8. Describe the database system managed by the NTSB. Why was NASA chosen to manage the Aviation Safety Reporting System? What is its function?
9. What is the purpose of flight data recorders and cockpit voice recorders? How might they be used for accident prevention purposes? What is the ICAO ADREP? Give several examples of information provided by ICAO and based on ADREP data.
10. Discuss OSHA's recording requirements for injuries and illnesses and discuss the reasons for collecting these data.
11. Discuss the role that BLS plays in recording and analyzing occupational injury/illness data.
12. Discuss some of the salient features of EPA's hazardous substance reporting requirements, giving reasons for the same.
13. What does 40 CFR Part 87 address?

REFERENCES

International Civil Aviation Organization. 2009. Safety Management Manual (SMM), 2d ed. Montreal, Canada: www.icao.int

___ 2006. Accident/Incident Reporting Manual (ADREP Manual) Montreal, Canada (ICAO Doc 9156).

Web References

http://www.icao.int/
www.ntsb.gov/
http://asias.faa.gov/
http://asrs.arc.nasa.gov/
www.epa.gov/
www.osha.gov/
www.nrc.uscg.mil/

CHAPTER FIVE

REVIEW OF SAFETY STATISTICS

LEARNING OBJECTIVES

After completing this chapter, you should be able to

- Explain why the accident rate is a better measure of safety than accident counts.
- Discuss some of the issues to be aware of when analyzing and comparing commercial aviation accident statistics.
- Discuss the results of Boeing's *Summary of Commercial Jet Transport Aircraft Accidents.*
- Summarize the trend in aviation accident statistics as reported by United States and international commercial aviation during the 1980s, 1990s, 2000s, and 2010s.
- Discuss future concepts in ICAO accident prevention.
- Discuss OSHA injury and illness rate statistics.

INTRODUCTION

In passenger transportation, *safety factors* (also referred to as *causal factors*) are events that are associated with or influence fatality rates. A *safety indicator* is a measurable safety factor. The probability of death (or injury) as a result of traveling on a given mode, when quantified, is the primary benchmark of passenger transportation safety. Vehicle accident rates also are commonly used as safety indicators since most passenger fatalities occur as a result of vehicle accidents.

If one were to look at risk as the probability of death, then the risk due to traveling can be established from fatality rates. However, commercial aviation fatality rates are poor indicators of short-term risk changes, as a single large jet can result in the deaths of a few hundred people. Hence, a single accident can greatly influence fatality rates. Therefore, the trending of fatality rates requires data from extended time periods (5 years or more). As an alternative, accident rates can be used instead of fatality rates as indicators of safety levels. The number of fatalities, even for a specific type of accident, varies greatly with each crash. However, while the number of accidents may have a narrower range of annual variance than the number of fatalities, it has similar analysis issues. While accidents exceed fatalities in numbers, they are still quite small. Also, accidents can vary significantly from one year to the next, and hence accident rates are also poor indicators of short-term estimates of risk trends.

Before one can use accident statistics for safety analysis, it is necessary to understand the denominators of *exposure data* used in transportation accident or fatality rates. Exposure data are information that indicates the amount of opportunity for an event to occur. Cycles, distance, and time for passengers and vehicles are the principal exposure types. They are used in the denominator of rates, such as fatalities per passenger departure or electrical system failures per aircraft-hour. The choice of type of exposure data will affect how rates are compared between and within the transportation modes. Passenger-miles (the number of passengers multiplied by the miles traveled) are most appropriate when one is comparing air transportation with other modes of transportation, as they allow generalized broad-based system comparisons. Using trips between the same city pairs to compare risks for different modes of travel would be very appealing. However, the number of city pairs in the United States is extremely large, and some modes of transportation do not have passenger data in the format required for this type of comparison. In addition, risk per passenger-mile is not uniform over a trip and can vary by the type of route taken or the time of day.

It is clear that the probability of an accident is significantly higher during takeoff or landing than in any other phase of flight. Hence, the bulk of commercial aviation passenger-miles occur under conditions when the overall average risk is much lower. Vehicle-miles (as opposed to passenger numbers) are preferred in the denominator for comparison of exposure and accident rates, as the number of passengers per vehicle usually vary. Finally, vehicle-miles traveled do not reflect the risks associated with the size of the vehicle and/or its speed.

Aviation accidents can vary greatly in severity, ranging from a flight attendant back injury from pushing carts during in-flight service or handling overhead luggage, to several hundred deaths due to an aircraft crash. To render a more equitable perspective on things, some databases categorize accidents as fatal and nonfatal. However, even here, a single death on a ramp during an aircraft pushback would still be classified as an aviation accident. To address this issue, the NTSB classifies accidents as *major, serious, injury,* or *damage* (see Chapter 4 for definitions).

Another classification (popular with the insurance and aircraft manufacturing industries) of accidents includes (aircraft) *hull loss* and *nonhull loss*. A hull loss is airplane damage that is beyond economic repair.

Accident counts by themselves cannot be reliably used to measure relative safety among organizations and their products. All things being equal, an airline that has a larger fleet of aircraft could be expected (statistically speaking) to have a larger number of accidents than an airline with far fewer planes. Similarly, aircraft models that are flown more often would be expected to be involved in more accidents than less frequently used models. For this reason the *accident rate*, which is the number of accidents divided by some common base variable (e.g., flight hours, departures, and miles flown), is a more valid indicator of relative safety than just accident counts. In this context, time (flight hours) is a popular measure of exposure in many types of risk analysis. Since flight-hour data are needed for economic, operational, and maintenance reasons, airlines keep accurate records of such data which are readily available for safety rate comparisons. Also, rate data are used by the NTSB to compare safety performances among airlines and other sectors of the air transportation industry.

It goes without saying that takeoffs and landings are the riskiest phases of flight where most accidents occur. So, if takeoffs and/or landings are used as a base for rate calculations, then the airline that predominately flies smaller aircraft more frequently on shorter routes would be favored more than the airline that predominately flies larger aircraft on long routes (and would consequently have fewer takeoffs and landings). The bias reverses in the above example if hours flown are used as the base for accident rate calculation. Then again, since most of the risk involved with air transportation is associated with takeoffs and landings, a 1000-mile trip is similar to a 100-mile trip when both are compared for safety. Overall, there is a stronger correlation between accidents and departures than there is between accidents and flight hours or between accidents and passenger-miles. Therefore, aircraft departures (or landings) are a valid exposure parameter for air transportation.

The air transportation industry is extremely dynamic with technological advances, operational strategies (point-to-point versus hub and spoke), and mergers, consolidations, and bankruptcies rapidly changing the aviation landscape. The aviation industry of today is very different from what it was 30 years ago. Hence, one should exercise care when comparing safety statistics over long periods. While there is no clear answer as to what time domain is appropriate for analyzing and comparing aviation safety data, the most recent 5- to 10-year span appears to be the accepted norm among federal regulators.

Aviation accidents are rare occurrences, and the risk of death or serious injury by air travel is minuscule. The domestic airlines as a group average just under four catastrophic accidents per year (even less if one were to exclude sabotage and terrorism). With such small numbers, making statistical inferences from the data to evaluate safety performance of the industry is very difficult. Regulatory agencies and the aviation industry maintain a wide variety of safety-related information. However, one must take into consideration the accuracy and completeness of these data when developing safety trends and recommending control measures.

Safety factors other than fatalities or accidents that include the nature and causes of accidents (covered in Chapter 6) should be studied and used for preemptive strikes against safety exposures and to provide timely feedback to management and policymakers.

In summary, no single measurement provides the complete safety picture. Passenger-exposure data are used when passenger risk is to be described. Passenger-miles are used when the influence of vehicle size or speed on the data is nonexistent. Departure-exposure data account for nonuniform risk over a trip. Time is the most widely used exposure measure, and time-based data are often readily available.

AVIATION ACCIDENT STATISTICS

Chapter 4 reviewed various data reporting systems, both voluntary and mandatory, that are used in aviation. While ensuring compliance or consistency in safety reporting is difficult in general, voluntary systems have added complexity in that they are inconsistent and less reliable. There are several reliable sources of accident data. One of the most easily accessible accident databases is maintained by Boeing, which publishes an annual *Statistical Summary of Commercial Jet Airplane Accidents*. Another excellent source document is the Aviation Safety Network of the Flight Safety Foundation found at http://aviation-safety.net/. Finally, the definitive and mandatory source of aircraft accident data in the United States is the NTSB database.

MANUFACTURERS' INVOLVEMENT WITH SAFETY DATA

Safety professionals with the airframe and engine manufacturers can be found at accident sites participating in the investigation. They collect and analyze data. They recommend improvements in the way aircraft are designed and built and in the way they are operated and maintained. The mandate is to learn to prevent future mishaps.

While manufacturers may undertake similar functions, the organizational framework for carrying out those functions can differ markedly between them. For example, accident investigation and safety data analysis are separate units at Boeing, while they are combined at other manufacturers and often linked to customer support in a single organization.

The closest thing to a constant among manufacturers' safety departments is their responsibility for accident investigation. When a company's product is involved in an accident, that company has a duty to help find the cause. In the parlance of the NTSB, the company becomes a party to the investigation. That means the manufacturer's representatives work alongside NTSB investigators in examining evidence at the accident site. The parties conduct subsequent tests and suggest findings, but the final analysis and published report are the NTSB's exclusively.

Safety departments scrutinize incidents as well as accidents. Committees are formed to represent various departments using new safety management systems (SMS) procedures.

Based on the events reviewed, the committees recommend design changes or revisions in maintenance or operating procedures. Accident reports produce a lot of data. Still more data come from incident reports and other files compiled by airlines, manufacturers, and government agencies. The FAA, for example, records Service Difficulty Reports. Manufacturers' safety departments have come to view these data as a resource to be developed and cultivated. The data come from a variety of sources. Manufacturers' service representatives around the world report regularly on anomalous events both large and small.

Airlines often report directly to manufacturers. Other data sources include civil authorities and international organizations such as the International Air Transport Association, the U.K. CAA, and U.S. FAA, as well as insurance underwriters and publications. Even with all those collection efforts, safety staff don't claim that a record of every event unfailingly finds its way to the appropriate database. When little or no damage is involved, airlines sometimes make no external reports.

While manufacturers of large airframes maintain what probably are the most extensive databases, others also are collecting such information. Makers of engines and other components are also in the business of collecting statistical data.

The purpose of gathering the data is trend analysis. Computers may be able to discern patterns that a human analyst would miss. Boeing has taken a proactive stance in the area of safety. Manufacturers can alert carriers to problems they didn't know they had. A team assembled by Boeing uses accident records and other data to identify current safety issues. For example, Boeing was a leading proponent in stressing the importance of installing GPWS and the need for proper training in its use.

Similarly, to prevent approach and landing accidents, Boeing has urged that every runway used by commercial transports be equipped with an instrument landing system (ILS). And several training measures have been advocated for pilots and controllers to alleviate the dangers associated with nonstabilized approaches.

Boeing research also has addressed "crew-caused accidents." Its data and other sources identify flightcrew error as the primary cause in close to 70 percent of commercial jet hull-loss accidents (see next section). However, accidents rarely have single causes. Manufacturers' prevention strategies address all the factors, not just the primary one. Removing even one link in the chain of events can prevent many accidents.

Airlines maintain databases and conduct trend analyses of their own. These analyses can benefit from work done by the manufacturers. For example, American studied a series of 757 tail strikes. After assessing its own records, the carrier checked with Boeing about the experiences of other 757 operators. Once the problem was identified, American and Boeing worked to solve it by revising training methods.

Metro operators receive a monthly trend monitoring report with statistics on factors such as dispatch reliability, in-flight engine shutdowns, and unscheduled component removals. The reports are based on operating data from more than 25 operators of close to 250 Metros.

The large airframe manufacturers also publish annual reports on their compilations of industrywide accident data, although they differ in the way the data are analyzed and presented. For day-to-day problem solving, airlines have more contact with a manufacturer's accident and incident investigators than its data analysts.

In the discussions that follow, databases from Boeing, the Flight Safety Foundation, and the NTSB will be explored to analyze aviation accident statistics.

BOEING'S ACCIDENT STATISTICAL SUMMARY

According to the Boeing statistical summary, in the 50-year history (worldwide) of scheduled commercial jet operations (1959 to 2009) there have been 1704 accidents resulting in 28,296 onboard fatalities. Of the 1704 accidents, 592 accidents caused fatal injuries of which 479 were hull-loss accidents, 25 were attributed to substantial damage accidents, and 88 were a result of less than substantial damage accidents. If one were to consider accidents by type of operation, 79 percent (1344) of the 1704 accidents were passenger operations, 14 percent (244) were cargo operations, and the remaining 116 accidents occurred during testing, training, demonstration, or ferrying. United States and Canadian operations collectively had about 31 percent (530) of the 1704 worldwide accidents, contributing to about 22 percent (6153) of the 28296 global onboard fatalities. Over this period, there have been in excess of 563 million cumulative departures and more than 993 million cumulative flight hours. The industry is now operating 20025 jet aircraft, with little over 21 million departures each year.

If we look at the plot of all accidents for the worldwide commercial jet fleet for the period 1959 to 2001, we can see that the rates for all accidents and those involving hull losses has been fairly stable for the past 35 years (Fig. 5-1). If we apply control limits to these data, generally 3 standard deviations on either side of the number of hull-loss accidents each year, we can clearly see that the jet airplane transportation process has been under statistical control for a number of years. However, even if this low accident rate remains constant over the next few years, we can expect to see an increase in the actual number of hull-loss accidents each year as the fleet increases in number of departures.

Hull losses and fatal accidents were also analyzed according to the phase of flight in which they occurred (Fig. 5-2). The combined final approach-and-landing phases accounted for 34 percent of the hull-loss and fatal accidents, followed by the combined phases from loading through initial climb (38 percent). Cruise, which accounts for about 57 percent of flight time in a 1.5-hour flight, occasioned only 10 percent of hull-loss accidents.

In past years, the summary also considered primary cause factors for commercial operation hull-loss accidents for the period 1992 to 2001 (Fig. 5-3). For accidents with known causes, flightcrews were considered the primary cause in most accidents—66 percent over the 10-year period from 1992 to 2001 (Fig. 5-3).

Finally, fatalities by accident categories were covered for the period 2000 to 2009 (Fig. 5-4). Loss of control in flight accounted for 1759 onboard fatalities followed by controlled flight into terrain (CFIT) which had 961 fatalities during the

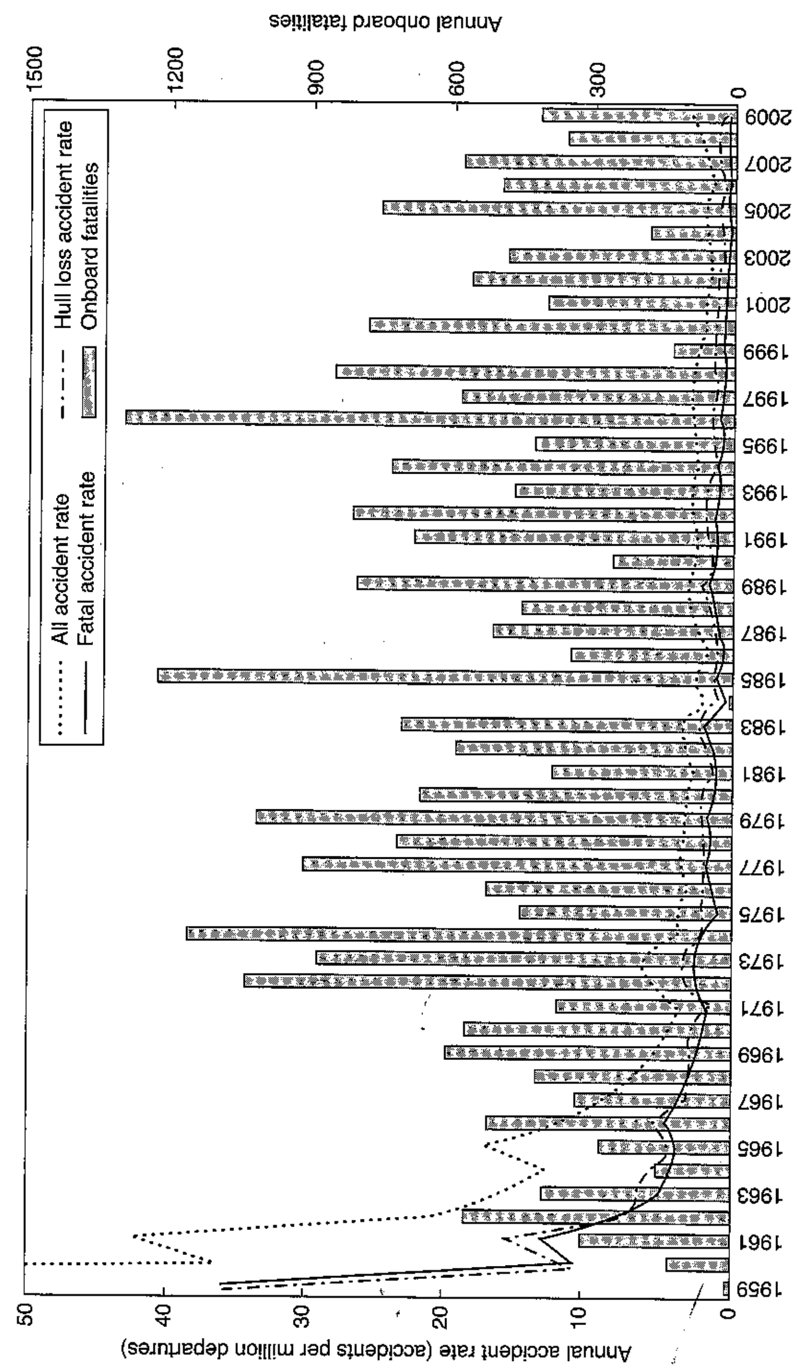

FIGURE 5-1 Accident rates and fatalities by year; all accidents, worldwide commercial jet fleet, 1959–2009. *(Source: Boeing 2009 Statistical Summary, July 2010)*

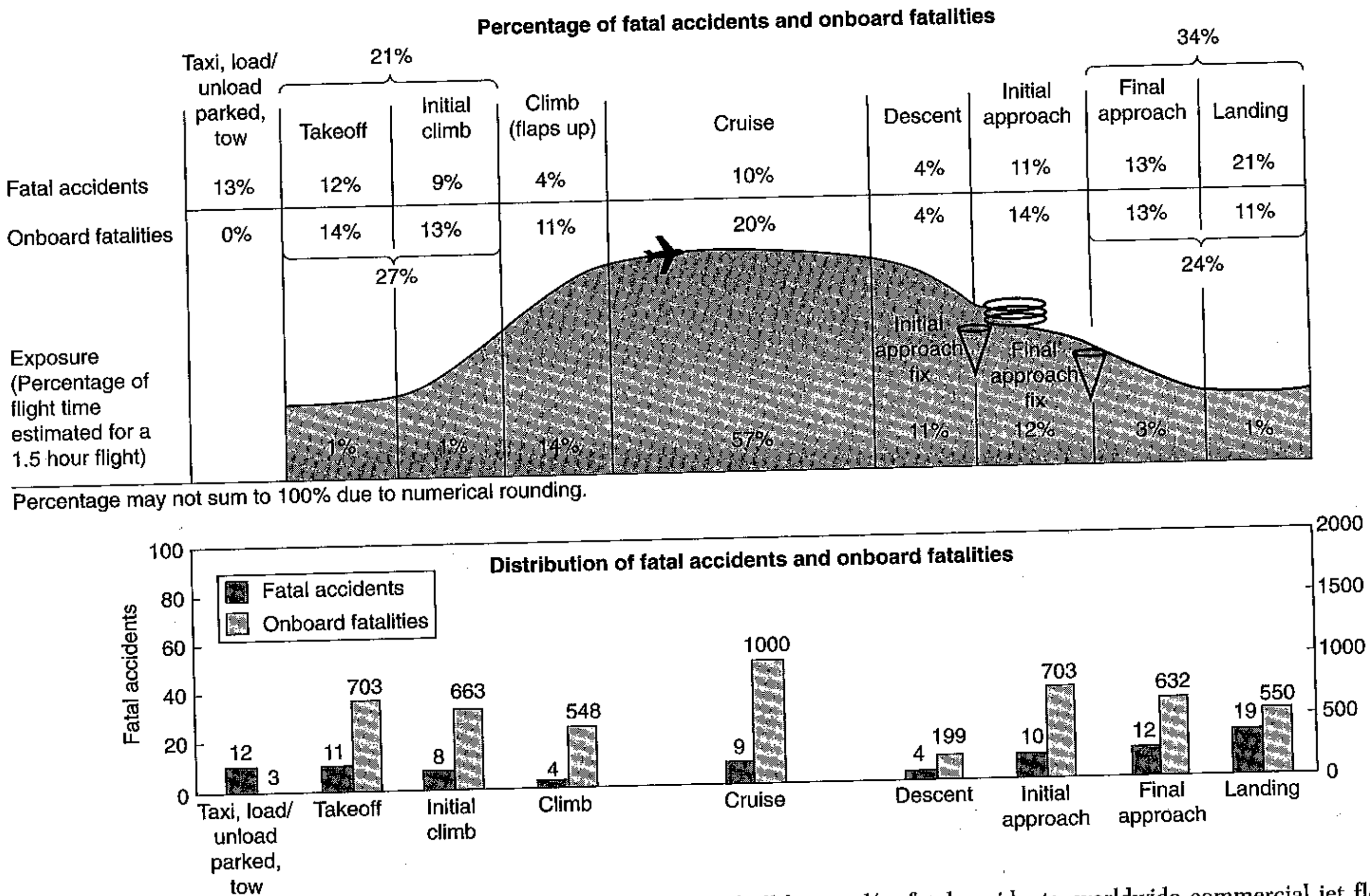

FIGURE 5-2 Accidents and onboard fatalities by phase of flight; hull-loss and/or fatal accidents, worldwide commercial jet fleet, 1992–2009. (*Source: Boeing 2009 Statistical Summary, July 2010*)

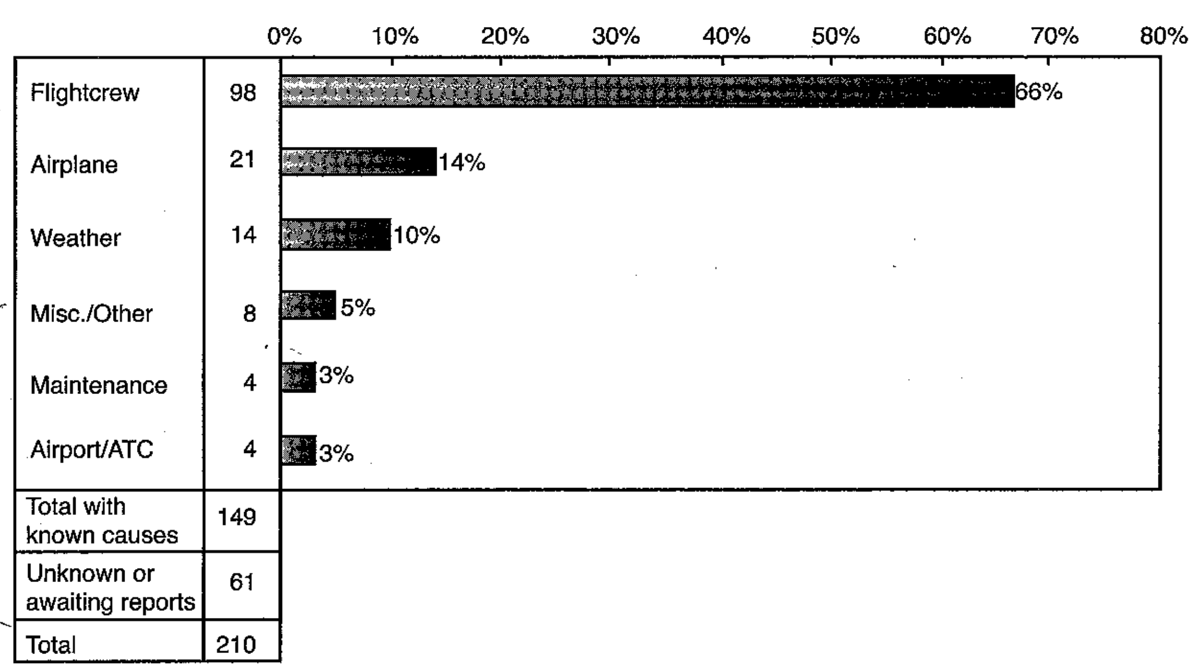

FIGURE 5-3 Accidents by primary cause,* hull loss, worldwide commercial jet fleet, 1992–2001.
(*As determined by the investigating authority; *Source: Boeing 2001 Statistical Summary, June 2002.*)

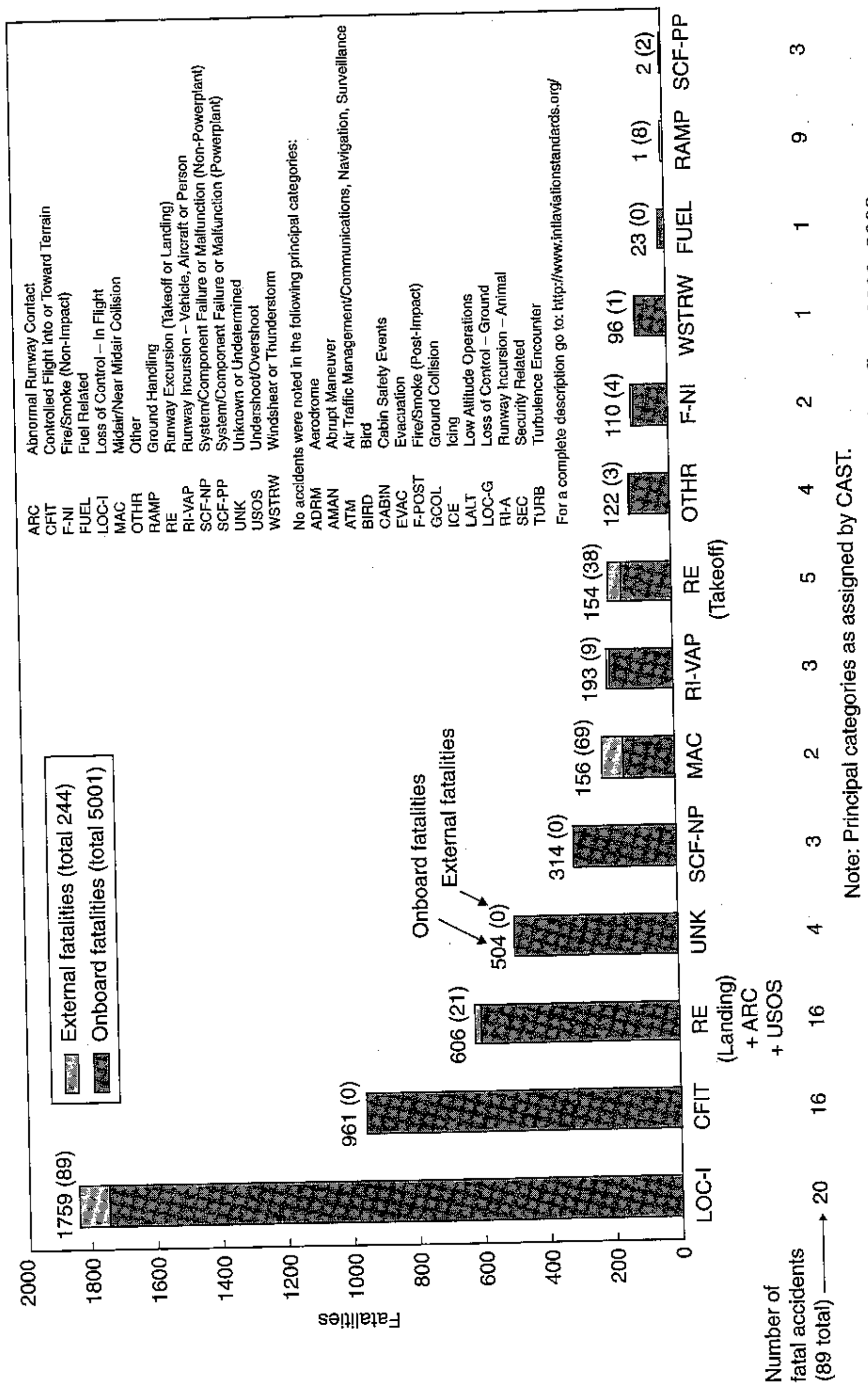

FIGURE 5-4 Fatalities by CICTT accident categories, fatal accidents, worldwide commercial jet fleet, 2000–2009.
(Source: Boeing 2009 Statistical Summary, July 2010)

Boeing's accident data exclude turboprop aircraft as well as those with maximum gross weight of 60,000 lb (27,216 kg) or less; Soviet Union and Commonwealth of Independent States accidents; and accidents resulting from sabotage, hijacking, suicide, and military action.

Several important lessons can be learned from the Boeing data. The most obvious of these is the issue of human error. The human factor is clearly and consistently the most frequent cause of incidents and accidents in the airline industry. It must be kept in mind that Fig. 5-3 only shows the tip of the human-error problem; flight crewmembers are not the only source of error in the aviation system. Hidden in each of the other categories of primary cause factors is a significant, although sometimes hard-to-determine, human-error component. In the maintenance category, for example, recent unpublished data suggest that more than one-half of these involve human factors, and it seems likely that similar rates of human-error involvement can be found in the other categories as well. This is why estimates of the total contribution of human error to aviation incidents and accidents can range as high as 80 to 90 percent.

Based largely on data such as these, it has become increasingly apparent that the management and control of human error are the largest single challenge facing airline safety management. This recognition is not new. In 1974, the Flight Safety Foundation held its 28th Annual International Aviation Safety Seminar in Williamsburg, Va. The theme was human factors in flight operations, and it is believed that this seminar was the first major airline industry safety conference devoted to human error. In 1975, IATA sponsored its 20th Technical Conference: Safety in Flight Operations. The conference proceedings almost exclusively focused on human factors and human-error issues, which were termed "the last frontier of aviation safety." These early industry efforts were at the vanguard of present-day approaches to the problem of management and control of human error in aviation operations.

The University of Texas, Human Factors Research project conducted aviation safety research funded by the FAA and industry for over 25 years. More recently, a current safety initiative of the Flight Safety Foundation is a project entitled Operators Guide to Human Factors in Aviation which contains an extensive compendium of Human Factors information on the flight safety website. The Flight Safety Foundation, in conjunction with AIRBUS, established an annual Human Factors in Aviation Safety Award which is presented at the FSF European Aviation Safety Seminar. Likewise, IATA and ICAO are very active in Human Factors training on an international basis. The subject of Human Factors is thoroughly explored later in Chapter 7 of this text.

United States and International Accident Statistics

For the United States, the primary source of safety data is the NTSB. Tables 5-1 through 5-5 present a year-by-year summary of accidents, fatalities, and accident rates for U.S. carriers operating in scheduled and nonscheduled service under FAR Part 121 (major air carriers) and Part 135 (commuter air carriers and on-demand air taxis), respectively. Note that these data reflect the NTSB's official definition of an accident, of which fatal accidents are a subset.

TABLE 5-1 Accidents, Fatalities, and Rates, 1990 through 2009, for U.S. Air Carriers Operating Under 14 CFR 121, Scheduled and Nonscheduled Service (Airlines)

	Accidents		Fatalities					Accidents per 100,000 Flight Hours		Accidents per 1,000,000 Miles Flown		Accidents per 100,000 Departures	
Year	All	Fatal	Total	Aboard	Flight Hours	Miles Flown	Departures	All	Fatal	All	Fatal	All	Fatal
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	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*	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	49	4	8	6	15,838,109	6,696,638,000	10,318,383	0.309	0.025	0.0073	0.0006	0.475	0.039
1998	50	1	1	0	16,816,555	6,736,543,000	10,979,762	0.297	0.006	0.0074	0.0001	0.455	0.009
1999	51	2	12	11	17,555,208	7,101,314,000	11,308,762	0.291	0.011	0.0072	0.0003	0.451	0.018
2000	56	3	92	92	18,299,257	7,524,027,000	11,468,229	0.306	0.016	0.0074	0.0004	0.488	0.026
2001*	46	6	531	525	17,814,191	7,294,191,000	10,954,832	0.236	0.011	0.0058	0.0003	0.383	0.018
2002	41	0	0	0	17,290,198	7,192,501,000	10,508,473	0.237	—	0.0057	—	0.390	—
2003	54	2	22	21	17,467,700	7,280,383,000	10,433,164	0.309	0.011	0.0074	0.0003	0.518	0.019
2004	30	2	14	14	18,882,503	7,930,159,000	11,023,128	0.159	0.011	0.0038	0.0003	0.272	0.018
2005	40	3	22	20	19,390,029	8,165,643,000	11,130,407	0.206	0.015	0.0049	0.0004	0.359	0.027
2006	33	2	50	49	19,263,209	8,139,357,000	10,820,915	0.171	0.010	0.0041	0.0002	0.305	0.018
2007	28	1	1	1	19,637,322	8,315,905,000	10,928,432	0.143	0.005	0.0034	0.0001	0.256	0.009
2008	28	2	3	1	19,097,962	8,068,288,000	10,437,197	0.147	0.010	0.0034	0.0002	0.268	0.019
2009	30	2	52	51	18,001,000	7,557,161,000	10,349,200	0.167	0.011	0.0040	0.0003	0.290	0.019

NOTES:
- 2009 data are preliminary.
- Flight hours, miles, and departures are compiled by the Federal Aviation Administration.
- Since March 20, 1997, aircraft with 10 or more seats used in scheduled passenger service have been operated under 14 CFR 121.
- Years followed by the symbol * are those in which an illegal act was responsible for an occurrence in this category. These acts, such as suicide, sabotage and terrorism are included in the totals for accidents and fatalities but are excluded for the purpose of accident rate computation. Table 12 contains a list of illegal act occurrences involving US air carriers for the period covered by this table. Other than the persons aboard aircraft who were killed, fatalities resulting from the September 11, 2001 terrorist act are excluded from this table.

SOURCE: http://www.ntsb.gov

TABLE 5-2 Accidents, Fatalities, and Rates, 1990 through 2009, for U.S. Air Carriers Operating Under 14 CFR 121, Scheduled Service (Airlines)

	Accidents		Fatalities					Accidents per 100,000 Flight Hours		Accidents per 1,000,000 Miles Flown		Accidents per 100,000 Departures	
Year	All	Fatal	Total	Aboard	Flight Hours	Miles Flown	Departures	All	Fatal	All	Fatal	All	Fatal
1990	19	4	11	9	11,524,726	4,689,287,000	7,795,761	0.165	0.035	0.0041	0.0009	0.244	0.051
1991	21	3	60	47	11,139,166	4,558,537,000	7,503,873	0.189	0.027	0.0046	0.0007	0.280	0.040
1992	15	3	29	27	11,732,026	4,767,344,000	7,515,373	0.128	0.026	0.0031	0.0006	0.200	0.040
1993	22	1	1	0	11,981,347	4,936,067,000	7,721,870	0.184	0.008	0.0045	0.0002	0.285	0.013
1994*	18	4	239	237	12,292,356	5,112,633,000	7,824,802	0.138	0.033	0.0033	0.0008	0.217	0.051
1995	30	1	160	160	12,776,679	5,328,969,000	8,105,570	0.235	0.008	0.0056	0.0002	0.370	0.012
1996	31	3	342	342	12,971,676	5,449,997,000	7,851,298	0.239	0.023	0.0057	0.0006	0.395	0.038
1997	43	3	3	2	15,061,662	6,339,432,000	9,925,058	0.285	0.020	0.0068	0.0005	0.433	0.030
1998	41	1	1	0	15,921,447	6,343,690,000	10,535,196	0.258	0.006	0.0065	0.0002	0.389	0.009
1999	40	2	12	11	16,693,365	6,689,327,000	10,860,692	0.240	0.012	0.0060	0.0003	0.368	0.018
2000	49	2	89	89	17,478,519	7,152,260,000	11,053,826	0.280	0.011	0.0069	0.0003	0.443	0.018
2001*	41	6	531	525	17,157,858	6,994,939,000	10,632,880	0.216	0.012	0.0053	0.0003	0.348	0.019
2002	34	0	0	0	16,718,781	6,927,954,000	10,276,107	0.203	—	0.0049	—	0.331	—
2003	51	2	22	21	16,887,756	7,015,935,000	10,227,924	0.302	0.012	0.0073	0.0003	0.499	0.020
2004	23	1	13	13	18,184,016	7,604,248,000	10,782,989	0.126	0.005	0.0030	0.0001	0.213	0.009
2005	34	3	22	20	18,712,191	7,843,717,000	10,910,460	0.182	0.016	0.0043	0.0004	0.312	0.027
2006	26	2	50	49	18,647,896	7,851,864,000	10,627,481	0.139	0.011	0.0033	0.0003	0.245	0.019
2007	26	0	0	0	19,014,677	8,024,313,000	10,734,170	0.137	—	0.0032	—	0.242	—
2008	20	0	0	0	18,551,362	7,821,849,000	10,271,639	0.108	—	0.0026	—	0.195	—
2009	26	1	50	49	17,470,000	7,316,000,000	10,199,000	0.149	0.006	0.0036	0.0001	0.255	0.010

NOTES:
- 2009 data are preliminary.
- Flight hours, miles, and departures are compiled by the Federal Aviation Administration.
- Since March 20, 1997, aircraft with 10 or more seats used in scheduled passenger service have been operated under 14 CFR 121.
- Years followed by the symbol * are those in which an illegal act was responsible for an occurrence in this category. These acts, such as suicide and sabotage are included in the totals for accidents and fatalities but are excluded for the purpose of accident rate computation. Table 12 contains a list of illegal act occurrences involving US air carriers for the period covered by this table. Other than the persons aboard aircraft who were killed, fatalities resulting from the September 11, 2001 terrorist acts are excluded from this table.

SOURCE: http://www.ntsb.gov

TABLE 5-3 Accidents, Fatalities, and Rates, 1990 through 2009, for U.S. Air Carriers Operating Under 14 CFR 121, Nonscheduled Service (Airlines)

	Accidents		Fatalities					Accidents per 100,000 Flight Hours		Accidents per 1,000,000 Miles Flown		Accidents per 100,000 Departures	
Year	All	Fatal	Total	Aboard	Flight Hours	Miles Flown	Departures	All	Fatal	All	Fatal	All	Fatal
1990	5	2	28	3	625,390	258,545,000	296,545	0.800	0.320	0.0193	0.0077	1.686	0.674
1991	5	1	2	2	641,444	266,287,000	311,002	0.779	0.156	0.0188	0.0038	1.608	0.322
1992	3	1	4	4	627,689	272,091,000	365,334	0.478	0.159	0.0110	0.0037	0.821	0.274
1993	1	0	0	0	724,859	313,402,000	351,303	0.138	—	0.0032	—	0.285	—
1994	5	0	0	0	831,959	365,485,000	413,504	0.601	—	0.0137	—	1.209	—
1995	6	2	8	2	728,578	325,100,000	351,895	0.824	0.275	0.0185	0.0062	1.705	0.568
1996	6	2	38	8	774,436	423,111,000	377,512	0.775	0.258	0.0142	0.0047	1.589	0.530
1997	6	1	5	4	776,447	357,206,000	393,325	0.773	0.129	0.0168	0.0028	1.525	0.254
1998	9	0	0	0	895,108	392,853,000	444,566	1.005	—	0.0229	—	2.024	—
1999	11	0	0	0	861,843	411,987,000	448,070	1.276	—	0.0267	—	2.455	—
2000	7	1	3	3	820,738	371,767,000	414,403	0.853	0.122	0.0188	0.0027	1.689	0.241
2001	5	0	0	0	656,333	299,252,000	321,952	0.762	—	0.0167	—	1.553	—
2002	7	0	0	0	571,417	264,547,000	232,366	1.225	—	0.0265	—	3.012	—
2003	3	0	0	0	579,944	264,448,000	205,240	0.517	—	0.0113	—	1.462	—
2004	7	1	1	1	698,487	325,911,000	240,139	1.002	0.143	0.0215	0.0031	2.915	0.416
2005	6	0	0	0	677,838	321,926,000	219,947	0.885	—	0.0186	—	2.728	—
2006	7	0	0	0	615,313	287,493,000	193,434	1.138	—	0.0243	—	3.619	—
2007	2	1	1	1	622,645	291,592,000	194,262	0.321	0.161	0.0069	0.0034	1.030	0.515
2008	8	2	3	1	546,600	246,439,000	165,558	1.464	0.366	0.0325	0.0081	4.832	1.208
2009	4	1	2	2	531,000	241,161,000	150,200	0.753	0.188	0.0166	0.0041	2.663	0.666

NOTES:
- 2009 data are preliminary.
- Flight hours, miles, and departures are compiled by the Federal Aviation Administration

SOURCE: http://www.ntsb.gov

TABLE 5-4 Accidents, Fatalities, and Rates, 1990 through 2009, for U.S. Air Carriers Operating Under 14 CFR 135, Scheduled Service

	Accidents		Fatalities					Accidents per 100,000 Flight Hours		Accidents per 1,000,000 Miles Flown		Accidents per 100,000 Departures	
Year	All	Fatal	Total	Aboard	Flight Hours	Miles Flown	Departures	All	Fatal	All	Fatal	All	Fatal
1990	15	3	6	4	2,341,760	450,133,000	3,160,089	0.641	0.128	0.0333	0.0067	0.475	0.095
1991	23	8	99	77	2,291,581	433,900,000	2,820,440	1.004	0.349	0.0530	0.0184	0.815	0.284
1992*	23	7	21	21	2,335,349	507,985,000	3,114,932	0.942	0.300	0.0433	0.0138	0.706	0.225
1993	16	4	24	23	2,638,347	554,549,000	3,601,902	0.606	0.152	0.0289	0.0072	0.444	0.111
1994	10	3	25	25	2,784,129	594,134,000	3,581,189	0.359	0.108	0.0168	0.0050	0.279	0.084
1995	12	2	9	9	2,627,866	550,377,000	3,220,262	0.457	0.076	0.0218	0.0036	0.373	0.062
1996	11	1	14	12	2,756,755	590,727,000	3,515,040	0.399	0.036	0.0186	0.0017	0.313	0.028
1997	16	5	46	46	982,764	246,029,000	1,394,096	1.628	0.509	0.0650	0.0203	1.148	0.359
1998	8	0	0	0	353,670	50,773,000	707,071	2.262	—	0.1576	—	1.131	—
1999	13	5	12	12	342,731	52,403,000	672,278	3.793	1.459	0.2481	0.0954	1.934	0.744
2000	12	1	5	5	369,535	44,943,000	603,659	3.247	0.271	0.2670	0.0223	1.988	0.166
2001	7	2	13	13	300,432	43,099,000	558,052	2.330	0.666	0.1624	0.0464	1.254	0.358
2002	7	0	0	0	273,559	41,633,000	513,452	2.559	—	0.1681	—	1.363	—
2003	2	1	2	2	319,206	47,404,000	572,260	0.627	0.313	0.0422	0.0211	0.349	0.175
2004	4	0	0	0	302,218	46,809,000	538,077	1.324	—	0.0855	—	0.743	—
2005	6	0	0	0	299,775	45,721,000	527,267	2.002	—	0.1312	—	1.138	—
2006	3	1	2	2	301,495	46,503,000	568,464	0.995	0.332	0.0645	0.0215	0.528	0.176
2007	3	0	0	0	291,701	46,049,000	592,577	1.028	—	0.0651	—	0.506	—
2008	7	0	0	0	293,499	46,428,000	576,203	2.385	—	0.1508	—	1.215	—
2009	2	0	0	0	292,000	46,251,000	566,000	0.685	—	0.0432	—	0.353	—

NOTES:
- 2009 data are preliminary.
- Flight hours, miles, and departures are compiled by the Federal Aviation Administration.
- Since March 20, 1997, aircraft with 10 or more seats used in scheduled passenger service have been operated under 14 CFR 121.
- Years followed by the symbol * are those in which an illegal act was responsible for an occurrence in this category. These acts, such as suicide, sabotage and terrorism are included in the totals for accidents and fatalities but are excluded for the purpose of accident rate computation. Table 12 contains a list of illegal act occurrences involving US air carriers for the period covered by this table.

SOURCE: http://www.ntsb.gov

TABLE 5-5 Accidents, Fatalities, and Rates, 1990 through 2009, for U.S. Air Carriers Operating Under 14 CFR 135, On-Demand Operations

	Accidents		Fatalities			Accidents per 100,000 Departures	
Year	All	Fatal	Total	Aboard	Flight Hours	All	Fatal
1990	107	29	51	49	2,249,000	4.76	1.29
1991	88	28	78	74	2,241,000	3.93	1.25
1992	76	24	68	65	2,844,000	2.67	0.84
1993	69	19	42	42	2,324,000	2.97	0.82
1994	85	26	63	62	2,465,000	3.45	1.05
1995	75	24	52	52	2,486,000	3.02	0.97
1996	90	29	63	63	3,220,000	2.80	0.90
1997	82	15	39	39	3,098,000	2.65	0.48
1998	77	17	45	41	3,802,000	2.03	0.45
1999	74	12	38	38	3,204,000	2.31	0.37
2000	80	22	71	68	3,930,000	2.04	0.56
2001	72	18	60	59	2,997,000	2.40	0.60
2002	60	18	35	35	2,911,000	2.06	0.62
2003	73	18	42	40	2,927,000	2.49	0.61
2004	66	23	64	63	3,238,000	2.04	0.71
2005	65	11	18	16	3,815,000	1.70	0.29
2006	52	10	16	16	3,742,000	1.39	0.27
2007	62	14	43	43	4,033,000	1.54	0.35
2008	58	20	69	69	3,205,000	1.81	0.62
2009	47	2	17	14	2,875,000	1.63	0.07

NOTES:
- 2009 data are preliminary.
- Flight hours are estimated by the Federal Aviation Administration (FAA). Miles flown and departure information for on-demand Part 135 operations is not available.

SOURCE: http://www.ntsb.gov

Because of the NTSB's very broad definition of an accident (any incident that involves, e.g., a broken bone is classified as an accident), the United States experiences an average of close to 36 reportable accidents involving scheduled and nonscheduled air service each year. However, serious accidents, those involving fatalities, are much rarer. The average number of fatal accidents from 1990 to 2009 has been about per year for scheduled and nonscheduled (Part 121) operations. Over this same period scheduled and nonscheduled (Part 121) departures increased from 8.1 million to 10.4 million having reached a high point of 11.5 million departures in 2000 before the terrorist incidents of September 11, 2001. Clearly, the trend in fatal accident rates in the United States is in the desired direction; however, the worldwide trend in developing third world aviation countries is not so optimistic.

The 1980s. In the NTSB's first 15 years, airline safety improved steadily. In 1967, the airline fatal accident rate was 0.006 for every 1 million aircraft miles flown. By 1980, this rate was down to 0.001, a reduction of 83 percent. And on January 1, 1982, U.S.

transport. The period spanned 1980 and 1981; never before had there been even one calendar year without such an accident. The previous record had been 15 months, from September 1971 to December 1972. The airlines flew more than half a billion passengers on more than 10 million flights in the 26-month period—more than half a trillion passenger miles. The aerial transportation involved would have taken every man, woman, and child in the country on a flight of more than 2000 miles.

Just 13 days into 1982, the air carriers' remarkable record came to a shattering end when Air Florida Flight 90, a Boeing 737, taking off from Washington National Airport, crashed onto a bridge in a snowstorm. Seventy passengers, four crewmembers, and four persons on the bridge were killed. There were five fatal accidents in 1982 that produced a fatal accident rate of 0.057 per 100,000 aircraft hours. This rate was down 7 percent from the 0.061 recorded in 1981, when there were four bizarre single-fatality accidents. The fatality total, however, was 235, the third highest in a decade, compared with 4 in 1981 and none in 1980.

In 1983, the commuter airlines achieved sharply lower accident rates for the second successive year. The commuters had only 16 total accidents, 2 of them fatal, compared to 26 total accidents in 1982, of which 5 were fatal. Fatalities dropped from 14 to 11. The rate of 0.687 total accident per 100,000 departures, the rate most often used to measure commuter safety, was 46 percent lower than that in 1982.

The scheduled airlines had 4 fatal accidents in 1983 that produced 15 fatalities. There were 22 total accidents in 1983 compared with 16 in 1982 for a 1983 rate of 0.318 total accident per 100,000 aircraft hours.

Only 13 accidents, fatal and nonfatal, occurred in scheduled airline service in 1984. A record low, this produced a total accident rate of 0.229 per 100,000 departures. By comparison, the same rate was almost 3 times higher, 0.659, in 1975.

By the end of 1984, there had not been a catastrophic crash of a U.S. turbojet airliner since the July 9, 1982, takeoff crash of a Pan American B-727 at New Orleans. That period of nearly 30 months marked the second time since 1979 that the airlines had operated for more than 2 years without a catastrophic crash of a jet airliner.

The year 1985 began in tragedy. On January 1, Eastern Airlines Flight 980, a B-727 smashed into the side of Mount Illimani, Bolivia, 22,000 feet above sea level during a descent for landing into La Paz. All 29 passengers and crew were killed. Although an NTSB-led expedition reached the accident site, deep snow, and severe cold made recovering any of the bodies or the cockpit voice and flight data recorders impossible.

The Bolivian accident was the first of 13 fatal U.S. commuter and major airline accidents in 1985, in which 563 people died. In addition to the Bolivian accident, major accidents involving substantial loss of life included these two serious crashes:

- Delta Airlines Flight 191, a L-1011 TriStar aircraft which slammed into the ground as it encountered a wind shear on final approach into the Dallas–Fort Worth airport on August 2. *Fatalities:* 135. This accident prompted major changes in FAA training and improvements in Doppler radar weather technology.
- A military-chartered DC-8, Arrow Air Flight 1285, which crashed on takeoff

Although the loss of life in commercial passenger flights was higher in 1985 than in any previous year in the 1980s, the overall record for U.S. civil aviation, as judged by accident rates and fatal accidents, was mixed.

For the scheduled (Part 121) airlines, the fatal accident rate of 0.066 per 100,000 departures in 1985 was more than 3.5 times that of 1984. For unscheduled (Part 121) airline service (the charters), the fatal accident rate of 1.261 per 100,000 departures was more than twice that of 1982, the last year before 1985 where there had been a fatal charter airline accident. In 1985, the total number of fatalities for both the scheduled and nonscheduled (chartered, Part 121) airlines was 526, making it the second-worst year in history for accidents involving U.S. air carriers. Only in 1977, when two charter B-747s collided on the runway at Tenerife Airport in the Canary Islands, were fatalities higher.

After 21 accidents and 5 fatalities in 1986, major mishaps of large, scheduled (Part 121) U.S. airlines hit a 13-year high in 1987 with 32 accidents, resulting in 231 deaths. This number was the highest since 42 accidents occurred in 1974 when departures were almost one-half of those in 1987. The 32 accidents for scheduled airlines resulted in an accident rate of 0.425 per 100,000 departures, up from the 0.289 (a 47 percent increase) recorded in 1986. However, the fatal accident rate of 0.041 represented an almost 200 percent increase from the year before. Among the major fatal accidents in 1987 was:

- Northwest Airlines Flight 255, an MD-82, crashed after liftoff from Detroit Metropolitan Wayne County International Airport due to the flight crew's failure to use the checklist to ensure the flaps and slats were extended for takeoff. *Fatalities:* 156, including 2 on the ground.

In the commuter or regional airlines, there also was a sharp turnabout from 1986. There were 33 accidents in 1987, of which 10 were fatal—the highest since 38 accidents were recorded in 1980. Fatalities hit an 8-year high of 59. There were 1.174 accidents per 100,000 departures, compared with 0.50 in 1986. The fatal accident rate of 0.356 rose from 0.071 in 1986 to the highest level since 1979.

Accident rates for U.S. scheduled air carriers declined in 1988 from the year before. According to the NTSB's statistics, there were 29 major air carrier accidents in 1988, which is 3 less than in 1987. Of the 29 accidents, 3 were fatal, resulting in 285 fatalities. The accident rate dropped from 0.425 per 100,000 departures in 1987 to 0.381 in 1988. The fatal accident rate fell from 0.041 per 100,000 departures to 0.027.

Commuter airline accidents decreased from 33 in 1987 to 18 in 1988. There were only 2 fatal accidents, compared to the 10 that occurred the previous year, with fatalities down from 59 to 21. The accident rate was 0.619 per 100,000 departures, compared with 1.174 in 1987, for the second-lowest rate in this decade.

The NTSB investigated two unusual major aviation accidents in 1988:

- Aloha Airlines Flight 243, which suffered an explosive decompression caused by [illegible] able to land safely in Maui with only one fatality. The U.S.

Congress passed the Aviation Safety Research Act of 1988 in the wake of the disaster which provided for enhanced research in the critical areas of aircraft maintenance and structural technology.

- Pan Am Flight 103, the explosion of a B-747 in the sky over Lockerbie, Scotland on December 21, 1988, claiming all 259 persons on board and an estimated 11 on the ground. When British investigators announced a week later that the aircraft was brought down by a bomb, the tragedy became the most deadly act of sabotage ever perpetrated against a U.S. airliner.

Although the total accident rates for U.S. air carriers and commuters declined in 1989, the fatal accident rates rose. The actual number of fatal accidents for the air carriers was the highest since 1968.

There were 28 accidents involving major U.S. scheduled and charter airlines in 1989, down from 30 in 1988. Of those 28, 11 involved fatalities, which was the highest since 15 fatal accidents in 1968. The fatal accident rate of 0.144 per 100,000 departures was the highest of the decade, up from 0.026 in 1988.

The major U.S. scheduled airlines suffered 24 accidents in 1989, down from 29 in the previous year. Of those 24, eight involved fatalities, the most since 1973. Of the 131 fatalities registered in 1989, 111 of them occurred in the crash of Flight 232, a United Airlines DC-10 in Sioux City, Iowa, on July 19, 1989, due to a fatigue crack in the engine, resulting in explosion and catastrophic loss of hydraulic pressure. United Flight 232's captain credited Crew Resource Management (CRM) techniques for saving the lives of the 185 survivors of this crash.

Commuter air carriers had 19 accidents in 1989, which is one more than in the previous year. The five fatal accidents, up from 2 in 1988, resulted in 31 fatalities, 10 more than in 1988. The 0.674 accident rate per 100,000 departures was slightly higher than the 0.619 rate in 1988, but the fatal accident rate rose from 0.069 to 0.177.

THE 1990s. The decade of the 1990s started off favorably with a decline in all accident rates for the scheduled, nonscheduled, and commuter air carriers in 1990.

The major U.S. scheduled airlines experienced 25 accidents in 1991, up slightly from the previous year. Of those 25, four involved fatalities. Of the total 62 fatalities in 1991, 59 involved two major accidents:

- On February 1, 1991, U.S. Air Flight 1493, a B-737, collided with a Skywest Metroliner on the runway while landing at Los Angeles International Airport (LAX). Both planes were destroyed in the accident, which killed 34 persons. The cause of the accident was a situational awareness human error made by an air traffic controller at this extremely busy airport. This type of accident is known as a classic "runway incursion" which has been on the list of the NTSB's most wanted safety improvements for many years.
- On March 3, 1991, all 25 persons aboard United Airlines Flight 585, a B-737, were killed when the plane crashed after an uncontrolled rudder flight problem

during final approach to Colorado Springs. The aircraft was approximately 1000 feet above the ground when the upset occurred. The Boeing 737 had an enviable safety record until that time, and the cause of this accident was undetermined by the NTSB for a number of years. Later similar 737 rudder problems near Pittsburgh and Richmond provided answers to solve the perplexing mystery of this accident.

Overall, commuter air carriers were involved in 23 accidents in 1991, resulting in 99 fatalities, the largest number in two decades. Fatal accidents per 100,000 departures rose from 0.095 in 1990 to 0.284, an increase of 200 percent.

In 1992, there were seven fatal commuter accidents, compared to eight in 1991. The number of fatalities aboard commuter air carriers dropped to 21 from 77 a year earlier. The accident rate for commuter airlines had not yet become a major concern to the flying public.

Scheduled air carriers recorded four fatal accidents and 33 fatalities in 1992, compared to the same number of accidents and 62 deaths in the year before. The 33 fatalities represented the lowest number of deaths since 1986, when five persons in that category died.

In 1993 the major scheduled airlines experienced only one fatal accident, that involving a ground crewmember being struck by a propeller. The fatal accident rate of 0.013 per 100,000 departures was the lowest since 1980, when there were no fatal accidents among the scheduled airlines.

Paradoxically, the scheduled air carriers experienced more accidents in 1993 (22) than in the previous year (16), resulting in a higher total accident rate, 0.285 versus 0.213.

The fatal accident rate for commuter airlines dropped from 0.225 to 0.111 per 100,000 departures, but fatalities rose from 21 in 1992 to 24 in 1993. The total accident rate dropped from 0.706 to 0.444.

In 1994 the scheduled air carriers had 19 accidents, four of them fatal, for a total of 239 deaths, versus 22 accidents and one fatality in 1993.

- On July 2, USAir Flight 1016, a DC-9 approaching Charlotte/Douglas International Airport, with thunderstorm activity in the area, crashed when the crew encountered a windshear and attempted to abort the landing. There were 37 fatalities; 20 people on board survived the accident. This brought to an end a 27-month period in which the major U.S. scheduled airlines did not suffer a passenger fatality.
- On September 8, USAir Boeing Flight 427, another 737-300 aircraft crashed while on approach to the Greater Pittsburgh International Airport. All 132 people on board were killed, and the plane was destroyed by impact, making it one of the worst aviation accidents in U.S. history. This accident was extremely similar to the United Flight 585 rudder control problem which occurred in Colorado Springs. Again, NTSB investigators were baffled at the cause of the uncontrolled rudder problem until another 737 survived a similar situation near Richmond in 1996. A thermal shock test finally confirmed that the 737 rudder could be subject to a hard over rudder reversal under certain conditions and it

- Finally, on October 31, a Simmons Airlines ATR-72, operating as American Eagle flight 4184, crashed south of Roselawn, Ind. The flight, en route from Indianapolis to Chicago's O'Hare Airport, had been placed in a holding pattern for about 32 minutes because of traffic delays. The weather conditions during the period of holding were characterized by icing, a temperature near freezing and visible moisture. All 64 passengers and four crewmembers were killed in the accident.

The 1994 fatal accident rate per 1 million miles flown for scheduled service rose to 0.0008, compared with 0.0002 in 1993. Per 100,000 aircraft departures, the fatal rate was up to 0.051 from 0.013.

Nonscheduled air carriers experienced their fifth consecutive year without a fatality. There were four accidents, compared with one in 1993. The 1994 total accident rate per 1 million miles flown was 0.0109 versus 0.0032 in 1993; 0.481 per 100,000 aircraft hours versus 0.138; and 0.967 per 100,000 departures versus 0.285.

Commuter air carrier fatalities rose from 24 persons to 25 in 10 accidents in 1994, of which three were fatal. There were 16 accidents in 1993, including four fatal. The 1994 fatal accident rate per 1 million aircraft miles flown declined to 0.005 from 0.007 in 1993, while the rate per 100,000 departures fell to 0.084 from 0.111 the year before. It was the fourth consecutive annual decline in accident rates.

The 1995 fatal accident rate per 1 million miles flown for the scheduled airlines declined to 0.0004 from 0.0008 the year before. Based on 100,000 departures, the fatal rate was 0.025, down from 0.051 in 1994.

- The fatal mountain crash of American Airlines Flight 965, a B-757, near Cali, Colombia in December, 1995, was the result of a navigation error entered in the aircraft's Flight Management System (FMS). This accident is a classic "Controlled Flight into Terrain" (CFIT) situation which caused 160 deaths.

The Part 121 charter airlines, after 5 years without fatalities, had two deaths in 1995 for a fatal accident rate per 1 million miles flown of 0.0031, and 0.284 in terms of 100,000 departures.

Commuter or regional airline fatalities dropped to nine persons from 25 in 1994. The fatal accident rate fell both in terms of million miles flown to 0.0036 from 0.005 in 1994, and from 0.084 to 0.062 in terms of 100,000 departures. It was the fourth consecutive annual decline in fatal accident rates.

Total accidents for the scheduled airlines declined slightly in 1996 from 34 to 32, but the three fatal accidents resulted in the loss of 342 persons.

- On May 11, 1996, ValuJet flight 592, a DC-9, crashed into the Everglades shortly after takeoff from Miami International Airport, en route to Atlanta. All 105 passengers and five crewmembers aboard were killed. This accident was caused by the improper packaging and storage of hazardous materials (oxygen canisters) which

- On July 17, 1996, TWA flight 800, a Boeing B-747 on a regularly scheduled flight to Paris, France, crashed into the Atlantic Ocean off the coast of Long Island, N.Y., shortly after takeoff from John F. Kennedy International Airport. All 230 people on board the aircraft were killed. The cause of the accident was an explosion from a short circuit electrical charge entering a fuel tank during an extended ground delay. These two disastrous crashes in 1996 resulted in the highest number of fatalities for a single year during the past two decades. The 1996 fatal accident rate per 100,000 departures for scheduled service increased from 0.025 to 0.038, and the rate per 100,000 flight hours rose from 0.016 to 0.023.

The nonscheduled carriers experienced five accidents, including two fatal ones, resulting in 38 fatalities. The total accident rate per 1 million aircraft miles almost doubled, from 0.0062 in 1995 to 0.0118 in 1996. The fatal accident rate per 100,000 departures increased from 0.284 to 0.530.

Commuter airlines had only one fatal accident in 1996. The fatal accident rate per miles, hours, and departures all declined for the fifth consecutive year. There were 90 accidents, including 29 fatal ones, for the air taxis during the same year, resulting in 63 fatalities. The accident rate per 100,000 hours declined to 2.80 from 3.02 in 1995, while the fatal accident rate declined to 0.90 from 0.97 in 1995.

The scheduled carriers experienced 44 accidents in 1997, an increase of 12 over the 32 in 1996. There were three fatal accidents, the same number as in 1996, which resulted in three fatalities. Given the increase in miles and hours flown and departures, the accident rates stayed about the same for the years 1996 and 1997.

Under the Commuter Safety Initiative, Effective March 20, 1997, aircraft with 10 or more seats were required to conduct scheduled passenger operations under 14 CFR 121, which resulted in a significant reduction in miles and hours flown and departures for the commuter air carriers that formerly operated under 14 CFR 135. Total accidents increased from 11 in 1996 to 16 in 1997, while fatal accidents rose during the same period from 1 to 5. As a result, the total accident rate per 1 million miles increased from 0.019 in 1996 to 0.065 in 1997. The rates per 100,000 aircraft hours went from 0.399 to 1.628 and, per 100,000 departures, rose from 0.313 to 1.148 during the same period.

In 1998, the scheduled air carriers experienced only one fatal accident and two fewer total accidents than in 1997. As a result, all accident rates declined. Charter air carriers had a total of seven accidents, an increase of two over 1997. There were no fatal accidents in 1998 or 1999. Commuter airlines also had an exceptionally good year in 1998 with total accidents being halved, from 16 to 8 and no fatal accidents. However, as previously noted in Chapter 1, the fatal crash of Colgan Air Flight 3407 in February of 2009 would result in significant changes in commuter airline operations. The total rate per 100,000 aircraft hours decreased from 2.65 to 2.03, and the fatal rate per 100,000 aircraft decreased from 0.48 to 0.45.

Scheduled commuter carriers recorded 13 total accidents, including five fatal ones with a loss of 12 persons in 1999. On June 1, 1999, American Airlines Flight 1420, an MD-82 landing in a thunderstorm with windshear conditions, overran the end of the runway, went down an embankment, and hit approach light structures at the Little Rock Airport. There were 11 fatalities, including the aircraft captain.

The nonscheduled carriers experienced five total accidents in 1999, 2 less than in 1998. The total accident rate per 1 million aircraft miles fell from 0.0178 to 0.0121, while the rate per 100,000 departures was reduced from 1.575 to 1.116.

Commuter airline accidents increased to 13 in 1999 versus 8 in 1998, and fatal accidents increased from none in 1998 to 5 in 1999. Combined with the decline in total operating statistics caused by more commuters becoming Part 121 operators, accident rates increased by 58 to 71 percent across the board between 1998 and 1999.

THE 2000s. The start of the new millennium saw an increase in total accidents to 51 from 47 in 1999 for scheduled Part 121 carriers. In 2000, there were three fatal accidents resulting in 92 deaths, as opposed to two fatal accidents resulting in 12 deaths in 1999. This equated to a 50 percent increase in the rate of fatalities per 100,000 departures between the two years. Chartered Part 121 operations continued to have no fatal accidents in 2000. Commuter Part 135 operations had only one fatal accident (as opposed to five in 1999) that resulted in five deaths (as opposed to 12 in 1999). This translated to a 78 percent reduction in the 2000 fatal accident rate of 0.164 per 100,000 departures over the 1999 rate of 0.744.

- On January 31, 2000, Alaska Airlines Flight 261 (McDonnell Douglas MD-83), en route from Puerto Vallarta, Mexico to San Francisco, California, reported control problems with its horizontal stabilizer and a loss of stability before it crashed into the Pacific Ocean near Point Mugu, California. There were 88 fatalities.
- On July 25, 2000, Air France Flight 4590, a Concorde SST, crashed on takeoff from Charles de Gaulle International Airport near Paris after striking a titanium metal strip on the runway from a Continental DC-10. The metal strip punctured a tire of the Concorde and debris ruptured a fuel tank causing a serious fire from which the Concorde could not recover. This type of damage is known as Foreign Object Damage (FOD) when it strikes another aircraft. There were 109 fatalities. This accident marked the beginning of the end of Concorde Supersonic Transport Service, since the aircraft was retired 3 years later due to safety concerns and lack of passengers in the wake of the 9/11 terrorist attacks in New York and Washington.
- On August 23, 2000, Gulf Air Flight 072, an Airbus 320, crashed into the Persian Gulf near Manama, Bahrain due to spatial disorientation. There were 143 fatalities.
- On October 31, 2000, Singapore Airlines Flight 006, a Boeing 747, crashed on takeoff at Taipei, Taiwan. There were 83 fatalities. The crew of this aircraft lost situational awareness in a rain storm and attempted to takeoff on a closed parallel runway, hitting several large pieces of construction/equipment.

The year 2001 changed the landscape of aviation for good. On September 11, four U.S. commercial aircraft (Part 121 scheduled) were crashed in separate acts of terrorism that collectively killed 265 individuals on board (and several thousands on the ground). Aviation Security will be covered in detail in Chapter 11. The four aircraft involved in the attacks on September 11, 2001 were as follows:

- American Airlines Flight 11, a B-767 which departed from Boston and struck the north tower of the World Trade Center in New York City.
- United Airlines Flight 175, a B-767 which departed from Boston and struck the south tower of the World Trade Center in New York City.
- American Airlines Flight 77, a B-757 which departed from Dulles and struck the Pentagon in Washington.
- United Airlines Flight 93, a B-757 which departed Newark and crashed in a field near Shanksville, PA.

This tragic day, coupled with two other fatal crashes, resulted in a total of 531 fatalities for Part 121 operations—the worst on record since the 1977 runway collision between two 747s at Tenerife Airport in the Spanish Canary Islands which resulted in the loss of 583 lives. If one were to discount the four terrorist disasters, Part 121 operations had only two fatal accidents (one less than in 2000), but this resulted in 266 deaths—almost a threefold increase over that in 2000. While the fatal rate per 1 million miles flown was not significant between the 2 years, the fatal rate per 100,000 departures actually decreased by 26 percent in 2001. The Part 121 nonscheduled operations continued to have no fatal accidents. Part 135 commuter operations had two fatal accidents (compared to one in 2000), resulting in 13 deaths—eight more than in 2000. This resulted in a 2.5-fold increase in the accident rate per 100,000 departures to 0.402.

- On November 12, 2001, American Airlines Flight 587, an Airbus 300-600 experienced a loss of control upon initial climbout and crashed into a residential area in Queens, NY killing 265. The accident was caused by excessive overuse of the rudder to counter a wake turbulence problem, resulting in a separation of the vertical stabilizer from the aircraft.

The following is a summary of major international and U.S. aircraft accidents which occurred for the remainder of the decade ending in 2010:

- On April 15, 2002, Air China Flight 129, a B-767 from Beijing to Busan South Korea crashed into a hillside during a circling approach in poor weather. There were 129 fatalities in this controlled flight into terrain (CFIT) accident.
- On May 7, 2002, China Northern Airlines Flight 6136, a MD-82 from Beijing to Dalian China crashed after a troubled passenger set the cabin on fire with gasoline to obtain the proceeds from seven insurance policies. There were 112 fatalities.

- On May 25, 2002, China Airlines Flight 611, a B-747 from Taiwan to Hong Kong broke up in flight and crashed due to a previous inadequate structural repair to the hull. There were 225 fatalities.
- On March 6, 2003, Air Algiers Flight 6289, a B-737, had an engine failure on takeoff, veered off the runway and crashed. There were 102 fatalities. Likewise, on July 8, 2003, Sudan Airways Flight 139, another Boeing 737, lost an engine and crashed with 117 fatalities.
- On January 3, 2004, Flash Airlines Flight 604, a B-737 from Egypt to France, crashed in the Red Sea with 148 fatalities. The cause of the accident was distraction of the pilot and spatial disorientation.
- On August 14, 2005, Helios Airways Flight 522, a B-737 traveling from Cyprus to Greece lost pressurization and crashed with 121 fatalities. The apparent cause of the accident was an improper setting of the cabin pressurization switch which incapacitated the crew and passengers due to hypoxia brought about by depressurization of the aircraft. The plane crashed near Athens after fuel starvation of the engines.
- On September 5, 2005, Mandala Flight 091, a B-737, crashed on takeoff in Indonesia. There were 117 fatalities. The cause of the accident was failure to use the checklist resulting in improper setting of the flaps and slats which were not placed in the takeoff configuration.
- On May 3, 2006, Armavia Flight 967, an A-320, crashed into the Black Sea at night on a missed approach in poor weather near Adler/Sochi airport in Russia. There were 113 fatalities. The cause of this accident was controlled flight into terrain (water) while climbing out with weather conditions below established minima. The official investigative report cited the psycho-emotional stress level of the captain, poor cockpit resource management, and air traffic control problems.
- On July 9, 2006, another domestic accident, S7 Airlines Flight 778, an A-310 from Moscow crashed in Siberia with 125 fatalities. The aircraft failed to decelerate on landing due to inadvertent movement of one throttle to the forward thrust position which caused the plane to overrun the runway and crash into a concrete barricade.
- On August 27, 2006, Comair Flight 191, a CRJ-100, crashed on takeoff from Lexington, Kentucky. The aircraft took off on the wrong (short) runway due to a loss of situational awareness and the crew's nonpertinent conversations in violation of the FAA "Sterile Cockpit Rule."
- On September 29, 2006, GTA Flight 1907, a new B-737-800, suffered a midair collision at Flight Level 370 with an Embraer Legacy business jet on a domestic flight over the Brazilian Amazon jungle. There were 154 fatalities. Although the Brazilian authorities initially charged the pilots of the Legacy with negligence, the NTSB report cited a combination of ATC errors that placed both aircraft on the same airway at the same altitude.
- On July 17, 2007, Tam Airlines Flight 3054, an A-320 on another domestic Brazilian flight, overran the runway and crashed on landing at Congonhas

Airport in Sao Paulo. There were 187 fatalities. The investigation indicated that the aircraft thrust reverser was deactivated, causing the plane to run off this short runway.

- On August 20, 2008, Spanair Flight JK 5022, a MD-82, crashed on takeoff in Madrid, Spain. There were 154 fatalities. The investigation indicated that after an interruption, the aircraft tried to take off in the wrong configuration with the flaps and slats retracted.
- Miracle on the Hudson—On January 15, 2009, US Airways Flight 1549 successfully ditched in the Hudson River near New York City after takeoff from LaGuardia Airport. The aircraft was disabled by striking a flock of Canadian Geese and lost thrust in both engines during its initial climb out after takeoff. All 155 occupants safely evacuated the airliner. The NTSB cited the excellent crew resource management, safety equipment, and fast rescue response from ferry boat operators.
- On February 12, 2009, Colgan Air Flight 3407, a Bombardier Dash 8 stalled and crashed on final approach to Buffalo, NY. There were 49 fatalities. The investigation revealed that the crew failed to monitor the airspeed in icing conditions and took an inappropriate response to the stick shaker stall alarm system, as well as failure to comply with the FAA Sterile Cockpit rule.
- On June 1, 2009, Air France Flight 447, an A-330 from Rio de Janeiro to Paris crashed into the Atlantic Ocean. There were 228 fatalities. The aircraft crashed in bad weather after receiving unusual airspeed indications from the plane's Pitot Static System.
- On May 22, 2010, Air India Express Flight 812, a B-737, crashed in Mangalore, India, after overshooting the runway and falling over a cliff on landing. Apparently, the aircraft was attempting to go around after landing long. There were 158 fatalities.
- On July 28, 2010, Air Blue Flight 202, an A-321, crashed into a mountain near Islamabad, Pakistan. There were 152 fatalities. This is a Controlled Flight into Terrain (CFIT) accident where the air traffic controller lost contact with the flight during dense fog and monsoon rain.

LOOKING FORWARD—2011 AND BEYOND

Looking forward in the United States, the Comair Flight 191 accident in Lexington, Kentucky, in 2006, and the Colgan Air Flight 3407 in Buffalo, New York, in 2009 changed the landscape of FAR Part 121 commercial aviation safety for the foreseeable future. The Airline Safety and Pilot Training Improvement Act, signed August 1, 2010, will certainly result in higher standards for pilot training, strong support for safety advocacy programs, and new pilot fatigue rules to improve air passenger safety. The FAA is on a very tight schedule to implement the requirements of this Act, and new FAR regulations will be forthcoming in the

Meanwhile, ICAO has taken a new approach to reducing the number of aviation accidents at the international level. A "High-level Safety Conference" (HLSC) was held at ICAO headquarters in Montreal in late March 2010 comprised of worldwide aviation safety leaders to consider new proactive safety management systems (SMS) concepts and formulate recommendations for improvement of key ICAO safety programs. As the result of HLSC 2010, the SMS proactive approach has been significantly strengthened and extended to ICAO member States through the State Safety Programme (SSP), a comprehensive system for the management of safety within a State.

Additionally, ICAO developed a Global Aviation Safety Plan (GASP) and published 12 Global Safety Initiatives in 2007 to be used as working tools to enhance international aviation safety where most needed. Since certain ICAO regions in the third world had twice the accident rate of modern aviation countries, ICAO recently decided to focus its limited resources to support States and regions whose safety performance was not at an acceptable level. In its 37th annual assembly, which concluded in October 2010, ICAO adopted two specific resolutions, ICAO Global Planning for Safety (Resolution A37-4) and the Universal Safety Oversight Audit Programme (USOAP) Continuous Monitoring Approach (Resolution A37-5). In the latter resolution, the assembly directed an evolution of the USOAP to achieve a continuous monitoring approach (CMA) which will incorporate the analysis of safety risk factors to be applied to assess the oversight capabilities of each member State. This CMA approach is one of the key elements of SMS which advocates continuous improvement as one if its precepts. Additional information on these future developments is provided in an article in the Flight Safety Foundation Magazine Aero Safety World, April 2010 edition entitled "A New Approach." (http://flightsafety.org)

OCCUPATIONAL ACCIDENT STATISTICS—DEPARTMENT OF LABOR, BUREAU OF LABOR STATISTICS (BLS) (www.bls.gov/iif/)

The death toll trend due to occupational injuries has been on the decline over the years because of new technology, stricter safety regulations, and a shift in the economy toward safer service-industry jobs. The Census of Fatal Occupational Injuries program reports that the preliminary count of fatal work injuries in the United States in 2009 was 4,340, down from a revised total of 5,214 in 2008. Overall, fatal work injuries are down 26 percent since 2006, having reached a 20-year peak of 6,632 in 1994.

The Bureau of Labor Statistics still remains the authoritative source for nonfatal occupational (work-related) illnesses and injuries in the United States. As mentioned in Chapter 4, the BLS in cooperation with OSHA and the states uses scientifically developed sample surveys to collect data on nonfatal injuries and illnesses. All deaths are reported directly to OSHA. The surveys exclude the self-employed, farms with fewer than 11 employees, private households, federal government agencies, and employees in state and local governments. The results are published in the *Standard Industrial Classification (SIC) Manual*, which was first developed and published in 1987. Information in the *SIC Manual* is published by industry type. Major groups are further divided into *industry groups* with each industry group having SIC codes within it.

One of the groups of relevance to aviation is Major Group 45, *Transportation by Air*. This Major Group contains Industry Group 451 (*Air Transportation, Scheduled, and Air Courier*), Industry Group 452 (*Air Transportation, Nonscheduled*), and Industry Group 458 (*Airports, Flying Fields, and Airport Terminal*). The other group of relevance to aviation is Major Group 37, *Transportation Equipment*. This Major Group contains Industry Group 372 (*Aircraft and Parts*). SIC codes contain a four-digit coding system to further identify industry segments.

NORTH AMERICAN INDUSTRY CLASSIFICATION SYSTEM (NAICS) (www.census.gov) Developed in cooperation with Canada and Mexico, the North American Industry Classification System (NAICS) is a profound change in government statistical reporting programs. NAICS uses a six-digit coding system to classify all economic activity into twenty service sectors. For example, the category of "Scheduled Air Transportation" is broken down into two codes as follows: 481111, "Scheduled Passenger Air Transportation" and 481112, "Scheduled Freight Air Transportation". The NAICS has been adopted to soon replace the Department of Labor's Standard Industrial Classification (SIC) coding system thus providing a new statistical tool in the area of occupational accident statistics.

The BLS Injuries, Illness, and Facilities program provides annual information on the rate and number of work related injuries, illnesses, and fatal injuries, and how these statistics vary by incident, industry, geography, occupation, and other characteristics. The number of nonfatal occupational injuries and illnesses reported in 2009 declined to 3.3 million cases, compared to 3.7 million cases in 2008. The total recordable case injury and illness incidence rate among private industry employers has declined significantly each year since 2003 when estimates were first published using NAICS data.

In recent years, the number of work-related fatalities, injuries, and illnesses has steadily decreased in the Air Transportation subsector, NAICS category 481. For example, the number of fatalities in this subsector decreased from 38 in 2008 to 28 in 2009, a reduction of over 26 percent. Similarly, the rate of injury and illness cases fell in the category of total recordable cases, cases involving days away from work, and cases involving days of job transfer or restriction. However, when compared with general industry injury and illness trends, the air transportation rates are 8.5 total recordable cases per 100 full-time workers which is nearly twice the national injury average. While general industry injury and illness trends have been at their lowest level in years, the air transportation sector could still use some significant improvement.

Like many collected data, the NAICS/BLS statistics do have some limitations. As ... There are also other sources

of error to which the data are subject. Some of these include the inability to obtain information about all cases in the sample, mistakes in coding or recording data, and definition difficulties. These statistics provide an estimate of workplace injuries and illnesses based on logs kept by employers during the year. The employer's understanding of which cases are work-related under OSHA's recordkeeping guidelines may not always be clear. Finally, the number of injuries and illnesses that get reported can be influenced by level of economic activity, working conditions and work practices, worker experience and training, and the number of hours worked.

KEY TERMS

- Safety factors
- Safety indicator
- (Safety) exposure data
- Accident rate
- Hull loss
- ICAO High Level Safety Conference (HLSC)
- State Safety Programme (SSP)
- Global Aviation Safety Plan (GASP)
- Universal Safety Oversight Audit Programme (USOAP)
- North American Industry Classification System (NAICS)
- NTSB accident definitions: major, serious, injury, damage
- *Standard Industrial Classification (SIC) Manual*
- OSHA injuries and illnesses
- Bureau of Labor Statistics (BLS)

REVIEW QUESTIONS

1. Why is the accident rate a better measure of safety than accident counts are?
2. Discuss some of the issues to be aware of in analyzing and comparing commercial aviation accident statistics.
3. What are hull-loss accidents and what are their primary cause? Describe the hull-loss accident trend since the early 1970s.
4. What is the most critical phase of flight? What are some lessons that can be learned from the Boeing summary?
5. Describe the general trend in aviation accidents during the 1980s and 1990s and 2000s.

6. Discuss future ICAO safety concepts and programs under the Global Aviation Safety Plan.
7. Explain how OSHA injury and illness rates are calculated.
8. What are SIC and NAICS codes and how are they used?

REFERENCES

Boeing, Commercial Airplane Co. 2010. *Statistical Summary of Commercial Jet Aircraft Accidents: Worldwide Operations* 1959–2009, Seattle, Wash., July 2010 http://www.boeing.com/

National Transportation Safety Board. 1982–2009. Annual reports. Washington, D.C. NTSB. http://www.ntsb.gov/

Web References

Flight Safety Foundation, http://flightsafety.org
International Civil Aviation Organization, http://www.icao.int/
North American Industry Classification System, http://www.census.gov/
OSHA statistics http://www.osha.gov/
U.S. Department of Labor, Bureau of Labor Statistics. www.bls.gov