, the nose undercarriage leg collapsed aft toward its retracted position," the report said. "The leg did not retract fully into its housing but swivelled unsupported rearwards, allowing the nose of the aircraft to drop onto the runway."

The airplane turned about 30 degrees right and stopped to the right of the runway centerline.

The report said that the most likely explanation for the landing gear's collapse was that "a combination of the landing forces on the nose undercarriage and drag strut movement, because of play in the drag-strut bushes, caused the drag strut to flex sufficiently for the strut to move from its over-center position and unlock the nose leg."

Corporate Business

Multiple Fractures Cited in Collapse of Nose Landing Gear

Beech Super King Air 200. Substantial damage. No injuries.

After a ferry flight from Belgium, the flight crew prepared for landing at an airport in England, extending the landing gear at 160 knots and observing three green lights indicating that the landing gear was locked in the down position. The surface wind for the landing on Runway 6R was from 020 degrees at 11 knots.

During the landing roll, the flight crew heard a cracking noise, and the airplane's nose fell toward the runway. The captain steered the airplane onto the grass next to the runway.

An inspection revealed that the nose-landing-gear strut was broken at the right-side upper fitting and drag-brace attachment. Buckling had occurred on the left-side and right-side nose-landing-gear upper-inboard and upper-outboard attachments and in the left-side and right-side forward-nose-wheel-bay skin between the attachments.

A metallurgical examination revealed that the fractures were consistent with overload and that the initial fracture had occurred in or near a grease hole on the front of the nose-landing-gear strut. Examination of the mating fracture face revealed that the separation had occurred in overload. Other fractures occurred in the right-side upper fitting and the drag-brace attachment of the nose landing gear.

No heavy landings had been recorded in the technical log since the nose landing gear had been overhauled one year before the accident. The accident report said that the attachment areas would not have been visible on a normal pre-flight inspection, which had been conducted by the captain.

Broken Rudder Cable Blamed for Abnormal Yaw Input

Raytheon Beechjet 400A. No damage. No injuries.

Visual meteorological conditions prevailed for the afternoon approach to an airport in the United States. The captain said that the airplane was about 20 miles (32 kilometers) west of the airport at 4,000 feet and was flying at 220 knots when there was an abnormal yaw input. The captain believed that the yaw damper had failed and selected the yaw damper to "OFF," but normal rudder control did not return.

The captain continued the approach and conducted an uneventful landing.

A maintenance inspection revealed that the right rudder cable had separated about one foot (30 centimeters) from the rudder attaching point; both ends were frayed. Maintenance records showed that the airplane had been towed while the nosewheel steering was engaged and that as a result, the rudder portion of the flight control system was damaged. The damage was repaired the month before the incident, and the left rudder cable and right rudder cable were replaced. The airplane had been flown 50.6 hours since replacement of the cables.

Manufacturer records showed that the rudder cable had come from a reel that had been tested before shipment; test results showed that the breaking strength of the sample was 3,190 pounds (1,447 kilograms), compared with required breaking strength of 2,500 pounds (1,134 kilograms).

Other General Aviation

Airplane Strikes Terrain During Transcontinental Flight

Yakovlev Yak-52. Destroyed. One fatality.

Instrument meteorological conditions (IMC) prevailed for the night flight to an airport in the United States. No flight plan was filed.

The pilot had purchased the airplane “a couple of days” before the accident and was completing a series of flights to transport the airplane across the country, the accident report said. The airplane was equipped for instrument flight rules flight, but the previous owner had warned the pilot against flying in IMC or night visual meteorological conditions because he was unaccustomed to the arrangement of the instrument panel.

Post-accident examination of the wreckage revealed that most of the airplane’s structure, flight instruments and system instruments were destroyed by a post-impact fire. Flight-control continuity could not be confirmed because of impact damage and fire damage.

A weather observation 30 minutes after the accident at an airport 22 miles (35 kilometers) to the northeast said that visibility was three miles (five kilometers) in rain and mist, with overcast clouds at 6,500 feet. Winds were calm. Weather radar 23 minutes before the accident showed that the accident site was in an area of heavy precipitation.

Airplane Skids off Departure End of Wet Grass Runway

Pitts S-1T. Minor damage. No injuries.

The airplane was flown in deteriorating weather to an airport in England for an aerobatics competition. In preparing to land on the short, wet, downsloping, grass runway, the pilot positioned his airplane behind another aircraft “at what appeared to be sufficient separation to allow the other aircraft to clear the runway,” the accident report said. After the other aircraft had cleared the runway, the pilot conducted his landing.

The nose of his airplane obscured the runway ahead, and the pilot did not know how much usable runway remained. Touchdown speed was faster than typical, and when the pilot applied the brakes, the wheels locked. The airplane skidded off the departure end of the runway into a farm field and flipped over.

The pilot said that he landed too far from the runway threshold because of concern about having to conduct a go-around in deteriorating weather, because the airplane had traveled farther than he thought while the preceding aircraft cleared the runway and possibly because of a depth-perception problem. The pilot also said that separation between his airplane and the previous landing airplane had decreased because the pilot of the other aircraft, while taxiing the airplane off the runway, had slowed his taxiing speed to prevent the airplane from skidding on the wet grass.

Rotorcraft

Main-rotor Blades Strike Trees During Search for Missing Person

Bell 206L-1 Long Ranger II. Minor damage. No injuries.

The helicopter was being flown on a night flight to search for a person missing after ice skating on a lake in Sweden.

The pilot and an assistant, who had no flight experience, observed a hole in the ice that they believed required investigation by a ground team in the area. The pilot used the searchlight to locate a wooden bridge where he believed the ground team could board the helicopter and placed the left landing skid on the bridge for the boarding process.

“In the searchlight beam, he saw that the shoreline was overgrown with birch saplings, but he judged that the safety margin to the rotor disk area was at least 1.5 meters [five feet],” the report said. “He was aware that the distance was less than the applicable safety distance, which is three meters [10 feet].”

After the ground team boarded the helicopter and the assistant closed door, the pilot heard the main rotor strike branches left of the helicopter and felt what he believed was a minor impact. He continued to hover the helicopter, moving slowly to the right, and observed no abnormal handling characteristics.

Nevertheless, after landing, the pilot observed that the rotor blades had been damaged “to such an extent that he didn’t consider it suitable to fly any further with the helicopter,” the report said.

Helicopter Rolls Over After Emergency Landing

Hughes 269C. Substantial damage. No injuries.

Visual meteorological conditions prevailed for the flight over a game farm in South Africa. The pilot and a passenger observed a deer that appeared to be ill and flew the helicopter lower for a closer look at the animal.

During the descent, the helicopter’s skid gear struck a telephone wire. The pilot conducted an emergency landing. After touchdown on the uneven terrain, the helicopter rolled over.♦

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