NTSB/ARG-04/01
PB2004-105928

Annual Review of Aircraft Accident Data

U.S. General Aviation, Calendar Year 2000

National Transportation Safety Board
Washington, D.C.

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National Transportation Safety Board
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Washington, D.C. 20594

National Transportation Safety Board. 2004. *U.S. General Aviation, Calendar Year 2000*. Annual Review of Aircraft Accident Data NTSB/ARG-04/01. Washington, D.C.

Abstract: A total of 1,837 accidents occurred during calendar year 2000, involving 1,861 aircraft. The total number of general aviation accidents in 2000 was higher than in 1999, with a 4% increase of 69 accidents. Of the total number of accidents, 345 were fatal, resulting in a total of 596 fatalities. The number of fatal general aviation accidents in 2000 increased 1.5% over calendar year 1999, but the total number of fatalities that resulted decreased by 4%. The circumstances of these accidents and details related to the aircraft, pilots, and locations are presented throughout this review.

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2000 General Aviation Accident Summary

A total of 1,837 accidents occurred during calendar year 2000,[1] involving 1,861 aircraft. The total number of general aviation accidents in 2000 was higher than in 1999, with a 4% increase of 69 accidents. Of the total number of accidents, 345 were fatal, resulting in a total of 596 fatalities. The number of fatal general aviation accidents in 2000 increased 1.5% over calendar year 1999, but the total number of fatalities that resulted decreased by 4%. The circumstances of these accidents and details related to the aircraft, pilots, and locations are presented throughout this review.

2000 General Aviation Accident Statistics

General Aviation Accidents	
Total	1,837
Fatal	345
General Aviation Accident Injuries	
Minor	532
Serious	309
Fatal	596
Persons Involved in GA Accidents with No Injuries	1,853
General Aviation Accident Rate	
General Aviation Hours Flown[a]	27,838,000
All Accidents	6.57/100,000 Hours
Fatal Accidents	1.21/100,000 Hours
Accidents per Pilot	2.92/1,000 Active Pilots
Fatal Accidents per Pilot	0.55/1,000 Active Pilots

[a] Federal Aviation Administration, *General Aviation and Air Taxi Survey, 2000.*

[1] In this review, a collision between two aircraft is counted as a single accident. The 19 midair collision accidents that occurred in 2000 involved 34 general aviation aircraft and 4 non-general aviation aircraft. In addition, 11 ground collision accidents involved 20 general aviation aircraft and 2 non-general aviation aircraft.

Introduction

Purpose of the Review

The National Transportation Safety Board's 2000 Annual Review of Aircraft Accident Data for U.S. General Aviation is a statistical compilation and review of general aviation accidents that occurred in 2000 involving U.S.-registered aircraft. As a summary of all U.S. general aviation accidents for 2000, the review is designed to inform general aviation pilots and their passengers and to provide detailed information to support future government, industry, and private research efforts and safety improvement initiatives.

The Safety Board drew on several resources in compiling data for this review. Accident data, for example, were extracted from the Safety Board's Aviation Accident/Incident Database.[2] Activity data were extracted from the General Aviation and Air Taxi Activity Survey (GAATA Survey)[3] and from U.S. Civil Airmen Statistics,[4] both of which are published by the Federal Aviation Administration (FAA), Statistics and Forecast Branch, Planning and Analysis Division, Office of Aviation Policy and Plans. Additional information was extracted from the General Aviation Statistical Databook, published by the General Aviation Manufacturers Association (GAMA).

What Is General Aviation?

General aviation can be described as any civil aircraft operation that is not covered under 14 Code of Federal Regulations (CFR) Parts 121, 129, and 135, commonly referred to as commercial air carrier operations.[5]

Which Operations Are Included in this Review?

This review includes accidents involving U.S.-registered aircraft operating under 14 CFR Part 91, as well as public aircraft[6] flights that do not involve military or intelligence gathering operations. Aircraft operating under Part 91 include aircraft that are flown for recreation and personal transportation and certain aircraft operations that are flown with the intention of generating revenue,[7] including business flying, flight instruction, corporate/executive flights, positioning or ferry flights, aerial application, pipeline/powerline patrols, and news and traffic reporting.

Which Aircraft Are Included in this Review?

General aviation operations are conducted using a wide range of aircraft, including airplanes, rotorcraft, gliders, balloons and blimps, and registered ultralight, experimental, or amateur-built aircraft. The diverse set of operations and aircraft types included

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[2] See Appendix A for more details.

[3] Although included in the GAATA Survey, data associated with air taxi and air tour operations are not included in this review.

[4] FAA, U.S. Civil Airmen Statistics, 2000, available online at http://api.hq.faa.gov/CivilAir/index.htm.

[5] For a review of accident statistics related to air carrier operations, see National Transportation Safety Board, Annual Review of Aircraft Accident Data, U.S. Air Carrier Operations, Calendar Year 2000 (Washington, DC: 2003), available at http://www.ntsb.gov.

[6] Although the precise statutory definition has changed over the years, public aircraft operations for NTSB purposes are qualified government missions that may include law enforcement, low-level observation, aerial application, firefighting, search and rescue, biological or geological resource management, and aeronautical research.

[7] See 14 CFR 119.1.

within the scope of general aviation must be considered when interpreting the data in this review. The type of aircraft being flown is usually closely related to the type of flight operation being conducted. Jet and turboprop aircraft are commonly used for corporate/executive transportation, smaller single-engine piston aircraft are commonly used for instructional flights, and a variety of aircraft types are used for personal and business flights.

Not included in this review are any accident data associated with aircraft operating under 14 CFR Parts 121, 129, or 135, such as scheduled Part 121 air carrier operations, Part 129 foreign air carrier operations, scheduled Part 135 air carrier operations (commuters), and nonscheduled Part 135 air carrier operations (air taxis). Also not included are data for military or intelligence-gathering flights, non-U.S.-registered aircraft, unregistered ultralights, and commercial space launches unless the accident also involved aircraft conducting general aviation operations. Crashes involving illegal operations, stolen aircraft, suicide, or sabotage are included in the accident total, but not in accident rates.[8]

Organization of the *Annual Review*

The 2000 Annual Review is organized into four parts.

1. The first part summarizes general aviation accident statistics for 2000, economic and industry markers related to general aviation activity in 2000, and contextual statistics from previous years.
2. The second part investigates trends over the past 10 years and provides context for such accident information as operation types, levels of aircraft damage, and injuries.
3. The third part focuses on specific circumstances of accidents that occurred during 2000. This section describes accident occurrences and summarizes the Safety Board's findings of probable cause and contributing factors.
4. The fourth and final section presents in-depth coverage of a special topic important to general aviation safety. The 2000 Annual Review focuses on the landing phase of flight, which has historically accounted for the largest number of accidents.

Graphics are used to present much of the information in this review. For readers who wish to view tabular data or to manipulate the data used in this review, the data set is available online at http://www.ntsb.gov/aviation/Stats.htm.

[8] In 2000, two accidents were attributed to pilot suicide and four accidents resulted from stolen or unauthorized use of aircraft.

The General Aviation Environment in 2000

General Economic and Aviation Industry Indicators

A theme that is repeated throughout this review is that general aviation accident numbers should be interpreted in light of related information, such as aircraft type, type of operation, and operating environment. Because personal and business flying account for the largest percentage of general aviation (GA) flying, prevailing economic conditions and/or trends may noticeably affect both the general aviation industry and flight operations.

General Economic and Aviation Industry Indicators, 1980-2000

	1980	1990	2000
Resident Population (Millions)[a]	227.3	248.8	281.4
Gross Domestic Product (Billions)[b]	$4,901	$6,708	$9,191
Disposable Personal Income (Billions)[c]	$3,658	$5,01	$6,630
Disposable Personal Income Per Capita[c]	$16,063	$20,058	$23,501
Number of GA Aircraft Sold[d]	11,877	1,144	2,816
Net Factory Billings for GA Aircraft (Millions)[d]	$2,486	$2,008	$8,558
Value of New GA Aircraft Sold: Piston (Millions)[d]	$794	$92	$446
Value of New GA Aircraft Sold: Turbine (Millions)[d]	$1,691	$1,916	$8,112

[a]U.S. Census Bureau; data are available at <http://eire.census.gov/poptest/archives/pre1980/popclockest.txt>.
[b]Bureau of Economic Analysis, real gross domestic product, using chained 2000 dollars; data are available at <http://www.bea.doc.gov/bea/dn/gdplev.xls>.
[c]Bureau of Economic Analysis, chained 2000 dollars; data are available at <http://www.bea.gov/bea/dn/nipaweb/>.
[d]General Aviation Manufacturers Association, *General Aviation Statistical Databook*, 2002. Washington, D.C.

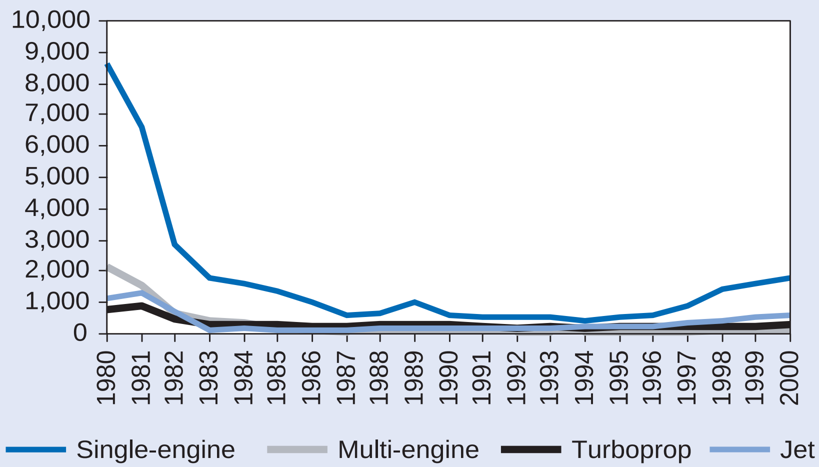
U.S. industrial and personal incomes grew steadily from 1980 through 2000. Between 1990 and 2000, the U.S. resident population increased by 13%, the gross domestic product rose by 37%, and disposable personal income per capita rose by 17%.

Economic indicators for the general aviation industry either declined or remained generally steady between 1980 and the mid-1990s. Production and sale of light piston aircraft, which account for most of the general aviation fleet, decreased substantially during these years from more than 10,750 in 1980 to about 500 in 1994. The total number of new general aviation aircraft shipped in 1994 was about 7% of the number shipped in 1980. However, overall factory billings for new aircraft were similar in 1980 and 1994 because the value of turbine aircraft sales increased, compensating for losses in piston aircraft sales.

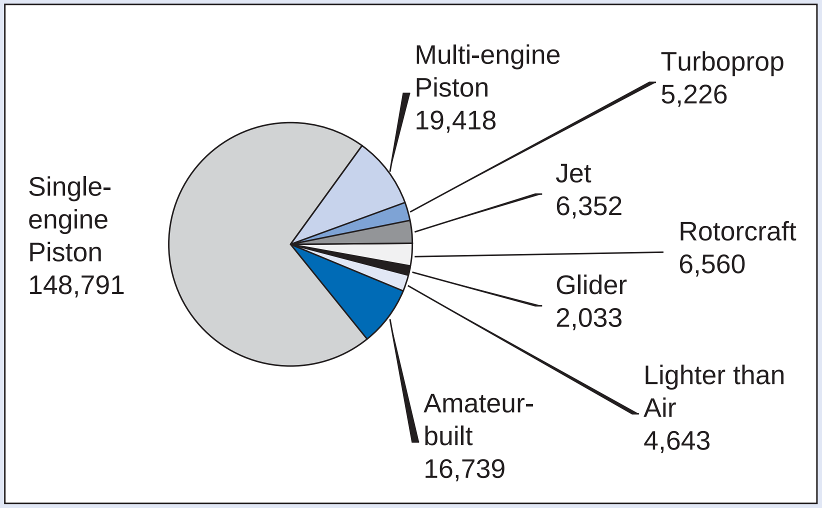
By 2000, general aviation industry indicators had increased noticeably. Aircraft shipments nearly tripled between 1995 and 2000, and the percent increase in net factory billings between 1995 and 2000 was equal to the total increase observed over the previous 20 years. This rapid growth was likely motivated by a combination of generally favorable economic conditions and increased general aviation aircraft production following the 1994 passage of the General Aviation Revitalization Act[9] limiting manufacturer liability.

[9] The General Aviation Revitalization Act, signed into law August 17, 1994, limited the liability of general aviation manufacturers to 18 years.

Annual Shipments of U.S.-Manufactured General Aviation Aircraft, 1980-2000



Number of Active Aircraft in General Aviation, 2000



Fleet Makeup

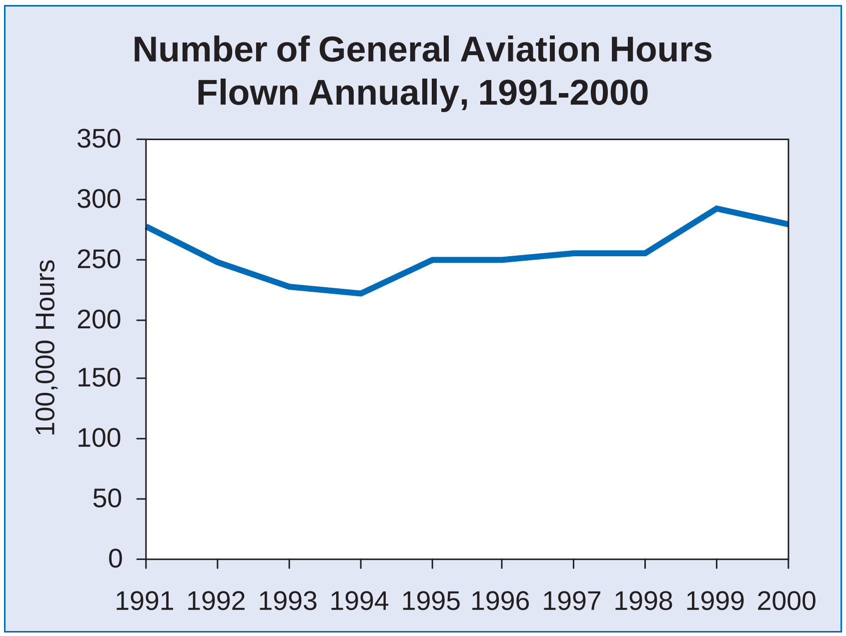
Although sales of new general aviation aircraft increased noticeably after the mid-1990s, most general aviation aircraft in use in 2000 were more than 25 years old. U.S. manufacturers delivered 2,816 new general aviation aircraft in 2000, compared to an estimated total of 213,500 already in service. Single-engine piston aircraft currently have the highest average age of all general aviation aircraft types and account for the largest percentage of the GA fleet. As a consequence, any structural or design changes incorporated into newly manufactured aircraft may not be reflected in the accident record for several years. The safety benefits of improved equipment such as avionics and aircraft equipment are also difficult to track because most new equipment is also available for installation in older aircraft.

Category	Engine Type	Seats	Average Age
Single-engine	**Piston**	1-3	28
		4	32
		5-7	25
		8+	43
	Turboprop	all	10
	Jet	all	27
Multi-engine	**Piston**	1-3	21
		4	28
		5-7	31
		8+	30
	Turboprop	all	19
	Jet	all	16
All Aircraft			**27**

GAMA, *General Aviation Statistical Databook*, 2000

General Aviation Activity

Because general aviation includes such a diverse group of aircraft types and operations, some measure of exposure must be considered to make meaningful comparisons of accident numbers. Flight activity is typically used to normalize accident numbers across different groups, with the level of activity corresponding to the level of exposure to potential accident risk. Total flight hours, departures, and miles flown are common indicators used to measure activity.



As the graph shows, annual general aviation flight hour estimates began to increase in 1994 after a decline during the preceding years. By 2000, the estimated number of general aviation flight hours was 29.1 million, the second highest number recorded annually from 1991 through 2000.

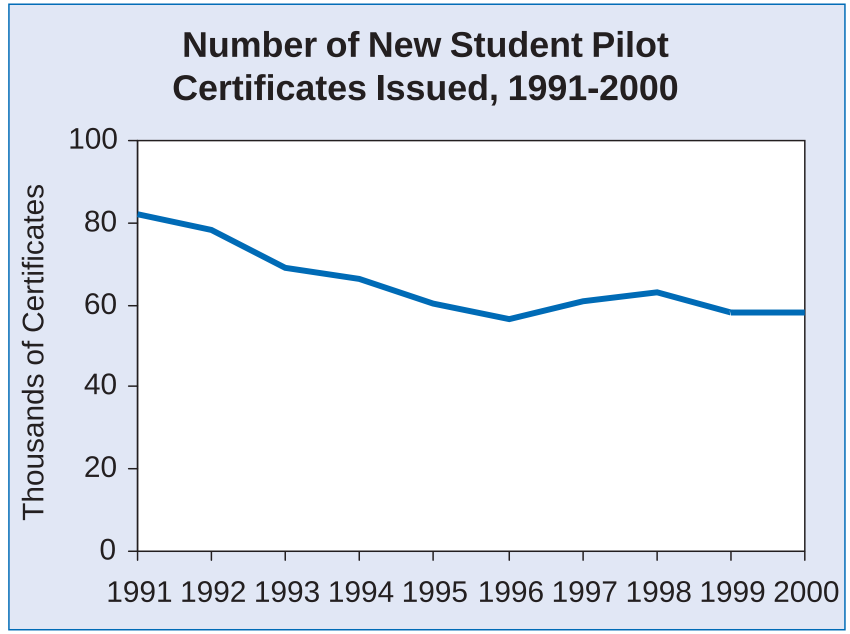
It should be noted that activity data for general aviation are far less reliable than data available for commercial air carriers. Unlike Part 121 and scheduled Part 135 air carriers, which are required to report total flight hours, departures, and miles flown to the Department of Transportation (DOT) Research and Special Programs Administration (RSPA),[10] operators of general aviation aircraft are not required to report actual flight activity data. As a result, activity for this group of aircraft must be estimated using data from the GAATA Survey.[11] The GAATA Survey was established in 1978 to gather information about aircraft use, flight hours, and avionics equipment installations from owners of general aviation and nonscheduled Part 135 aircraft. General aviation activity data are considered less reliable because a limited sample[12] of aircraft is selected from the registry of aircraft owners for use in the GAATA Survey, and reporting is not required.

[10] Part 121 operators report activity on a monthly basis, and scheduled Part 135 operators report quarterly.
[11] Available at http://api.hq.faa.gov/pubsarchive.asp.
[12] The 2000 GAATA Survey sample frame consisted of 290,269 registered aircraft, from which 31,039 records (10.7%) were selected in a sample stratified by state/territory and aircraft type. From that sample, 16,044 (52.2% of the sample and 5.5% of the total population) completed surveys were collected (GAATA Survey, Calendar Year 2000).

In addition, specific general aviation activity data could not be calculated in many cases because the survey data represented an aggregate of all aircraft activity, including both general aviation and nonscheduled Part 135 operations, which are not included in this review of general aviation accidents. Such aggregate data included the number of landings, flight hours by state or region, and flight hours by day/night or weather conditions. For this review, therefore, general aviation activity measures were determined by subtracting nonscheduled Part 135 data from activity totals whenever possible. Such data are not included in this review.

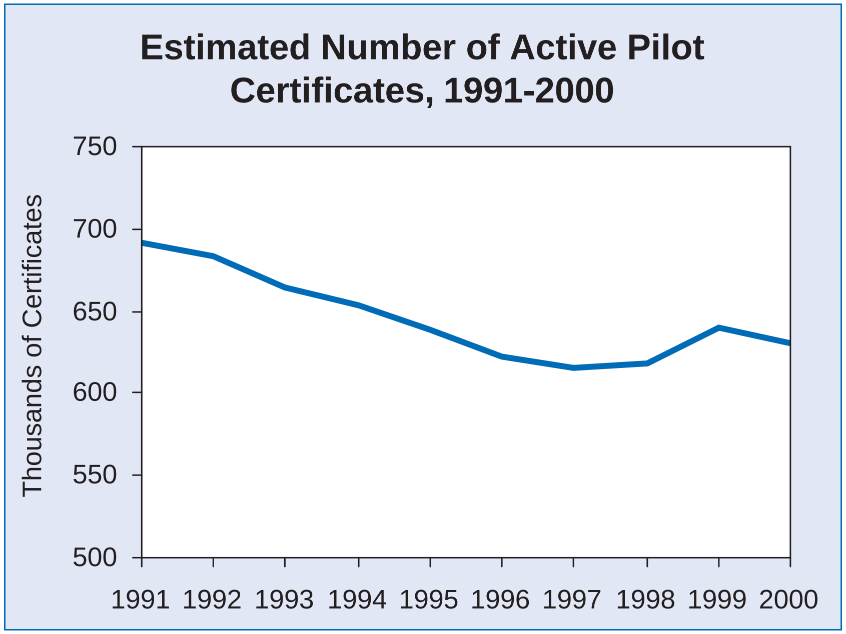
In addition to flight hour estimates, the number of pilots can be used to establish the level of exposure to risk for the various types of operations included in general aviation. Available measures of the pilot population include both the number of certificates issued to new pilots and medical certificates issued to active pilots. The number of new student pilot certificates represents positive growth in the pilot population, and the number of medical certificates issued represents an informal census of all active pilots.

From 1991 through 1996, the number of new student pilot certificates each year decreased steadily from 88,586 to 56,653.[13] The number fluctuated after 1996, but remained generally even, with a total of 58,042 new student certificates issued in 2000.



The total number of pilots active in U.S. general aviation decreased steadily throughout the early and mid 1990s, from 702,659 in 1991 to 622,261 in 1996. Between 1997 and 2000, the number of active pilots fluctuated, with an estimated total of 629,989 active U.S. pilots in 2000.

[13] FAA, U.S. Civil Airmen Statistics, available at http://api.hq.faa.gov/CivilAir/docs/air22-99.XLS.

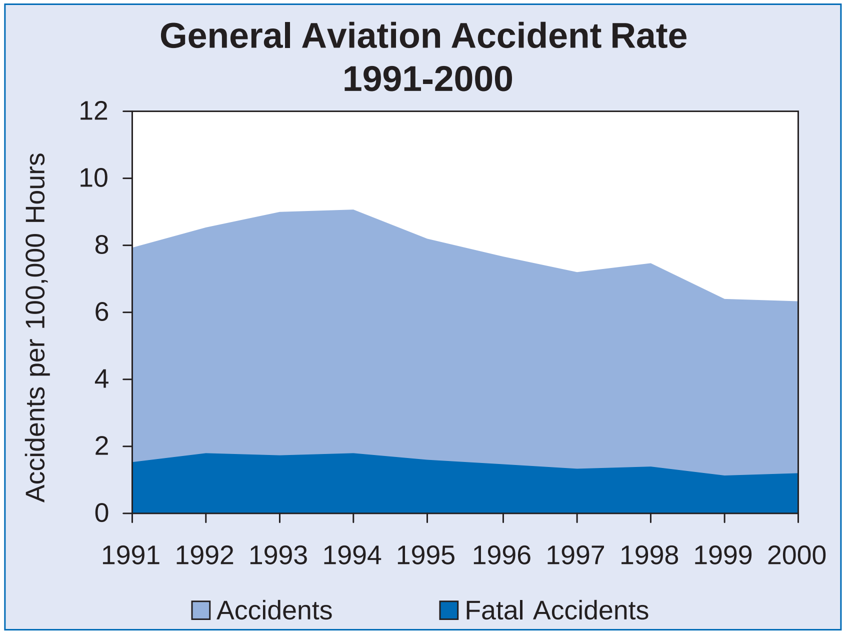


In summary, general aviation indicators—flight hours and the total number of active and newly issued pilot certificates—decreased annually between 1990 and about 1996. From 1996 through 2000, the number of active and new student pilots fluctuated at generally the same level while estimates of flight activity increased. The increase in estimated activity over the period had a noticeable effect on accident rate and should be considered when attempting to interpret the general aviation accident record for 2000 in the context of previous years.

Historical Trends in Accident Data

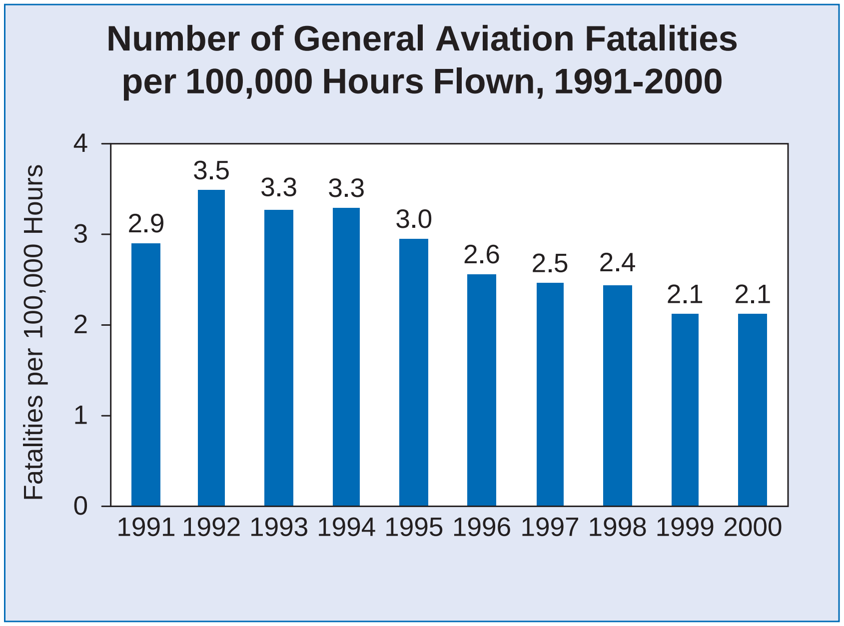
Accident Rates

After 1994, the calculated general aviation accident rate declined overall as annual estimates of general aviation activity increased noticeably[14] without a corresponding increase in the number of accidents. The rate of 6.57 accidents per 100,000 hours flown in 2000 was substantially lower than the 10-year high of 9.08 accidents per 100,000 hours in 1994. In fact, the 2000 rate was only slightly higher than that of 1999, which had the lowest rate since the Safety Board began reporting general aviation-only annual accident rates in 1975.[15] Despite the observed decrease in accident rate, the relative percentage of fatal accidents remained fairly constant from 1991 through 2000, at 18 to 21% of the total rate. The 2000 rate of 1.21 fatal accidents per 100,000 flight hours was only slightly higher than the 1999 fatal accident rate.

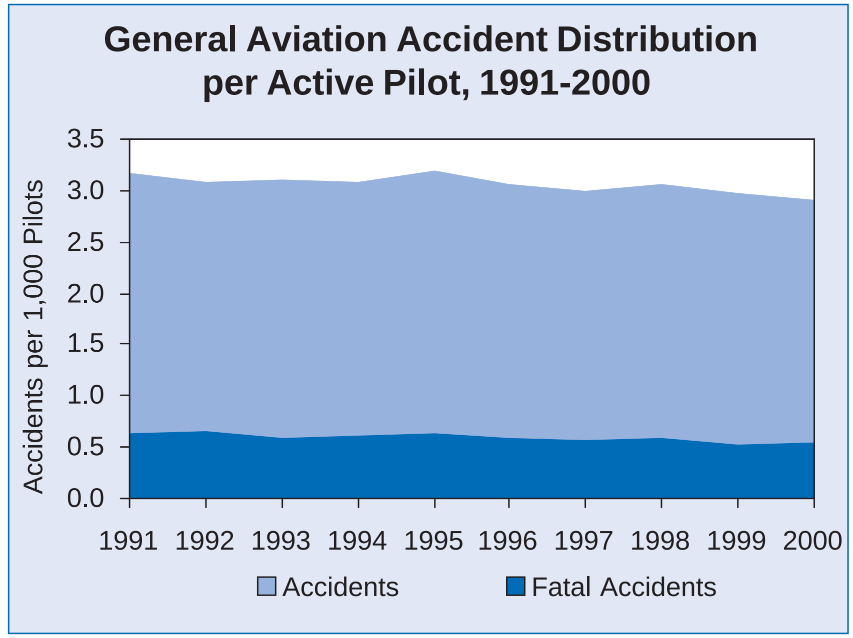


[14] FAA estimates of annual general aviation activity increased noticeably after 1998 due to a change in GAATA Survey methodology that increased the estimated GA aircraft population by approximately 10%. See Appendix A of the GAATA Survey, Calendar Year 2000 for an explanation of the changes in survey methodology.
[15] Prior to 1975, scheduled 14 CFR 135 "commuter" and non-scheduled 14 CFR 135 air taxi aircraft operations were included in the Safety Board's annual general aviation accident total and rate.

In 2000, the number of accident-related deaths per flight hour was equal to 2.1 fatalities per 100,000 hours flown, matching 1999 for the lowest fatality-per-hour rate of the 10-year period.



Another measure of accident distribution is the number of accidents per active pilot. Although this measure was considerably more stable from 1991 through 2000 than the per-hour accident rate, it did decrease slightly overall with the lowest number of accidents per pilot for the period occurring in 2000.

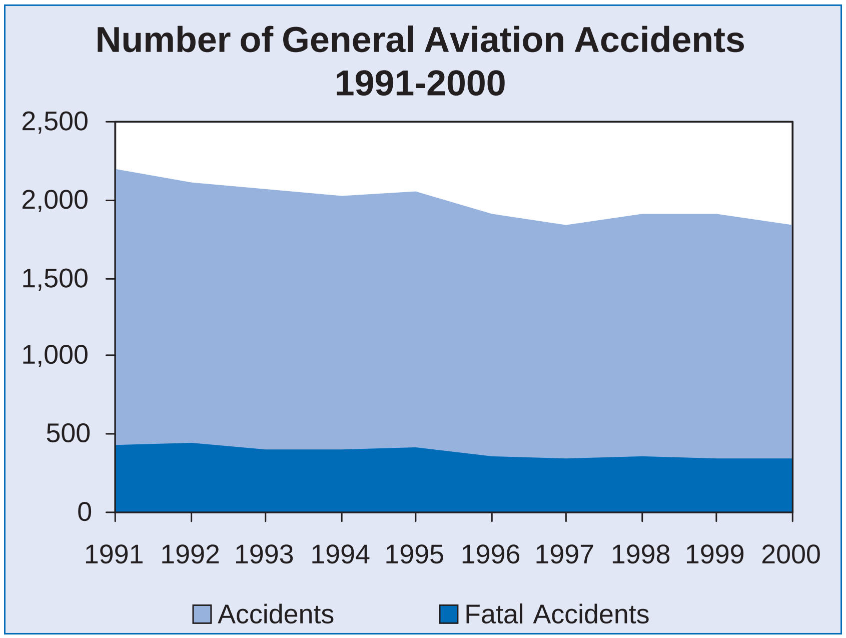


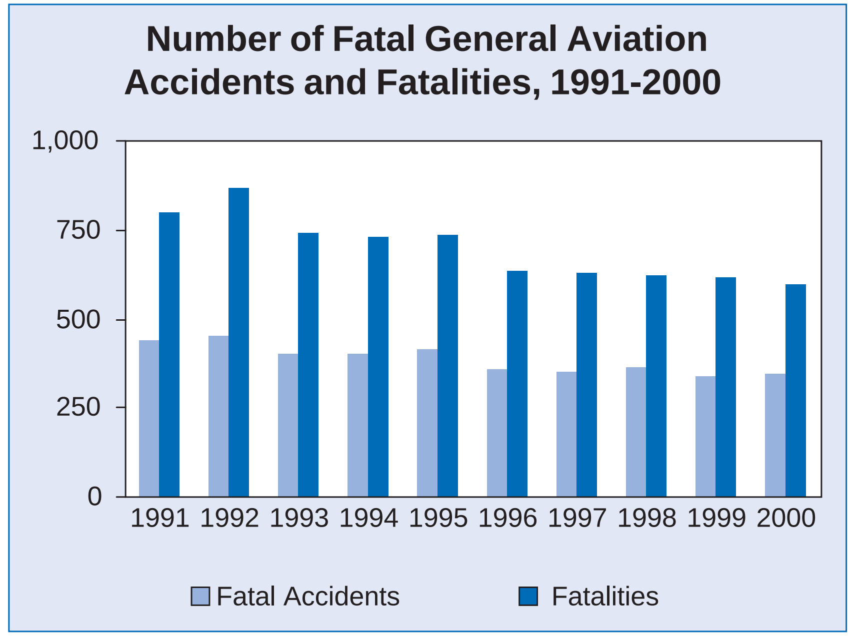
Accident rate calculations based on flight hours require the use of GAATA Survey activity data extrapolated from a relatively small sample of aircraft owners. As a result, the calculated values are accurate only to the extent that the sample represents the larger population of general aviation operators. For this reason, accident rate data presented in this review typically also include raw frequency data for comparison.

Number of Accidents and Fatalities

Although the number of general aviation accidents fluctuated slightly from year to year, the number of accidents that occurred annually between 1991 and 2000 declined overall from 2,197 in 1991 to a 10-year low of 1,837 in 2000. The number of fatal accidents also decreased slightly overall, from 439 in 1991 to 345 in 2000. The number of fatal accidents was up slightly from the 10-year low of 340 reached in 1999.

In 1992, the total number of fatalities resulting from general aviation accidents reached a high of 867. After that, the number of fatalities exhibited a generally downward trend and reached a record low of 596 deaths from 345 fatal accidents in 2000. This observed decline in fatalities was consistent with other trends for the 10-year period, which showed a decline in the number of active pilots, the number of accidents, and the number of fatal accidents.





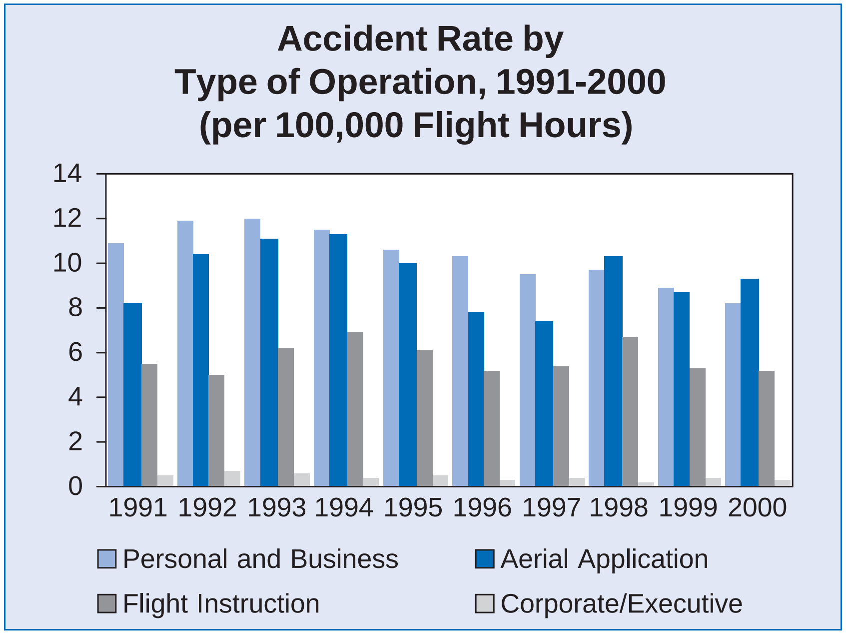
Accident Rate by Type of Operation

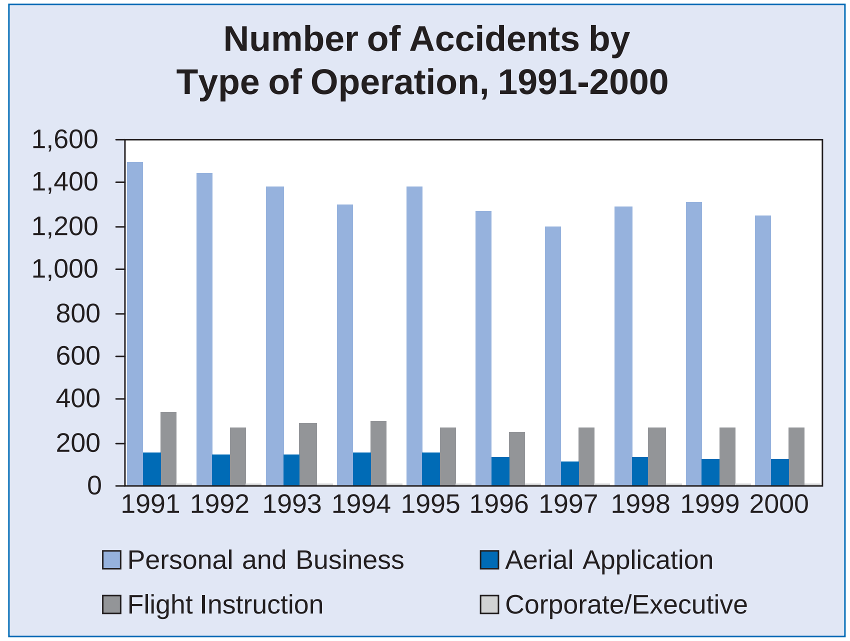
General aviation includes a wide range of operations, each with unique aircraft types, flight profiles, and operating procedures. This diversity is evident in the accident record. However, the flight data collected in the GAATA Survey allow for only a coarse representation of the many types of general aviation operations. For some types of operations, such as public aircraft flights,[16] no activity data are available. The data presented here include four operational categories selected because they are representative of general aviation and have activity information available. The categories selected as being typical of general aviation activity include personal/business flying,[17] corporate flying, aerial application, and instructional flights.

- Personal flying makes up the largest portion of general aviation activity and includes all flying for pleasure and/or personal transportation. Although similar to personal flying, business flying includes the use of an aircraft for business transportation without a paid, professional crew. Personal and business flights are typically conducted in single- and multi-engine piston airplanes, but may include a range of aircraft including gliders, rotorcraft, and balloons.
- Corporate flying includes any business transportation with a professional crew and usually involves larger, multi-engine piston, turboprop, and jet airplanes.
- Aerial application includes the use of specially equipped aircraft for seeding and for spraying pesticides, herbicides, and fertilizer. Aerial application is unique because it requires pilots to fly close to the ground.
- Instructional flying includes any flight under the supervision of a certificated flight instructor.[18] This typically includes both dual training flights and student solo flights. Aircraft used for instruction are often similar to those used for personal flying. However, instructional operations are unique because they often involve the repeated practice of takeoffs and landings, flight maneuvers, and emergency procedures.

From 1991 through 1999, personal and business flying had the highest average accident rate, followed by aerial application and instructional flights. In 2000, however, the accident rate for aerial application operations was 9.33 accidents per 100,000 flight hours. This rate exceeded the accident rate for personal/business operations, which had a rate of 8.22 accidents per 100,000 flight hours. The lowest accident rate was for corporate/executive transportation, which for the 10-year period ranked lowest overall each year. In 2000, at 0.27 accidents per 100,000 hours, the accident rate for corporate/executive flying was only 5% of the rate of instructional flying, the third-lowest rate.

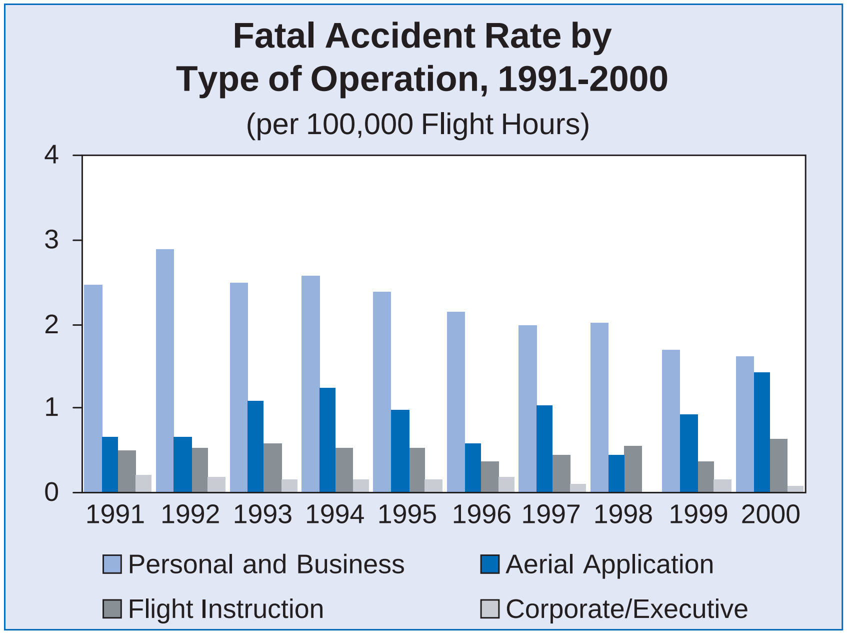
[16] The Annual Review, 2000 data include 37 public aircraft accidents, 12 of which resulted in one or more fatality.
[17] Because of the difficulty of accurately distinguishing between personal and business flying for both the activity survey and the accident record, the rate presented in this review is calculated using combined exposure data (hours flown).
[18] See 14 CFR Subpart H for flight instructor certificate and rating requirements.

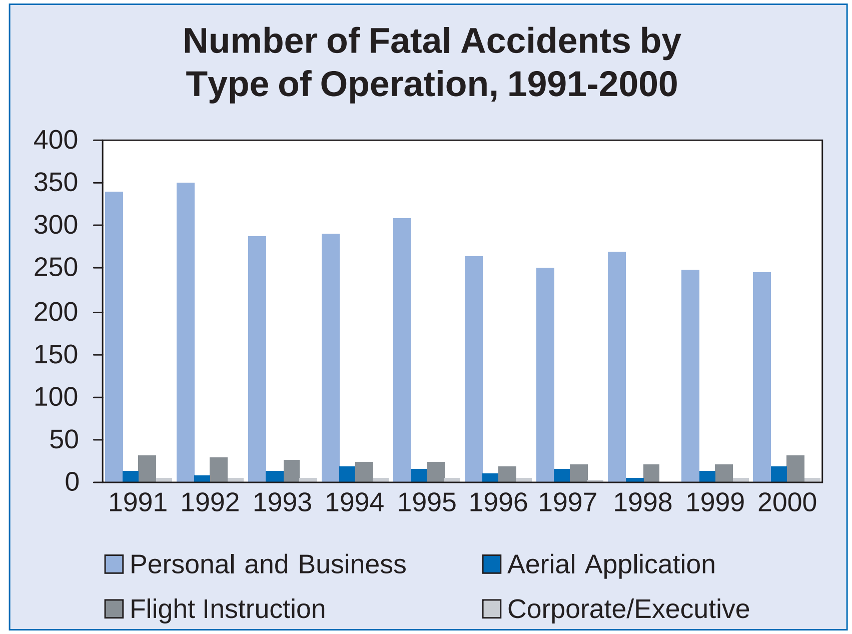




As previously mentioned, the highest percentage of general aviation accidents typically involves personal and business operations. Between 1991 and 2000, personal/business flying accounted for an average of 67.1% of all general aviation accidents. In 2000, 66.8% of all general aviation accidents involved personal/business flying, a percentage consistent with the 10-year average. Instructional flying accounted for the next highest percentage with 14.2% compared with a 10-year average of 14.0% of all general aviation accidents. The lowest number of accidents from 1991 through 2000 involved corporate/executive flights. Averaging less than 12 accidents per year, annual totals for corporate/executive accidents are barely visible when graphed in comparison to accidents involving other types of operations.

Throughout the 10-year period, the combined category of personal/business flying also had the highest fatal accident rate. Except for the year 2000, the rate was typically more than double the rate for any other type of flying.





An average 286 fatal accidents per year were associated with personal/business flying, compared to an average 25 fatal accidents per year related to instructional flying, 13 for aerial application, and 4 for corporate executive flights. Differences in the number and rate of fatalities and injuries among types of operation are likely related to the type of aircraft and equipment, the level of pilot training, and the operating environments unique to each type of operation. The total fatal accidents per year among each type of flight operation exhibit a distribution similar to the total number of accidents per operation, with personal and business flying accounting for an average 74% of all fatal general aviation accidents and 75% of all fatal injuries for 1991 through 2000.

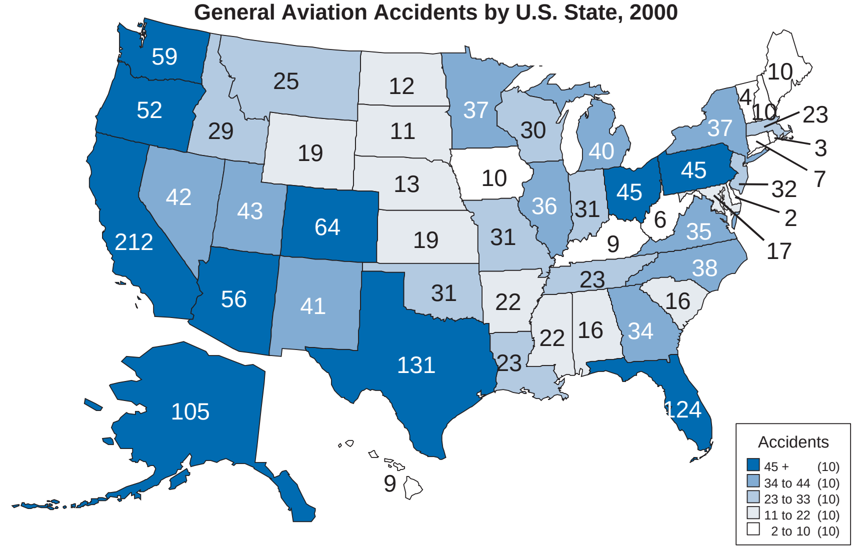
2000 in Depth

Location of General Aviation Accidents in 2000

United States Aircraft Accidents

Geographic location can contribute to general aviation accident totals because of increased activity due to population density or increased risk due to hazardous terrain, a propensity for hazardous weather, or a concentration of particularly hazardous flight operations. The map shows state by state the number of all general aviation accidents that occurred within the United States in 2000. The number of general aviation accidents occurring annually in a state is related to the population, general aviation activity level, and flying conditions unique to that state. Although the specific hourly activity data needed to calculate general aviation accident rates for each state are not available, some assumptions can be made about general aviation activity levels based on the size and population of each state. For example, California,[19] Texas, and Florida[20] had the greatest number of accidents in 2000. U.S. Census Bureau data[21] indicate that California had the highest state population in 2000, followed by Texas (second), and Florida (fourth). In addition, all three of these states have warm climates that favor flying year-round, and all three are popular travel destinations that attract general aviation traffic from other states. These states also had the largest numbers of active pilots[22] and active aircraft.[23] These data suggest that the high number of accidents in California, Texas, and Florida may be related primarily to a high level of activity.

General Aviation Accidents by U.S. State, 2000

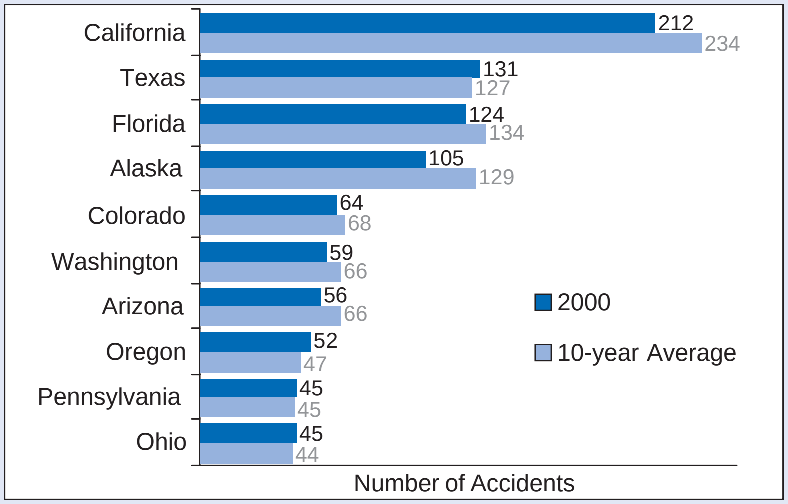


Regional differences that affect general aviation accident numbers may also include hazards unique to the local terrain and weather. For example, the operating environment, infrastructure, and travel requirements in Alaska present unique challenges[24] to aviation that are reflected in the general aviation accident record. After California, Texas, and Florida, Alaska had the most general aviation accidents in 2000.

[19] The total of 182 accidents for California includes one accident off the coast in the Pacific Ocean.
[20] The total of 140 accidents for Florida includes one accident off the coast in the Gulf of Mexico.
[21] U.S. Census Bureau; data are available at http://factfinder.census.gov/.
[22] FAA, U.S. Civil Airmen Statistics, 2000, available at http://apo.faa.gov/CivilAir/docs/air5-99.XLS.
[23] FAA, GAATA Survey 2000, available at http://www.api.faa.gov/GA2001/tab_2-3.pdf.
[24] For an analysis of aviation safety in Alaska, see National Transportation Safety Board, Aviation Safety in Alaska, Safety Study, NTSB/SS-95/03 (Washington, DC: 1995). The Safety Board is also supporting an ongoing effort to identify and mitigate risk factors specific to aviation operations in Alaska; for details, see http://www.ntsb.gov/aviation/AK/alaska_stat.htm.

The top 10 states by number of general aviation accidents in 2000 are presented here along with the 10-year average. Note that many of the state accident totals for 2000 were below historical averages, but the distribution of accidents among states remained similar during the period.

Top 10 General Aviation Accident States, 2000



Foreign Aircraft Accidents

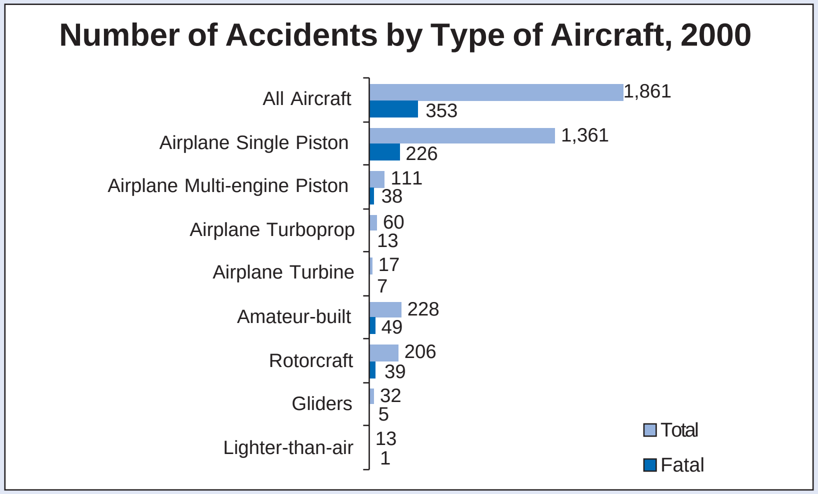
In 2000, U.S.-registered aircraft were involved in 46 accidents that occurred outside the 50 United States. Those accidents occurred in 17 different countries and territories, the Atlantic and Pacific Oceans, and the Gulf of Mexico. Of those accidents, 15 were fatal, resulting in 40 deaths. The largest number of accidents outside the 50 states occurred in Canada, with 8 accidents, followed by Mexico with 4. Although most general aviation accidents involving U.S.-registered aircraft outside the United States usually occur in neighboring countries like Canada and the Caribbean island nations, the 2000 accident record includes accidents that occurred as far away as Germany, Saudi Arabia, and New Zealand.

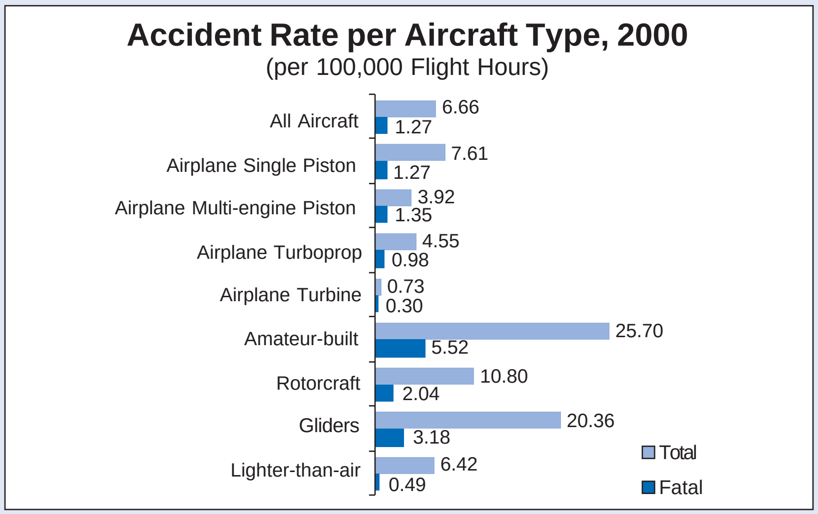
Accidents Involving U.S.-Registered General Aviation Aircraft Outside the 50 United States, 2000

	Number of Accidents	Number of Fatal Accidents	Number of Fatalities
Pacific Ocean			
Off California	1	0	0
From Fishing Vessel	1	0	0
Subtotal	**2**	**0**	**0**
Atlantic Ocean			
Off Bahamas	1	0	0
Off Florida	1	1	1
Off Portugal	1	0	0
Subtotal	**3**	**1**	**1**
Gulf of Mexico			
Off Louisiana	1	1	1
From Oil Platform	3	1	1
Subtotal	**4**	**2**	**2**
Other Countries/Territories			
Argentina	1	0	0
Austria	1	1	2
Bahamas	3	0	0
Canada	8	6	16
Colombia	1	0	0
Costa Rica	3	1	2
Fiji	1	0	0
French West Indies	1	0	0
Germany	3	2	4
Guatemala	3	1	7
Haiti	1	0	0
Mexico	4	2	9
New Zealand	1	0	0
Pohnpei	1	0	0
Puerto Rico	3	0	0
Sao Tome Island	1	0	0
Saudi Arabia	1	0	0
Subtotal	**37**	**13**	**40**
Total	**46**	**16**	**43**

Aircraft Type

The following graphs summarize the total number of general aviation accidents and the number of fatal accidents occurring in 2000 by type of aircraft. Most notable is the large number of accidents involving single-engine piston airplanes, which accounted for 73% of all accident aircraft and 64% of all fatal accident aircraft.





In 2000, the per-aircraft accident rate for all aircraft types was 6.66 accidents and 1.27 fatal accidents per 100,000 hours flown.[25] Among fixed-wing powered aircraft, the rate for single-engine piston airplanes was 7.61 accidents and 1.27 fatal accidents per 100,000 hours flown. Amateur-built aircraft[26] had the highest accident rate in 2000 with 25.70 accidents and 5.52 fatal accidents per 100,000 flight hours. Rotorcraft had the second highest rate among powered aircraft, with 10.80 accidents and 2.04 fatal accidents per 100,000 hours flown. However, glider operations had the second highest accident rate overall, with 20.36 accidents and 3.18 fatal accidents per 100,000 hours flown.

Purpose of Flight

As previously mentioned, general aviation includes a wide range of operation types, each with unique aircraft types, flight profiles, and operating procedures. The total number of accidents and the accident rates can vary considerably as a result of these differences. To allow comparisons among different operations, risk exposure is standardized across different operations by using flight hours as a common measure of activity.

The type of operation or purpose of flight can be defined as the reason a flight is initiated. Activity data by purpose of flight are derived from the GAATA Survey, which includes 14 purpose/use categories. Two of these categories, air taxis and air tours, are covered under 14 CFR Part 135 and are therefore not included in this review. The remaining 12 categories include the previously

[25] Note that the reported rates are per aircraft and differ from per-accident rates because each aircraft is counted separately in the event of a collision. Included in the accident totals, but excluded from the associated rates, are 4 single-engine piston, 2 multi-engine piston, and 1 turboprop accident aircraft with a probable cause attributed to suicide, sabotage, or stolen/unauthorized use.
[26] Title 14 CFR 21.191(g) provides for the issuance of a Special Airworthiness Certificate in the experimental category to permit the operation of amateur-built aircraft. Amateur-built aircraft may be fabricated from plans or assembled from a kit, so long as the major portion (51%) of construction is completed by the amateur builder(s).

mentioned categories of "personal," "business," "instructional," "corporate," and "aerial application," which together accounted for 90% of all general aviation operations during 2000. The remaining 10% of general aviation operations are included in more specific categories, such as "external load" and "medical use." A limitation of the GAATA activity data is that its categories provide only a coarse representation of the range of possible flight operations. For example, "personal flying" includes but does not distinguish between travel, recreation, or proficiency flying. At the same time, the differences between similar categories like "personal" and "business flying" are not easily identified. Accordingly, the purpose-of-flight information presented in this review is limited to the combined categories of personal and business flying, as well as corporate, instructional, and aerial application flights.

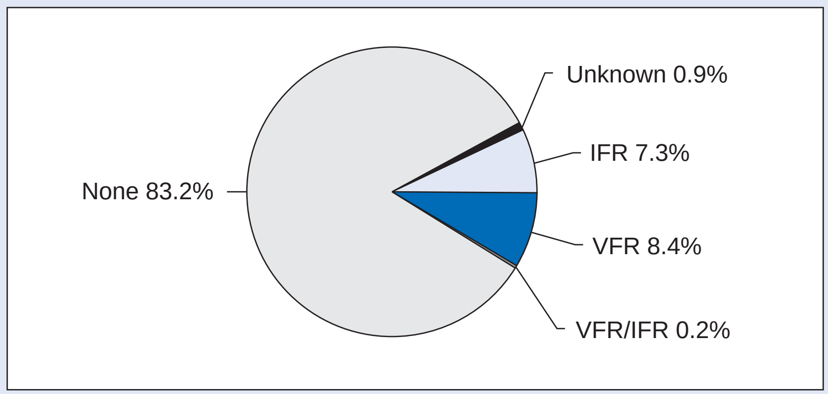
According to the GAATA Survey, most general aviation operations are conducted for personal and/or business purposes. Of the estimated 27.8 million general aviation hours flown in 2000, more than half—15.1 million—were conducted for personal or business reasons.[27] A result of this level of activity is that a large percentage of general aviation accidents involve personal/business flying. However, personal/business flying is still over-represented in the accident record: although this segment represented about 54% of the general aviation hours in 2000, it accounted for 67% (1,244) of all general aviation accident aircraft and 70% (247) of all fatal accident aircraft in 2000.

The accident rate for flight instruction operations was about half that of aerial application and personal/business flights. This relatively low rate is surprising because student pilots could be expected to make more mistakes than experienced pilots while they are learning to fly. Flight instruction accidents were also less likely to be fatal. Only 12% of the flight instruction accidents that occurred in 2000 resulted in fatalities, compared to 20% of personal/business accidents. When compared with the number of hours flown, the fatal accident rate for instructional flights was 0.63 fatal accidents per 100,000 hours flown. The fatal accident rate for personal/business flying remained the highest in general aviation with 1.61 fatal accidents per 100,000 hours flown.

Flight Plan

Of the 1,861 pilots involved in general aviation accidents in 2000, 1,549 (83.2%) did not file a flight plan. In most cases, a flight plan is required only for flight under instrument flight rules (IFR). However, pilots operating under visual flight rules (VFR) on point-to-point flights have the option of filing a flight plan, which aids search and rescue efforts for pilots who fail to arrive at their intended destinations. VFR flight plans are typically not filed for local flights and, in general, the filing of a flight plan may be more indicative of the type of flight operation than the safety of a particular flight.

Flight Plan Filed by Accident Pilot, 2000

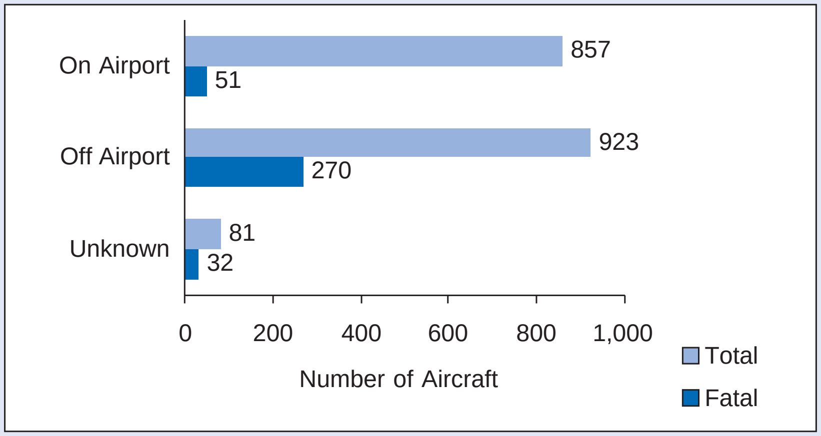


[27] FAA, GAATA Survey 2000, available at http://apo.faa.gov/GA2001/tab_1-6.pdf.

Airport Involvement

Aircraft accident locations were closely split between those occurring away from an airport (49.6%) and those occurring on airport property (46.1%). Comparing accident risk based on location is difficult because of the exposure differences between different operations and aircraft types. For example, a single-engine piston aircraft used for instructional flights will spend a large percentage of its operating time near an airport while a jet aircraft used for corporate transportation will not. However, a relationship can be observed between the location and severity of accidents. Accidents on or near an airport or airstrip typically involve aircraft operating at relatively low altitudes and airspeeds while taking off, landing, or maneuvering to land. Accidents that occur away from an airport typically involve aircraft in the climb, cruise, maneuvering, and descent phases of flight, which typically occur at higher altitudes and higher airspeeds. As a result, accidents that occur away from an airport are more likely to result in higher levels of injury and aircraft damage than accidents that occur on an airstrip or near an airport. Most aircraft involved in fatal accidents in 2000 (76.5%) were located away from an airport or airstrip.

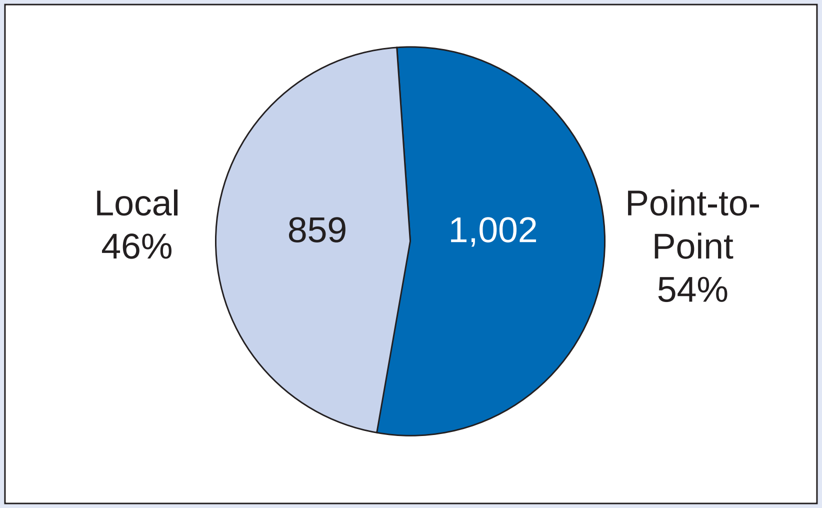
Location of Accident Aircraft, 2000



Another distinction that can be drawn between flight profiles is between local and point-to-point operations. A local flight is one that departs and lands at the same airport, and a point-to-point flight is one that lands at an airport other than the one from which it departed. Typical local flight operations include sightseeing, flight instruction, proficiency flights, pleasure flights, and most aerial observation and aerial application flights. Conversely, point-to-point flights include any operation conducted with the goal of moving people, cargo, or equipment from one place to another. Typical point-to-point operations include corporate executive transportation, personal and business travel, and aircraft repositioning flights.

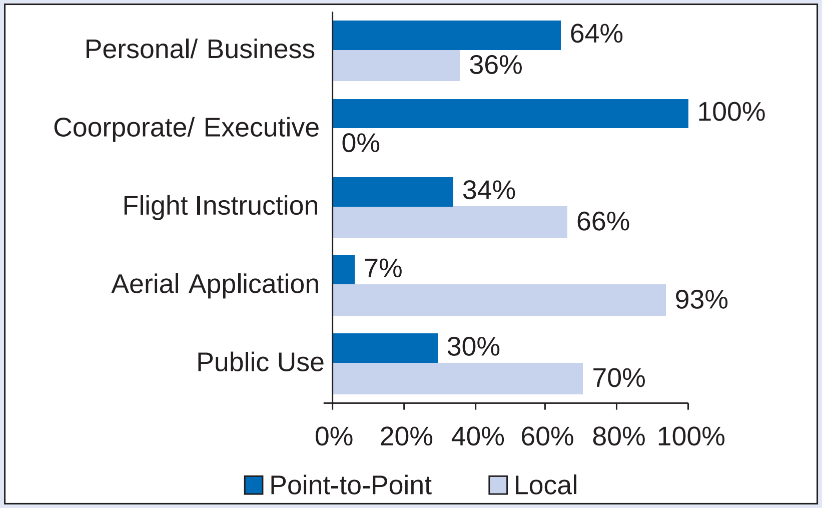
A comparison of the numbers of accident aircraft on local flights with those on point-to-point flights illustrates that the percentages of aircraft on each type of flight were similar although point-to-point flights accounted for slightly more accident aircraft.

Local and Point-to-Point Flights, 2000



The activity data necessary to compare accident rates for local and point-to-point flights are not available. However, a comparison of the percentage of local and point-to-point accident flights conducted for different purposes of flight provides an indirect measure of the types of flying represented in both flight profiles. The following graph shows that most personal/business flights were point to point, while most instructional flights were local. Corporate executive transportation and aerial application operations were also inversely proportionate, with 100% of corporate flights being point to point and 93% of aerial application flights being local.

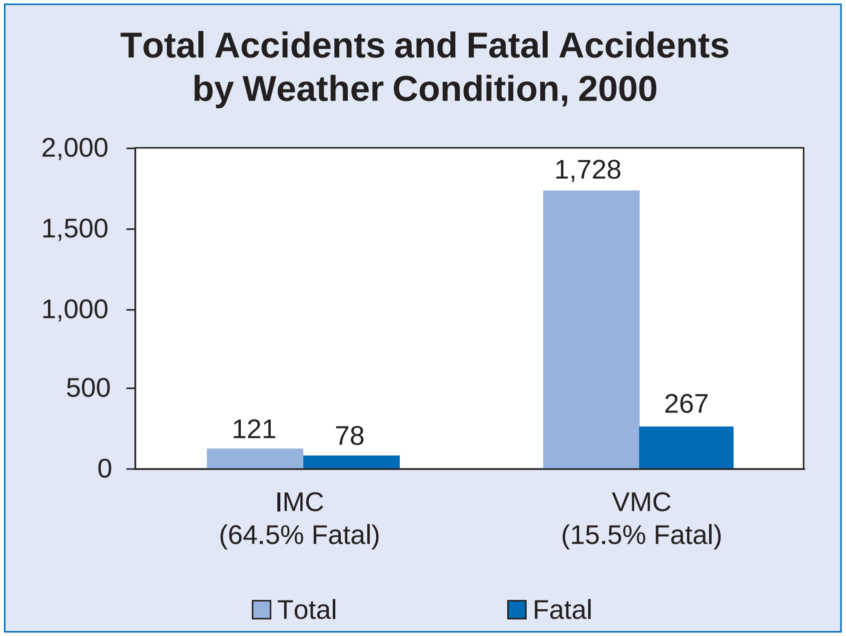
Local and Point-to-Point Comparison by Type of Operation, 2000



Environmental Conditions

Many hazards to safety are unique to the type of flight operation, type of aircraft, and flight profile, but environmental conditions may be hazardous to all flight operations and all types of aircraft to some degree. Aircraft control, for example, is highly dependant on visual cues related to speed, distance, orientation, and altitude. When visual information is degraded or obliterated because of clouds, fog, haze, or precipitation, pilots must rely on aircraft instruments. Because of the difficulties associated with flying an aircraft solely by reference to instruments, the FAA has established specific pilot, aircraft, and procedural requirements[28] for flight in instrument meteorological conditions (IMC). According to the FAA *Pilot/Controller Glossary*,[29] "instrument meteorological conditions" are defined as "meteorological conditions expressed in terms of visibility, distance from cloud, and ceiling less than the minima[30] specified for Visual Meteorological Conditions (VMC)." Weather minima differ based on altitude, airspace, and lighting conditions, but 3 statute miles visibility and a cloud clearance of 1,000 feet above, 500 feet below, and 2,000 feet horizontal distance is typical. The following chart illustrates the percentage of accidents and fatal accidents that occurred in VMC and IMC. A comparison of the percentages of accidents in each weather condition that resulted in a fatality illustrates the hazards associated with flight in IMC. In 2000, only 15.5% of the accidents that occurred in visual conditions resulted in a fatality, but 64.5% of accidents in instrument conditions were fatal.

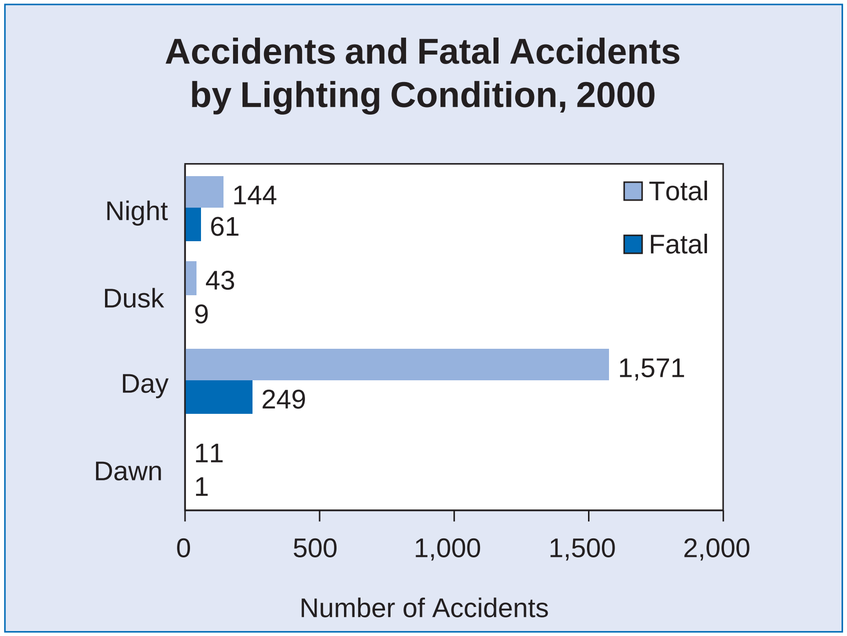
[28] Title 14 CFR 61.579(c), 91.167-193, 91.205(d).
[29] Federal Aviation Administration, *Pilot/Controller Glossary*, Washington, D.C., available online at http://www.faa.gov/atpubs/PCG/INDEX.HTM.
[30] Minima for visual meteorological conditions are specified in 14 CFR 91.155.



Although instrument conditions accounted for only 7.3% of all accidents, 22.1% of fatal general aviation accidents in 2000 occurred in IMC. One reason for the disproportionate number of fatal accidents in IMC is that such accidents are more likely to involve pilot disorientation, loss of control, and collision with terrain or objects—accident profiles that typically result in high levels of damage and injury. Instrument conditions may also contribute to accident severity by further complicating situations that might be more easily handled in visual conditions. For example, a forced landing due to an engine malfunction or failure, which might result in minor damage if it were to occur in visual conditions, might pose an even greater threat to a pilot flying in instrument conditions because reduced visibility would make the selection of a suitable landing site more difficult.

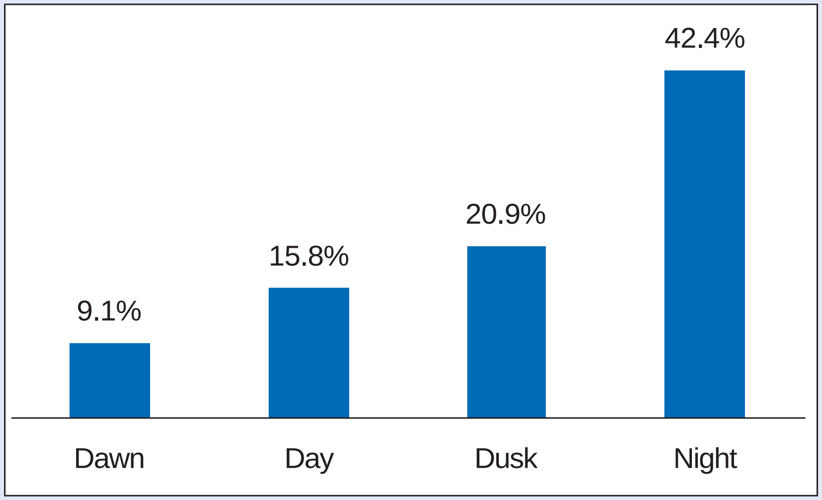
Lighting Conditions

Lighting conditions can present a similar hazard to pilots because of physiological factors related to night vision, difficulties in seeing potential hazards such as mountains, terrain, and unlighted obstructions, and perceptual illusions associated with having fewer visual cues. The following graphs illustrate that, similar to IMC, most accidents occur in daylight conditions but a larger percentage of the accidents that occur at night result in fatalities.



In fact, accidents that occurred at night were more than two-and-a-half times more likely than daylight accidents to be fatal. Like weather-related accidents, accidents at night are more likely to involve disorientation, loss of control, and/or collision with objects or terrain that result in higher levels of injury. The reduction in visual cues at night also hinders pilots from identifying deteriorating weather conditions and further complicates any aircraft equipment malfunctions.

Percentage of Accidents Resulting in a Fatality by Lighting Condition, 2000



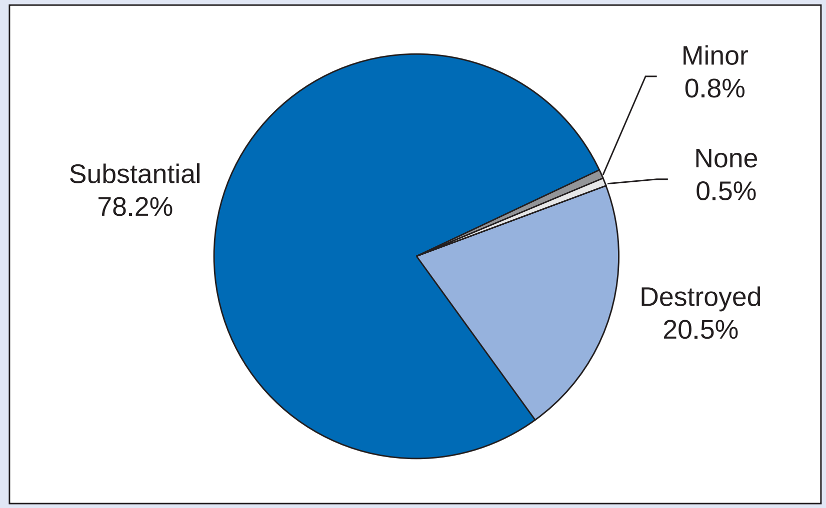
Injuries and Damage for 2000

Aircraft Damage

Safety Board investigators record aircraft damage as either "destroyed," "substantial," or "minor." "Substantial damage" is defined in 49 CFR 830.2 as "damage or failure which adversely affects the structural strength, performance, or flight characteristics of the aircraft, and which would normally require major repair or replacement of the affected component." "Destroyed" and "minor" are not specifically defined in 49 CFR 830.2. However, "destroyed" can be operationally defined as any damage in which repair cost would exceed the value of the aircraft,[31] and "minor" damage as any damage that is not classified as either "destroyed" or "substantial."

Most aircraft involved in accidents during 2000 sustained substantial damage (78.2%), and about one in five accident aircraft (20.5%) were destroyed. "Minor" and "no damage" classifications included less than 1% each of accident aircraft.

Damage to Accident Aircraft, 2000



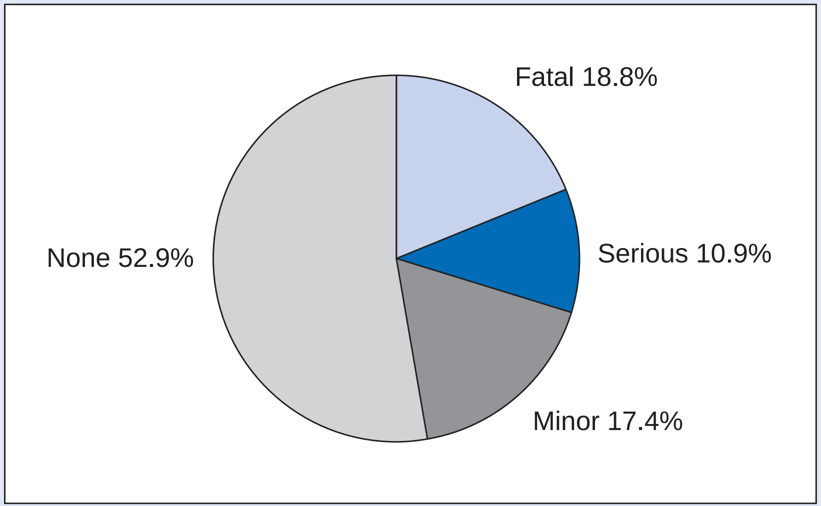
Accident Injuries

Safety Board investigators categorize injuries resulting from general aviation accidents as "fatal," "serious," or "minor." Title 49 CFR 830.2 defines a fatal injury as "any injury which results in death within 30 days of the accident." Title 49 CFR 830.2 also outlines several qualifications[32] of serious injury that include, but are not limited to, hospitalization for more than 48 hours, bone fracture, internal organ damage, or second- or third-degree

[31] Missing or unrecoverable aircraft are also considered "destroyed."
[32] See Appendix B for the complete definition of injury categories.

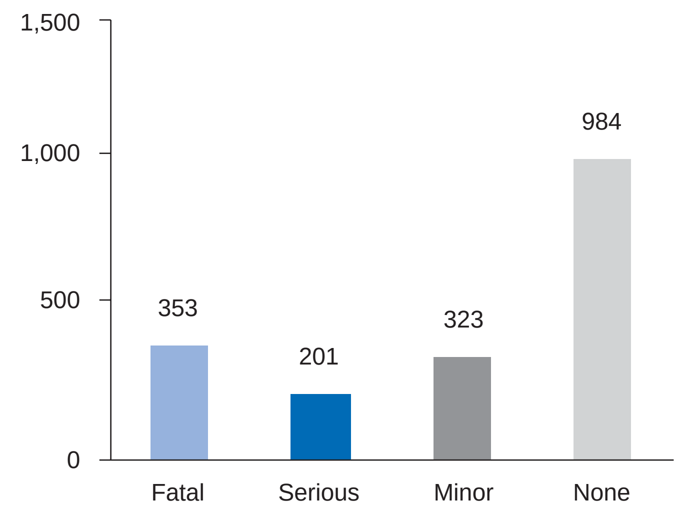
burns. The following graph depicts the percentage of general aviation accidents resulting in each level of injury during 2000. Most notable is the fact that more than half (52.9%) of accidents did not result in injury.

Highest Level of Accident Injury, 2000

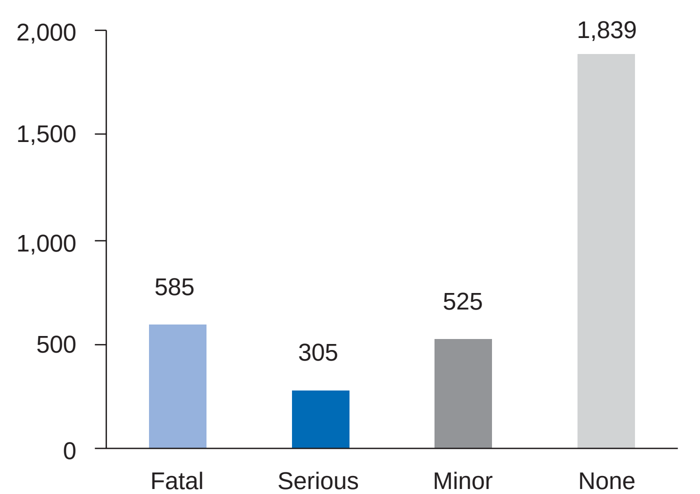


The following graphs illustrate both the number of accident aircraft in each injury category and the corresponding number of persons aboard those aircraft who sustained injuries in each category. Aircraft injury level is equal to the highest level of injury sustained by an occupant of that aircraft. Again, most persons who were aboard general aviation aircraft that were involved in accidents sustained no injuries.

Highest Level of Injury Aboard Accident Aircraft 2000



Total Injuries Sustained by Persons Aboard Accident Aircraft, 2000



Injuries by Role for 2000

The following table presents detailed information about the types of injuries incurred by all persons involved in general aviation accidents during 2000. The distribution of general aviation accident injuries varies with the type of operation and the size of aircraft, and the number of injuries experienced by any group of persons varies with their level of activity (that is, their exposure risk). For example, all aircraft have a pilot, but not all aircraft have passengers on board. In 2000, 490 passengers suffered some level of injury in general aviation accidents, compared to the 820 pilots who were injured. Despite the apparent difference, the injury rate for passengers was similar to that of pilots, considering that only 1,121 of 1,861 accident aircraft had passengers on board. Although the total number of injured passengers is equal to only 59.8% of the number of injured pilots, only 60.2% of accident flights were carrying passengers. As noted previously, most general aviation accidents involve personal/business flights in single-engine piston aircraft, which are likely to have only one pilot. Because of this exposure difference, pilots sustained the highest percentage of injuries in general aviation accidents in 2000, suffering 56% of all fatalities, 60% of all serious injuries, and 56% of all minor injuries.

In addition to injuries sustained by persons on board the accident aircraft, 13 persons who were not aboard aircraft also sustained injuries. Examples of such accidents include a ground crew member who died from head injuries received from a fall on concrete while mooring a blimp and two motorists who received minor injuries when a business jet overran the end of a runway, slid across a public roadway, and collided with passing vehicles.

Personal Injuries	Fatal	Serious	Minor	None	Total
Pilot	335	186	299	1,041	1,861
Copilot	22	6	17	52	97
Dual student	16	6	21	87	130
Check pilot	0	2	0	10	12
Other crew	8	3	4	18	33
Passenger	204	102	184	631	1,121
Total aboard	585	305	525	1,839	3,254
On ground	2	4	7	--	13
Other Aircraft	9	0	0	14	23
Total	596	309	532	1,853	3,290

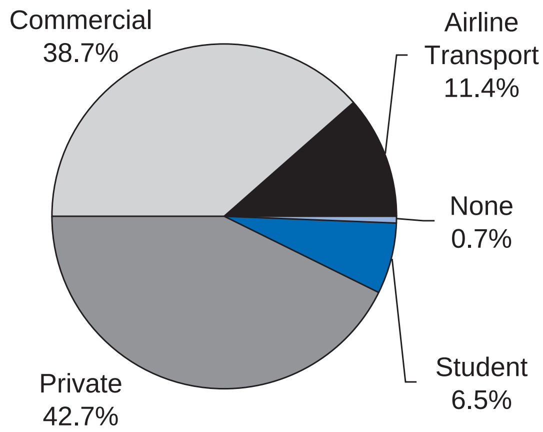
Accident Pilots

Rating

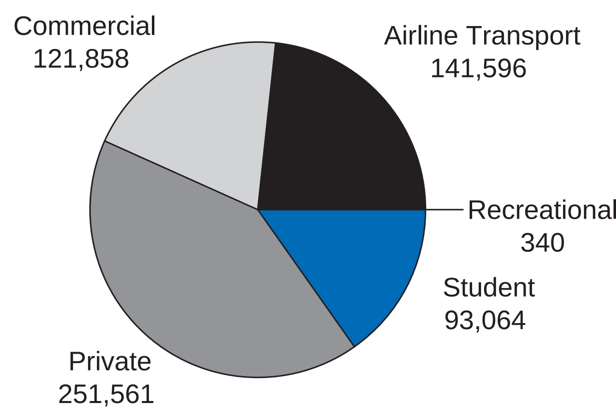
Of the 1,861 pilots involved in general aviation accidents in 2000, the largest percentage (42.7%) held a private pilot certificate.[33] The second-largest percentage (38.7%) held a commercial pilot certificate, which is required for any person to act as pilot-in-command of an aircraft for compensation or hire.[34]

[33] FAA, U.S. Civil Airmen Statistics, available at http://api.hq.faa.gov/CivilAir/index.htm.
[34] See 14 CFR 61.133 for the privileges granted by a commercial pilot certificate.

Highest Certificate Held by Accident Pilot, 2000

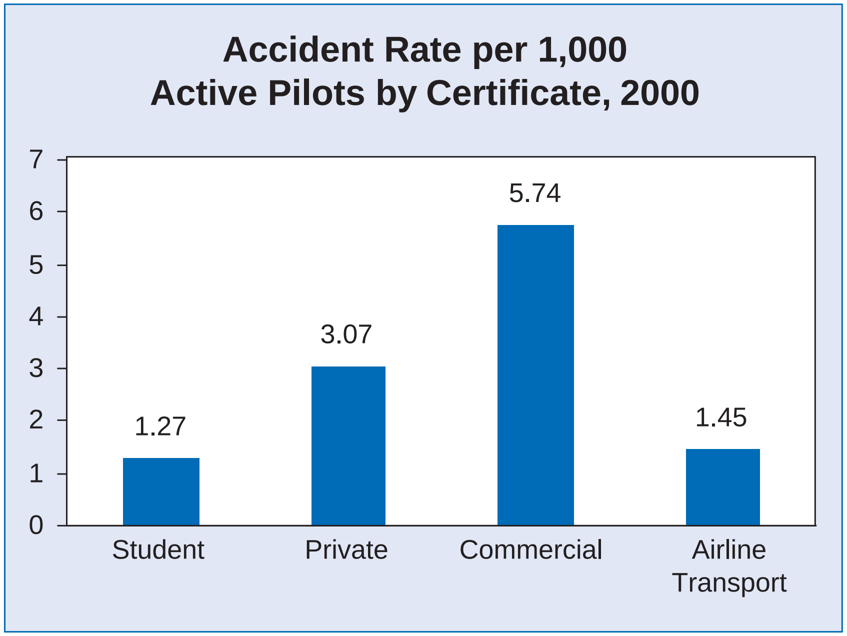


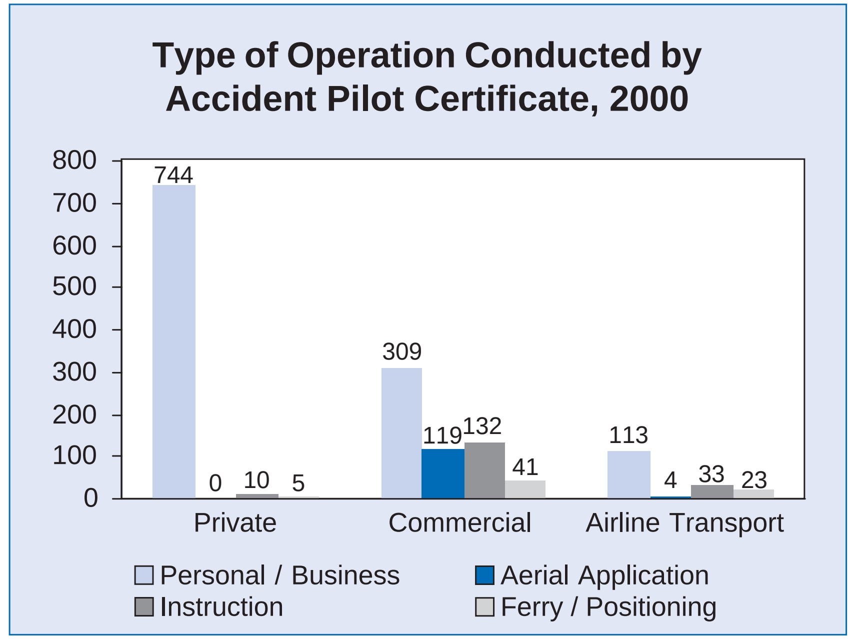
Number of Active Pilots by Highest Certificate, 2000



When compared to the number of active pilots in 2000 holding each type of pilot certificate, commercial pilot certificate holders were over-represented among general aviation accidents. Although commercial pilot certificate holders accounted for only 20% of all active pilots, they were involved in 38.7% of all general aviation accidents in 2000.

Similarly, the per-pilot accident rate was highest for commercial pilot certificate holders during 2000, with 5.74 accidents per 1,000 active pilots. One possible explanation for the higher numbers of accidents is that commercial certificate holders may be employed as pilots and would therefore be likely to fly more hours annually than student or private pilots.





(1,806 of accident pilot records with data available, 2000)

However, the largest percentage of commercial pilots involved in accidents during 2000 (44.3%) were conducting personal flights and were not involved in commercial operations at the time of the accidents.

Because annual flight-hour data are not compiled separately for pilots holding each type of certificate, it is not possible to make comparisons between activity-based accident rates. The U.S. Civil Airmen Statistics[35] also do not include information about the type of operation that certificate holders engage in. However, the high number of commercial pilot accidents attributed to aerial application operations might suggest that the historically high accident rate of such flights may have contributed to the increased rate observed for commercial pilots. Examples of other commercial operations not presented in the chart include corporate executive transportation, sightseeing flights, banner towing, and aerial observation.

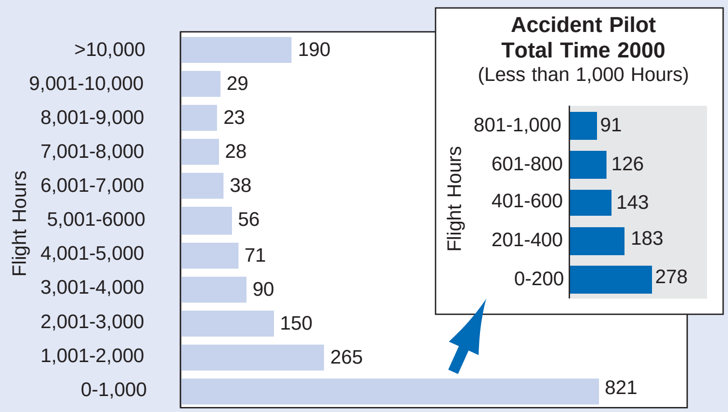
[35] FAA, U.S. Civil Airmen Statistics, 2000, available online at http://api.hq.faa.gov/CivilAir/index.htm.

Airline Transport Pilot (ATP) certificate holders, in addition to being employed as pilots,[36] can engage in air carrier operations,[37] which are not included in this review. As a result, ATP certificate holders may fly fewer general aviation hours and have a lower general aviation accident rate.

Total Time

Of the 1,761 accidents in 2000 for which pilot total flight experience data are available, 46.6% involved pilots with a total flight time of 1,000 hours or less. The following chart depicts the distribution of experience among accident pilots. The inset focuses on those pilots with less than 1,000 hours. The largest percentage of accident pilots in this group had 200 hours or less of total flight time. When compared to all accident pilots with available data, about 16% of accident pilots had 200 hours of flight experience or less.

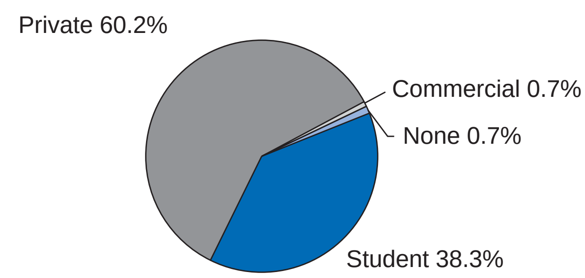
Accident Pilot Total Time, 2000



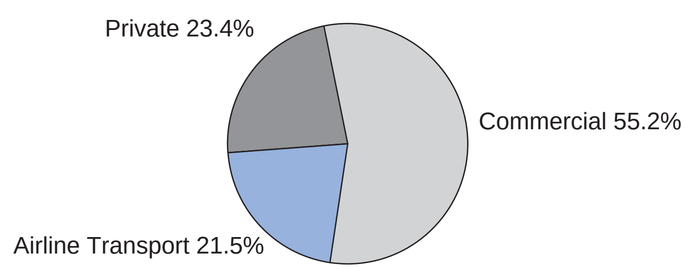
(1,761accident pilot records with total flight time information)

Because of the flight hour requirements[38] for obtaining commercial and ATP certificates, it is not surprising that nearly all accident pilots with 200 total hours or less of flight time held either private pilot certificates (60.2%) or student pilot certificates (38.3%).[39] Most pilots with more than 1,000 total hours of flight time held commercial pilot certificates (55.2%).

Pilot Certificate Held by Accident Pilots with 200 Hours or Less Total Time, 2000



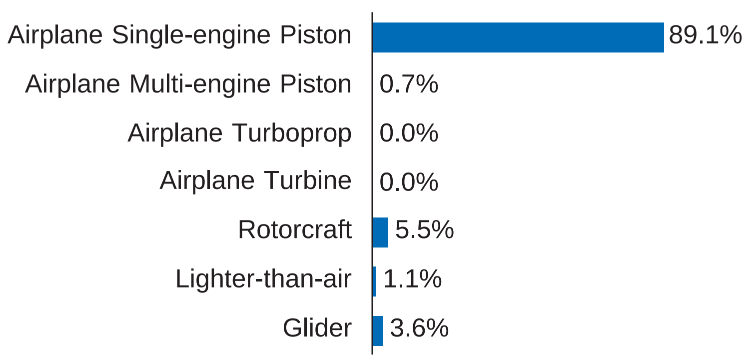
Pilot Certificate Held by Accident Pilots with More Than 1,000 Hours Total Time, 2000



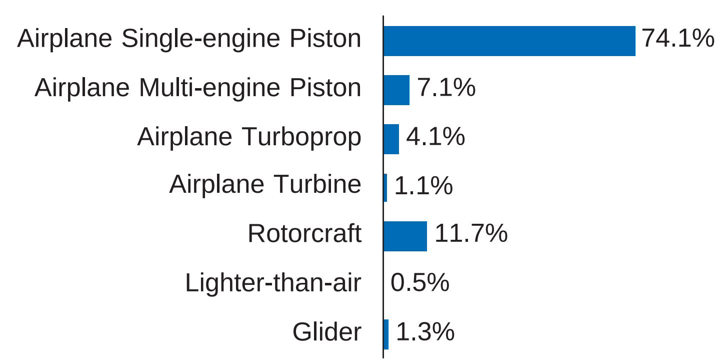
[36] Refer to 14 CFR 61, Subpart G, for the privileges and limitations of the Airline Transport Pilot certificate.
[37] See 14 CFR 121.437.
[38] Refer to 14 CFR Part 61 for the requirements of each type of pilot certificate and to 14 CFR Part 141 for differences in those requirements for training conducted at approved flight schools.
[39] Two accident pilots held commercial certificates but had less than 200 hours total time; one was a balloon pilot and the other was a foreign citizen operating a U.S.-registered aircraft.

It is also not surprising that most accident pilots with 200 hours total flight time or less were flying single-engine piston airplanes when the accidents occurred. Accident pilots with more than 1,000 hours were flying a more diverse selection of aircraft, including significantly higher percentages who were flying multi-engine piston, turboprop, and turbine-powered airplanes, and about twice as many who were flying helicopters.

Type Aircraft Flown by Accident Pilots with 200 or Less Hours Total Flight Time, 2000



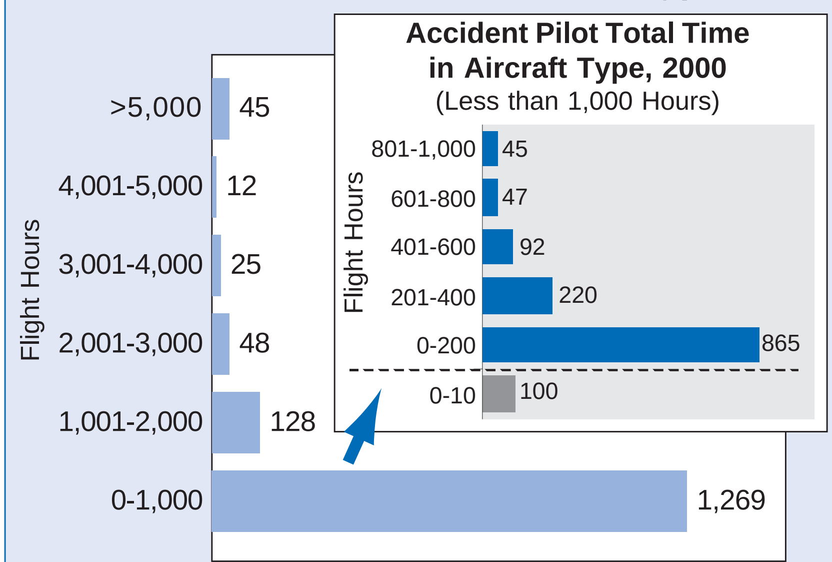
Type Aircraft Flown by Accident Pilots with More than 1,000 Hours Total Flight Time, 2000



Time in Type of Aircraft

Of the 1,527 accidents in 2000 for which data are available about pilot experience in the accident aircraft make and model, 82.4% involved pilots with 1,000 hours of time in the accident aircraft make and model or less. Most accident pilots in this group (68.2%) had less than 200 hours of total flight time in the accident aircraft type, and a total of 100 pilots (6.5% of all accident pilots for whom data are available) had less than 10 hours in type. Most accident pilots with less than 10 hours of flight time in make and model were flying single-engine piston aircraft.

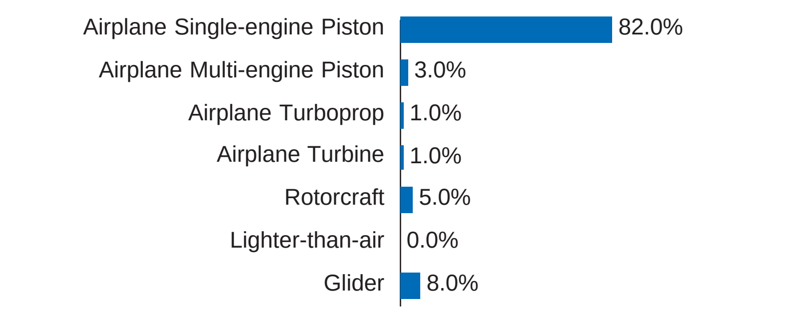
Accident Pilot Total Time in Aircraft Type 2000



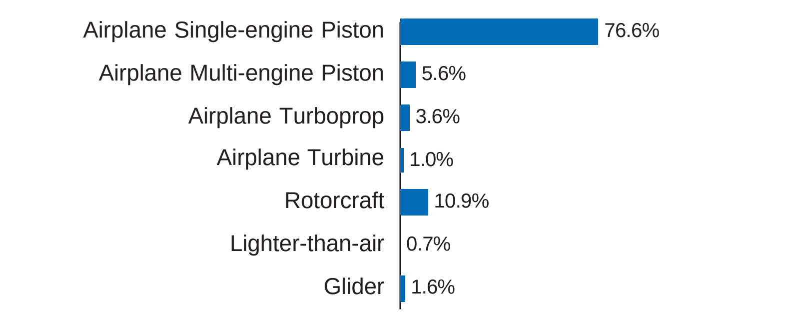
(1,527accident pilot records with time in aircraft type information)

Pilots may have low time in type because they are new pilots with low total time or they are experienced pilots who are transitioning to a new aircraft. Two groups of pilots who might be expected to have accumulated significant time in make and model are those who own their own airplanes and fly them often and professional pilots who fly the same aircraft often. A large number of general aviation pilots who own aircraft have single-engine piston airplanes. Helicopters and multi-engine piston, jet, and turboprop airplanes are more likely to be operated by professional pilots. Although not specifically detailed in the chart, it is particularly worth noting that 23 of the 100 accident pilots in 2000 who had less than 10 hours in the accident aircraft type were operating amateur-built aircraft.

Type Aircraft Flown by Accident Pilots with 10 or Less Hours in Accident Aircraft Type, 2000



Type Aircraft Flown by Accident Pilots with More than 200 Hours in Accident Aircraft Type, 2000

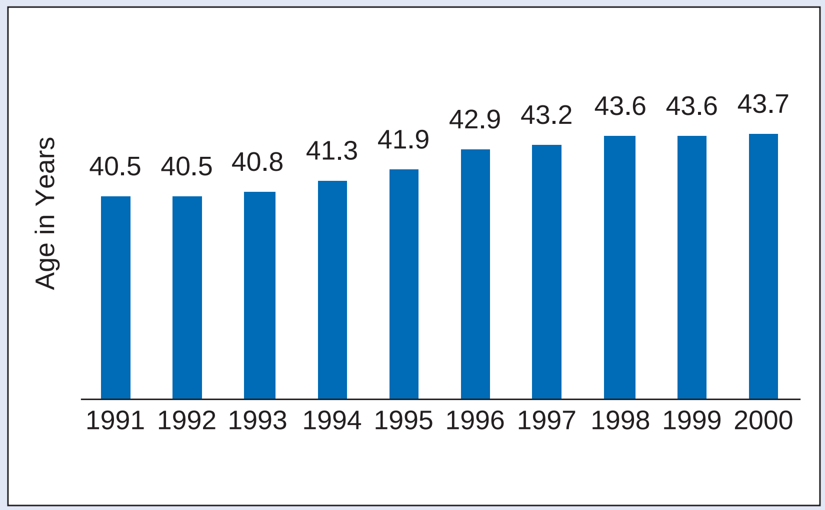


Comparison of these two graphs shows that pilots with more than 200 hours in make and model were more likely than pilots with fewer hours in type to be flying rotorcraft or multi-engine piston, jet, or turboprop airplanes.

Age

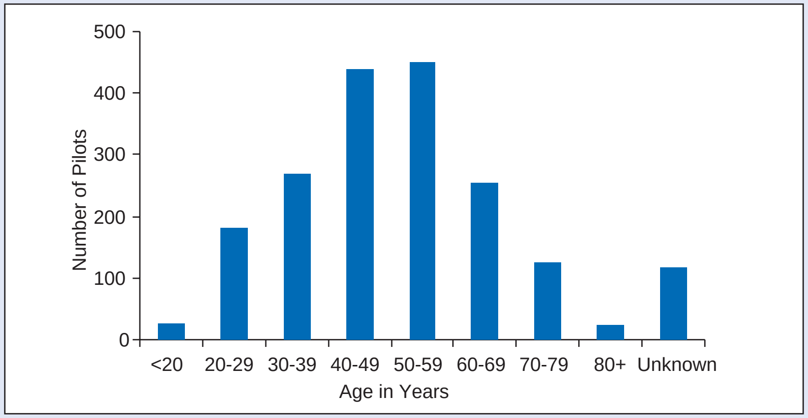
Most accident pilots in 2000 were between the ages of 40 and 59. The average age of all active pilots in the U.S. increased steadily from 1991 through 2000 and by 2000 was equal to 43.7[40] years. In contrast, the average age of general aviation accident pilots was 48.1 years. Despite the difference in average age, no meaningful conclusions can be made regarding specific age-related accident risk because FAA flight hour activity numbers are not available for each age group. Age differences could be the result of activity if opportunities for recreational flying were to increase with age.

Average Age of Active Pilots 1991-2000



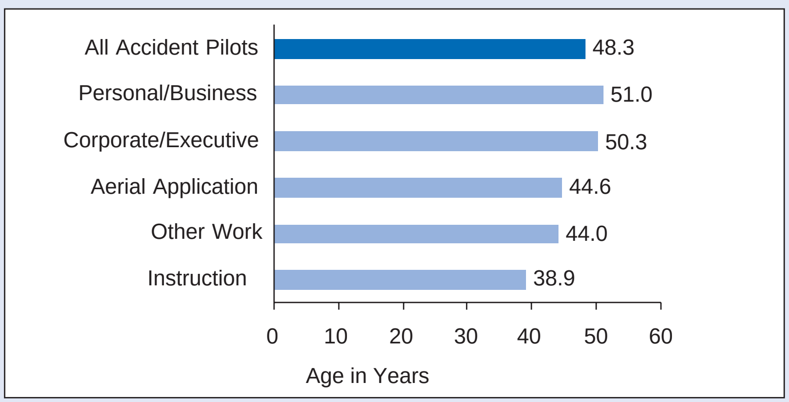
[40] FAA, U.S. Civil Airmen Statistics, 2000, available at http://apo.faa.gov/CivilAir/docs/air13-00.xls.

Age of Accident Pilot, 2000

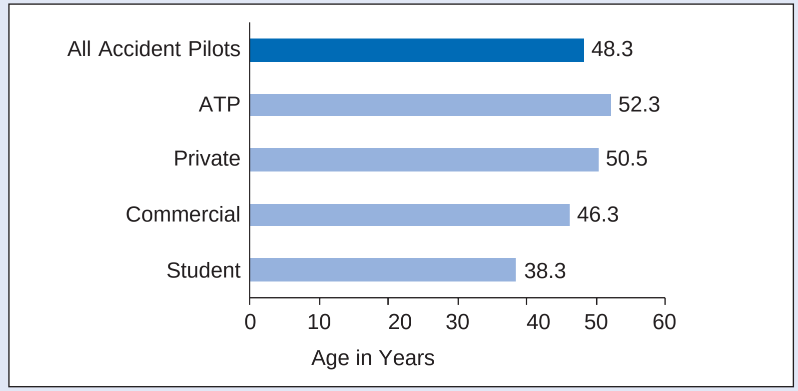


Accident pilots conducting flight instruction operations, which include both flight instructors and their students, had the lowest average age of all pilots at 38.9 years. Accident pilots conducting personal/business flights had the highest average age at 51.0 years, followed closely by pilots of corporate/executive flights at 50.3 years.

Average Age of Accident Pilot by Type of Operation, 2000



Average Age of Accident Pilot by Highest Pilot Certificate, 2000



Accident Occurrences for 2000

Safety Board accident reports document the circumstances of an accident as "accident occurrences" and the "sequence of events." Occurrence data can be defined as what happened during the accident. A total of 54[41] occurrence codes are available to describe the events for any given accident. Because aviation accidents are rarely limited to a single occurrence, each occurrence is coded as part of a sequence (that is, occurrence 1, occurrence 2, etc.), with as many as five different occurrence codes in one accident. For accidents that involve more than one aircraft, the list of occurrences may be different for each aircraft.

Of the 1,808 accident aircraft in 2000 for which data are available, 1,340 had 2 or more occurrences, 552 had 3 or more, 83 had 4 or more, and 8 had a total of 5 occurrences (each). The excerpt from a brief report shown here is for an

[41] Two of the codes, "missing aircraft" and "undetermined," do not represent operational events.

accident with five occurrences. The brief illustrates how an accident with multiple occurrences is coded. In this accident, which occurred in 2000, the airplane overran the end of the runway during landing and collided with a fence. As it slid to a stop, the airplane went into a ditch, nosed over, and a fire resulted. Each of these occurrences was coded in order, as shown.

Example of Occurrence Findings Cited in an NTSB Accident Brief, 2000

Occurrence #1: OVERRUN
Phase of Operation: LANDING - ROLL

Findings
1. (C) PROPER TOUCHDOWN POINT - EXCEEDED - PILOT IN COMMAND
2. ABORTED LANDING - NOT PERFORMED - PILOT IN COMMAND

Occurrence #2: ON GROUND/WATER COLLISION WITH OBJECT
Phase of Operation: LANDING - ROLL

Findings
3. (F) OBJECT - FENCE

Occurrence #3: ON GROUND/WATER ENCOUNTER WITH TERRAIN/WATER
Phase of Operation: LANDING - ROLL

Findings
4. (F) TERRAIN CONDITION - DITCH

Occurrence #4: NOSE OVER
Phase of Operation: LANDING - ROLL

Occurrence #5: FIRE
Phase of Operation: OTHER

Occurrence data do not include specific information about why an accident may have happened; the first occurrence can instead be considered the first observable link in the accident chain of events. The following table displays first occurrences for all year 2000 general aviation accident aircraft with sequence of events data available. To simplify the presentation of accident occurrence data, similar occurrences are grouped into eight major categories.

Among the eight major categories of first occurrences, the largest percentage of accidents (26.4%) included occurrences related to aircraft power. Among the individual occurrences, the most common involved a loss of control either in flight (14.4%) or on the ground (12.3%). Although occurrences involving loss of aircraft control on the ground resulted in only 1 fatal accident in 2000, loss-of-control occurrences in flight resulted in a total of 110 fatal accidents—nearly one-third of all fatal accidents and more than twice that of any other single occurrence.

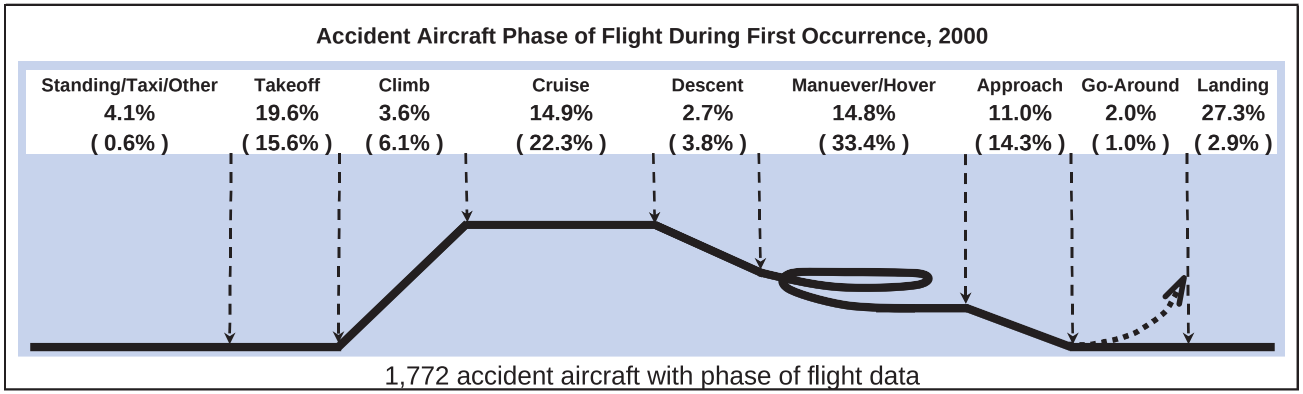
2000 Accident First Occurrences

	Total	Fatal
Collision – In-flight	293	105
In-flight Collision with Object	152	45
In-flight Collision with Terrain/Water	101	48
Midair Collision	25	11
Undershoot	15	1
Near Collision Between Aircraft	0	0
Noncollision – In-flight	445	162
Loss of Control – In-flight	260	110
Airframe/Component/System Failure/ Malfunction	106	20
In-flight Encounter with Weather	70	31
Vortex Turbulence Encountered	5	1
Forced Landing	3	0
Altitude Deviation, Uncontrolled	1	0
Abrupt Maneuver	0	0
Decompression	0	0
Collision – On-ground or Water	95	2
On-ground/Water Collision with Object	48	1
On-ground/Water Encounter with Terrain/Water	31	0
Collision Between Aircraft (Other Than Midair)	8	1
Dragged Wing, Rotor, Pod, Float, or Tail/Skid	8	0
Noncollision – On-ground or Water	409	4
Loss of Control – On-ground/Water	223	1
Hard Landing	93	1
Overrun	39	1
Nose Over	29	0
On-ground/Water Encounter with Weather	12	0
Roll Over	8	0
Propeller/Rotor Contact to Person	2	1
Nose Down	1	0
Propeller Blast or Jet Exhaust/Suction	1	0
Ditching	1	0

	Total	Fatal
Power Related	478	45
Loss of Engine Power	157	16
Loss of Engine Power (Total) – Nonmechanical	155	14
Loss of Engine Power (otal) – Mech Failure/Malfunction	81	8
Loss of Engine Power (Partial) – Nonmechanical	41	5
Loss of Engine Power (Partial) – Mech Failure/Malfunction	36	1
Propeller Failure/Malfunction	6	1
Rotor Failure/Malfunction	2	0
Engine Tear-away	0	0
Landing Gear	38	0
Wheels-up Landing	14	0
Gear Collapsed	9	0
Nose Gear Collapsed	5	0
Main Gear Collapsed	4	0
Gear Retraction on Ground	4	0
Wheels-down Landing in Water	2	0
Complete Gear Collapsed	0	0
Tail Gear Collapsed	0	0
Other Gear Collapsed	0	0
Gear Not Extended	0	0
Gear Not Retracted	0	0
Miscellaneous	34	6
Miscellaneous/Other	25	4
Fire	8	1
Fire/Explosion	1	1
Explosion	0	0
Hazardous Materials Leak/Spill	0	0
Cargo Shift	0	0
Undetermined	3	3
Missing Aircraft	3	3
Undetermined	0	0

Phase of Flight

The following illustration displays the percentage of accident aircraft in each phase of flight at the time of first occurrence. The phase of flight can be defined as when, during the operation of the aircraft, the first occurrence took place. There are 50 distinct phases of flight that investigators may use to describe the operational chronology of occurrences. To simplify the presentation of this information, the detailed phases are grouped into the nine broad categories shown in this illustration. For example, the category "approach" includes any segment of an instrument approach or position in the airport traffic pattern and continues until the aircraft is landing on the runway. The upper set of numbers represents the percentage of all accidents that occurred in each phase, and the numbers in parentheses indicate the percentage of all accidents that were fatal.

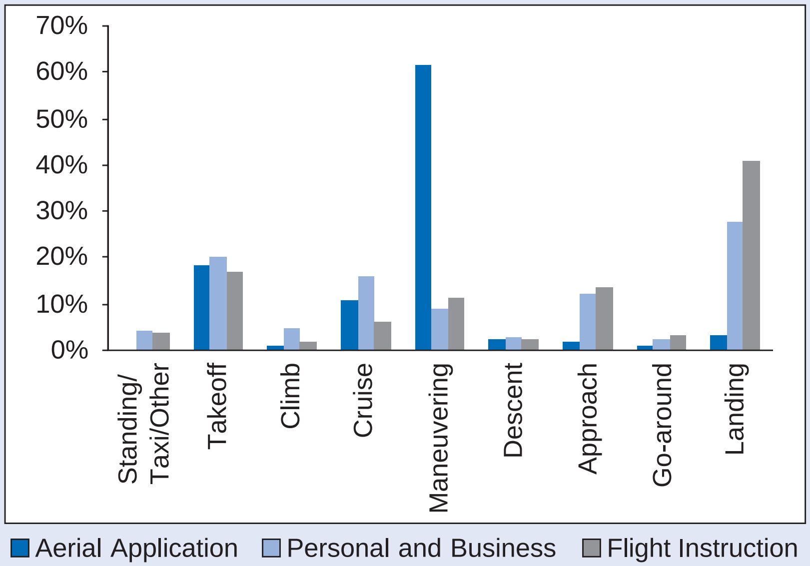


As shown in the illustration, most accidents occurred during takeoff and landing, despite the relatively short duration of these phases compared to the entire profile of a normal flight. The high number of accidents that occurred during takeoff and landing reflects the increased workload placed on both the flight crew and the aircraft during these phases. During both takeoff and landing, the flight crew must control the aircraft, change altitude and speed, communicate with air traffic control (ATC) and/or other aircraft, and maintain separation from obstacles and other aircraft. Aircraft systems are also stressed during takeoff and landing with changes to engine power settings, the possible operation of retractable landing gear, flaps, slats, and spoilers, and changes in cabin pressurization. While the aircraft is at low altitude during takeoff and landing it is also most susceptible to any hazards caused by wind and weather conditions.

Notably, the landing phase of flight accounted for the largest percentage of total accident first occurrences (27.3%) but only 2.9% of fatal accident first occurrences. The largest percentage of fatal accident first occurrences (33.4%) occurred during the maneuvering phase of flight, but only 14.8% of all accident first occurrences occurred during this phase. These differences reflect the relative severity of accidents that are likely to occur during each of these phases. Accidents that occur during cruise and maneuvering are more likely to result in higher levels of injury and aircraft damage due to the higher speeds and altitudes associated with these phases of flight.

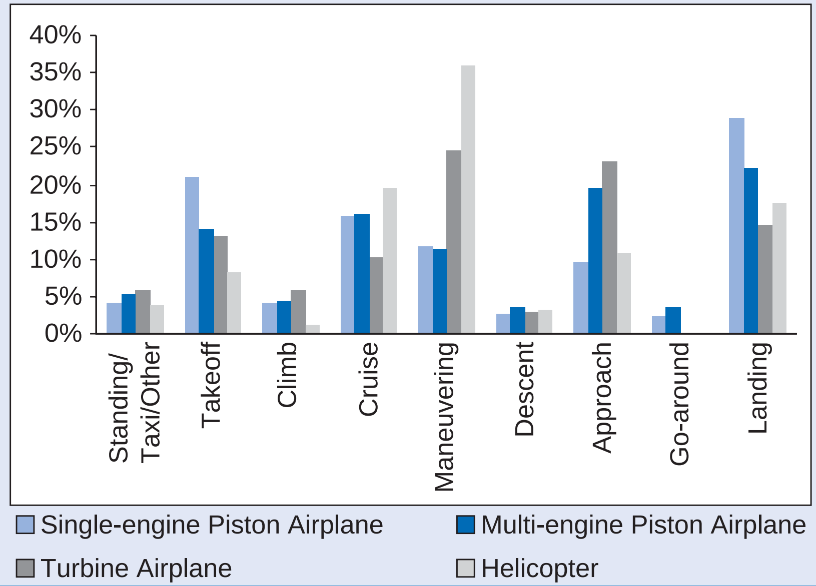
The likelihood of an aircraft accident first occurrence during each phase of flight varies by aircraft type and type of operation due to the unique hazards associated with each. For example, aircraft conducting aerial application flights fly at very low altitudes while spraying and therefore have an increased risk of colliding with terrain or obstructions. As a result, about 61% of all first occurrences for 2000 accidents involving aerial application flights occurred during the maneuvering phase compared to less than 9% of personal/business flights and 11% for instructional flights.

Accident Aircraft Phase of Flight During Accident First Occurrence by Type of Operation, 2000



Accident phase-of-flight differences among aircraft types are the result of the amount of time spent in each phase, aircraft-specific hazards associated with that phase, and the type of operations typically conducted with that aircraft. For example, the largest percentage of first occurrences for accidents involving helicopter flights, about 36%, occurred while maneuvering. The percentage of accidents during this phase reflects the hazards unique to helicopters during hover, and during operations that are unique to helicopters, such as carrying external loads. In contrast, the largest percentage of accidents involving single and multi-engine piston aircraft occurred during landing.

Accident Aircraft Phase of Flight During Accident First Occurrence by Aircraft Type, 2000



Chain of Occurrences

An accident's first occurrence and phase of flight during first occurrence indicate how and when an accident begins. However, the entire accident can also be viewed as a chain of all the accident occurrences cited in the order in which they happen. As previously discussed, accident events often include a combination of multiple occurrences, with many possible combinations. For example, of the 1,822 accidents that occurred during 2000 for which occurrence data are available, 407 unique combinations of accident occurrences were cited. The following tables, which list the top ten combinations of occurrences for all accidents and fatal accidents, illustrate the most common events.

Rank	Chain Of Occurrences - All GA Accidents, 2000	Number of Accidents
1	Loss of Control In-flight → In-flight Collision with Terrain/Water	175
2	In-flight Collision with Terrain/Water	88
3	In-flight Collision with Object	85
4	Hard Landing	52
5	Loss of Control On-ground/water → On-ground/water Collision with Object	47
6	Loss of Control On-ground/water → On-ground/water Encounter with Terrain/Water	46
7	On-ground/water Collision with Object	45
8	In-flight Collision with Object → In-flight Collision with Terrain/Water	40
9	Loss of Control On-ground/water	39
10	Loss of Control On-ground/water → Nose Over	29

The top ten occurrence chains cited in fatal accidents are similar to those cited for all accidents. Loss of control followed by in-flight collision with terrain tops both lists, with more than half the accidents included in that category being fatal. It is important to note that, although this was the most frequent chain of occurrences in 2000, it accounted for less than 9.5% of all accidents for the year.

Rank	Chain Of Occurrences - Fatal GA Accidents, 2000	Number of Accidents
1	Loss of Control In-flight → In-flight Collision with Terrain/Water	95
2	In-flight Collision with Terrain/Water	47
3	In-flight Collision with Object	25
4	In-flight Collision with Object → In-flight Collision with Terrain/Water	17
5	In-flight Encounter with Weather → In-flight Collision with Terrain/Water	15
6	Airframe/Component/System Failure/Malfunction → In-flight Collision with Terrain/Water	9
7	In-flight Encounter with Weather → Loss of Control In-flight → In-flight Collision with Terrain/Water	8
8	In-flight Encounter with Weather → In-flight Collision with Object	7
9	Loss of Control In-flight → In-flight Collision with Object	7
10	Airframe/Component/System Failure/Malfunction → Loss of Control In-flight → In-flight Collision with Terrain/Water	6

A diverse range of events can, in combination, result in an accident. Fatal accidents, however, are usually the result of a more specific set of events. A comparison of the two lists provides insight as to why some accidents are fatal and others are not. Six of the top ten chains of accident occurrences for all accidents in 2000 involved ground events associated with taxi, takeoff, or landing. In contrast, each of the top ten chains of fatal accident occurrences included an in-flight collision with terrain or object, accident profiles that are more likely to result in the high impact forces likely to cause serious injury. As these differences show, most accidents in 2000 did not involve catastrophic events, and a large number of accidents involved aircraft on the ground.

Most Prevalent Causes/Factors for 2000

Probable Causes, Factors, Findings, and the Broad Cause/ Factor Classification

In addition to coding accident occurrences, the Safety Board makes a determination of probable cause. The objective of the probable cause statement is to define the cause and effect relationships in the accident sequence. The probable cause could be described as a determination of why the accident happened. In determining probable cause, the Board considers the facts, conditions, and circumstances of the event. Within each accident occurrence, any information that helps explain why that event happened is identified as a "finding" and may be further designated as either a "cause" or "factor." The term "factor" is used to describe situations or circumstances that contributed to the accident cause. The details of probable cause are coded as the combination of all causes, factors, and findings associated with the accident. Just as accidents often include a series of events, the reason why those events led to an accident reflects a combination of multiple causes and factors. For this reason, a single accident report can include multiple cause and factor codes, as shown in the following brief.

Occurrence #1: FIRE/EXPLOSION
Phase of Operation: CRUISE

Findings
1. (C) FLUID,FUEL - LEAK
2. (C) FLUID,FUEL - EXPLODED

Occurrence #2: LOSS OF ENGINE POWER(TOTAL) - MECH FAILURE/MALF
Phase of Operation: DESCENT - EMERGENCY

Findings
3. FLUID,OIL - LEAK
4. FLUID,OIL - EXHAUSTION
5. ENGINE ASSEMBLY,BEARING - OVERTEMPERATURE
6. ENGINE ASSEMBLY,CONNECTING ROD - FRACTURED
7. ENGINE ASSEMBLY,CRANKCASE - FRACTURED

Occurrence #3: FORCED LANDING
Phase of Operation: EMERGENCY DESCENT/LANDING

Occurrence #4: IN FLIGHT COLLISION WITH OBJECT
Phase of Operation: EMERGENCY DESCENT/LANDING

Findings
8. (F) FUSELAGE,CREW COMPARTMENT - SMOKE
9. (F) VISUAL LOOKOUT - REDUCED - PILOT IN COMMAND
10. OBJECT - TREE(S)

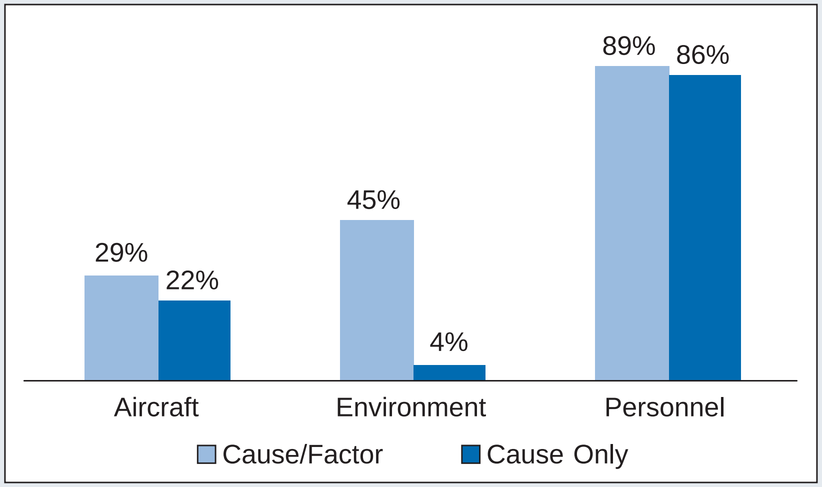
Findings Legend: (C) = Cause, (F) = Factor

The National Transportation Safety Board determines the probable cause(s) of this accident as follows.
An engine compartment explosion due to a fuel/fuel vapor leak of undetermined origin. A secondary explosion resulted from a lack of lubrication to the number 6 connecting rod bearing. Contributing to the pilot's injuries was his reduced visibility during the forced landing, resulting from a heavy concentration of smoke in the cockpit.

This accident sequence began with an explosion in the engine compartment of a single-engine airplane due to a fuel leak. Because of the explosion, the aircraft engine experienced a complete mechanical failure and the pilot made a forced landing. The pilot could not control the aircraft and impacted trees during landing because smoke filled the aircraft cabin and restricted visibility. The fuel leak and resulting explosion were both cited as causes in the findings of this accident. Smoke in the cabin, and the pilot's resulting reduced visibility, were both cited as factors. An oil leak, oil exhaustion, engine bearing over-temperature, fractured connecting rod, and fractured crankcase were all also cited in the findings but were not assigned as causes or factors.

To simplify the presentation of probable cause information in this review, the hundreds of unique codes used by investigators to code probable cause are grouped into broad cause/factor categories. This broad cause/factor classification provides an overview of fundamental accident origins by dividing all accident causes and factors into three groups: aircraft, environment, and personnel. The following graph shows the percentage of general aviation accidents that fall into each broad cause/factor classification. Personnel-related causes or factors were cited in 89% of the 1,758 general aviation accident reports for 2000 for which cause/factor data were available. Environmental causes/factors were cited in 45% of these accident reports, and aircraft-related causes/factors were cited in 29%.[42] Environmental conditions are rarely cited as an accident cause but are more likely to be cited as a contributing factor. In 2000, only 74 of 792 environmental citations (9.3% of all environmental causes/factors) were listed as a cause, with the remainder listed as contributing factors. For example, rough terrain might be cited as a contributing factor, but not a cause, to explain why an aircraft was damaged during a forced landing due to engine failure. In that case, the origin(s) of the engine failure would be cited as "cause," but the terrain would be cited as a factor because it contributed to the accident outcome.

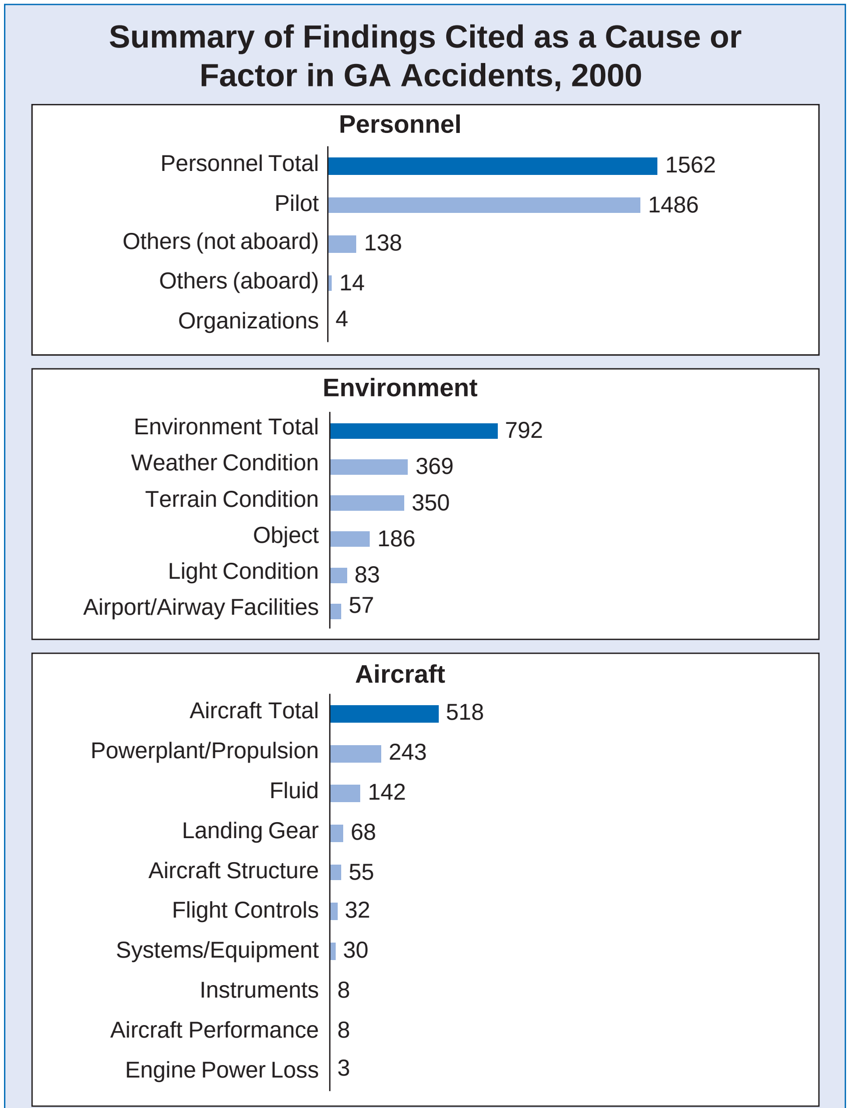
Accident Broad Cause/Factor and Cause, 2000



(1,758 accidents with findings)

As mentioned previously, several hundred unique codes are available to document causes/factors. A more detailed summary of the cause/factor codes is illustrated in the following graph, grouped into the categories of personnel, environment, and aircraft.

[42] Because the Safety Board frequently cites multiple causes and factors for an aircraft accident, the number of causes and factors will result in a sum greater than the total number of accidents.



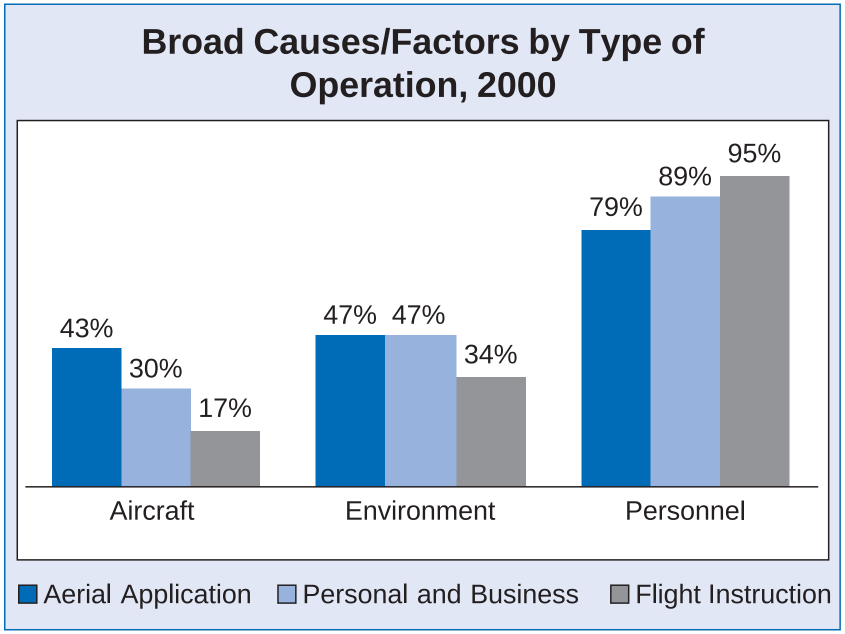
(1,758 accidents with findings in 2000)

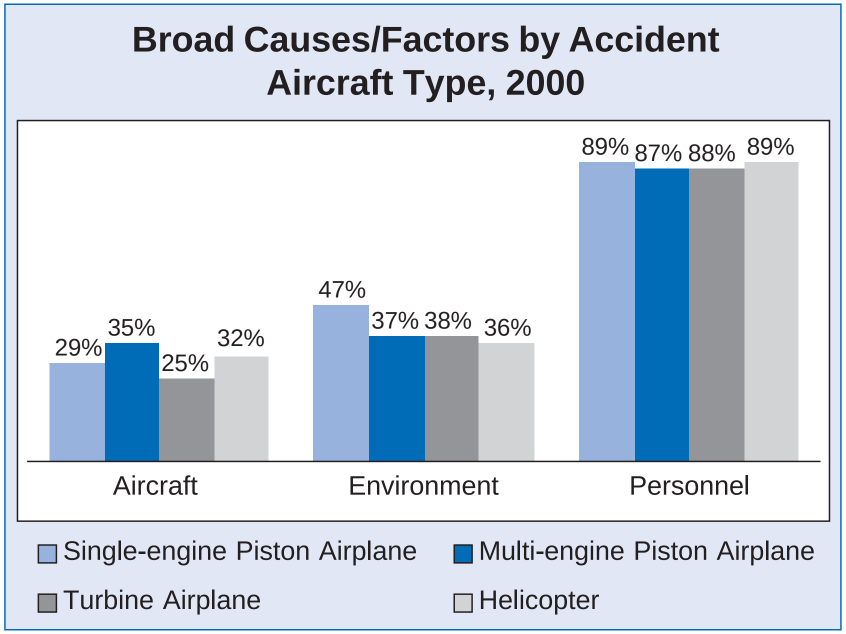
As this graph shows, most causes and factors attributed to general aviation accidents in 2000 were personnel related. Much like the pilot and passenger injury differences discussed previously, part of the reason for personnel being cited so often may have to do with exposure to risk. Personnel, and pilots in particular, are associated with every flight. However, the potential aircraft and environmental accident causes and factors depend on a range of variables, including the type of flight, type of aircraft, time of day, time of year, and location.

Although the pilot was the most frequently cited individual in the personnel category in 2000, other persons not aboard the aircraft were also cited as a cause or factor in 138 accidents. Such personnel included flight instructors, maintenance technicians, and airport personnel. In the broad category of environmental factors, weather conditions were cited in 369 (20%) accidents. Powerplant-related[43] causes/factors, cited in 243 (13%) of all general aviation accidents in 2000, were the most commonly cited aircraft factors.

The following graph shows how specific accident causes and factors vary by type of flight operation. For example, personnel were cited in 95% of instructional flight accidents, compared to 89% for personal/business accidents and 79% for aerial application accidents. The high percentage of personnel causes/factors for flight instruction accidents is likely the result of aircraft control and decision-making errors due to students' lower level of skill and ability. In contrast, aerial application accidents cited a higher percentage of aircraft causes/factors, most likely because the low altitude flown during spray operations allows few options for recovery in the event of a mechanical failure.

[43] "Powerplant/propulsion" causes and factors include any partial loss or disruption of engine power, as well as the malfunction or failure of any part(s), equipment, or system associated with engine propulsion; "engine power loss" refers only to the total loss of engine power.





A comparison of the causes/factors cited in accidents involving different types of aircraft reveals surprisingly similar results. The slightly higher percentage of helicopter and multi-engine piston accidents that cited aircraft causes/factors is likely a result of the mechanical complexity and reliability of the aircraft and powerplants. The higher percentage of environmental causes/factors cited in single-engine aircraft accidents may be due to the range, performance, and equipment limitations of smaller aircraft.

Human Performance

The information recorded in the personnel category refers primarily to whose actions were a cause or factor in an accident. To increase the level of detail about the actions or behavior that may have led to an accident, causal data related to human performance issues and any underlying explanatory factors are also recorded. The information in these categories can be thought of as how and why human performance contributed to the accident. For example, if a pilot becomes disoriented and loses control of an aircraft after continuing visual flight into instrument flight conditions, the pilot would be cited as a “cause” in the personnel category, and planning/decision-making would likely also be cited in the human performance issues category.

Of the 1,468 accidents for which the cause or factor was attributed to human performance in 2000, the most frequently cited cause/factor was aircraft handling and control (65.6%), followed by planning and decision-making (41.1%) and use of aircraft equipment (12.2%). Issues related to personnel qualification were cited in almost half of the 209 accidents with underlying explanatory factors related to human performance. Examples of qualification issues that were cited in the 2000 accident record include lack of total experience, lack of recent experience, and inadequate training.

Human Performance and Explanatory Causes/Factors 2000

	All Accidents	Fatal Accidents
Human Performance Issues	1,468	278
Aircraft Handling/Control	963	204
Planning/Decision	604	136
Use of Aircraft Equipment	180	12
Maintenance	88	14
Communications/Information/ATC	73	15
Meteorological Service	12	7
Airport	3	1
Dispatch	0	0
Underlying Explanatory Factors	209	86
Qualification	101	39
Physiological Condition	57	40
Psychological Condition	42	17
Procedure Inadequate	8	2
Aircraft/Equipment Inadequate	6	0
Material Inadequate	6	0
Information	5	0
Institutional Factors	4	2
Facility Inadequate	1	0

Weather as a Cause/Factor

Because general aviation aircraft are often smaller, slower, and limited in maximum altitude and range in comparison to transport-category aircraft, they can be more vulnerable than larger aircraft to hazards posed by weather. Smaller aircraft are affected to a greater degree by adverse wind conditions, and precipitation, icing, and convective weather have a greater effect on aircraft that lack the speed, altitude, and/or range capabilities to avoid those conditions. Weather conditions cited most often as a cause or factor in general aviation accidents are related to winds, including "crosswind," "gusts," and "tailwind."

Of the top five environmental causes/factors cited in general aviation accidents in 2000, three were related to wind. Because aircraft are most susceptible to the effects of wind during takeoffs and landings, the effect of adverse wind was reflected in a high percentage of general aviation accidents that occurred during those phases of flight.

Weather Condition	All Accidents 369	Fatal Accidents 87
Crosswind	86	0
Gusts	54	3
Tailwind	53	7
Low Ceiling	38	29
High Density Altitude	29	6
Fog	25	15
Downdraft	21	1
Carburetor Icing Conditions	20	2
Snow	17	9
High Wind	15	3
Clouds	12	10
Icing Conditions	10	4
Windshear	9	4
Variable Wind	9	0
Obscuration	8	6
Unfavorable Wind	7	0
Sudden Windshift	6	1
Rain	6	3
Thunderstorm	5	3
Turbulence, Terrain Induced	5	1
Below Approach/Landing Minimums	5	4
Turbulence	4	2
Dust Devil/Whirlwind	4	0
Drizzle/Mist	3	2
Turbulence In Clouds	2	1
Freezing Rain	2	1
Haze/Smoke	2	1
No Thermal Lift	2	1
Turbulence, Clear Air (CAT)	1	0
Temperature Extremes	1	0
Temperature, High	1	1
Temperature, Low	1	0
Whiteout	1	1
Turbulence (Thunderstorms)	1	1
Mountain Wave	1	0
Updraft	1	0
Lightning Strike	1	1

Note: due to the possibility of multiple findings, the sum of causes/factors is greater than the accident total.

As previously discussed, most landing accidents do not result in fatal injuries. Because of the strong association of wind with landing accidents in 2000, it is not surprising that most wind-related accidents are also not fatal. The wind-related weather factors "crosswind," "gusts," and "tailwind" were cited as a cause/factor in a total of 193 accidents, but only 10 of those accidents were fatal. Among fatal general aviation accidents, four of the five most frequently cited weather factors were related to conditions that resulted in reduced visibility, including "low ceiling," "fog," and "clouds." Accidents under conditions of low visibility typically involve either loss of aircraft control and/or collision with obstacles or terrain, both of which are likely to result in severe injuries and aircraft damage.

Focus on General Aviation Safety: Landing Accidents

A review of current and historic accident data reveals that although rarely fatal, landing accidents represent a significant risk to general aviation safety. In light of this safety concern, the following section includes statistical data and a discussion of several issues pertaining to general aviation landing accidents. This section is not meant to be an exhaustive discussion of all safety concerns, but rather a summary of the issues important to general aviation.

2000 GA Landing Accident Statistics

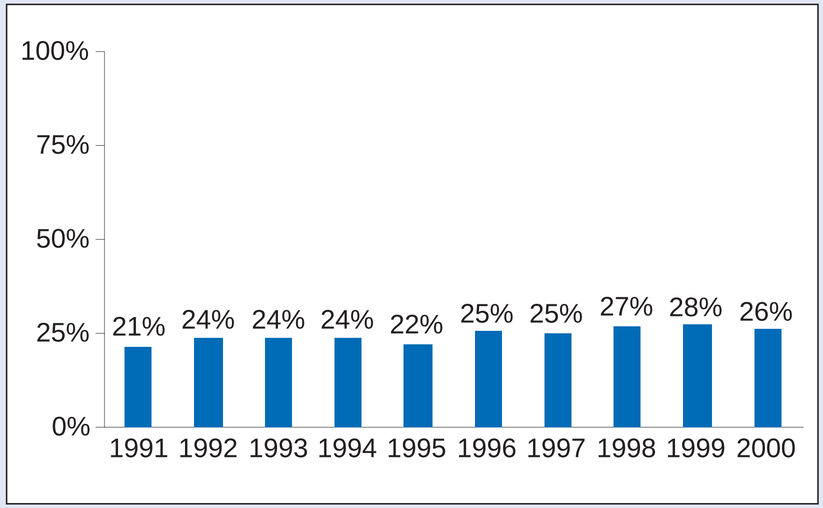
Landing Accidents	
Total Accidents	478
Accident Aircraft	483
Landing Accident Highest Injury	
None	374
Minor	66
Serious	29
Fatal	9
Landing Accident Injuries	
Minor	102
Serious	29
Fatal	11
Persons involved in GA accidents with no injuries	688
Landing Accident Aircraft Damage	
Destroyed	13
Substantial	464
Minor*	2
None*	4

*Note that a landing mishap that results in no damage or minor damage to the aircraft is classified as an incident unless combined with one or more injury classified as substantial or greater severity.

Landing Accidents

Historically, a large number of general aviation accidents have occurred during the landing phase of flight. Charting the annual percentage of these general aviation accidents for each year from 1991 through 2000 shows that the relative accident frequency during landing was consistent year to year and increased slightly.

Percentage of Accident Aircraft First Occurrences During the Landing Phase, 1991-2000

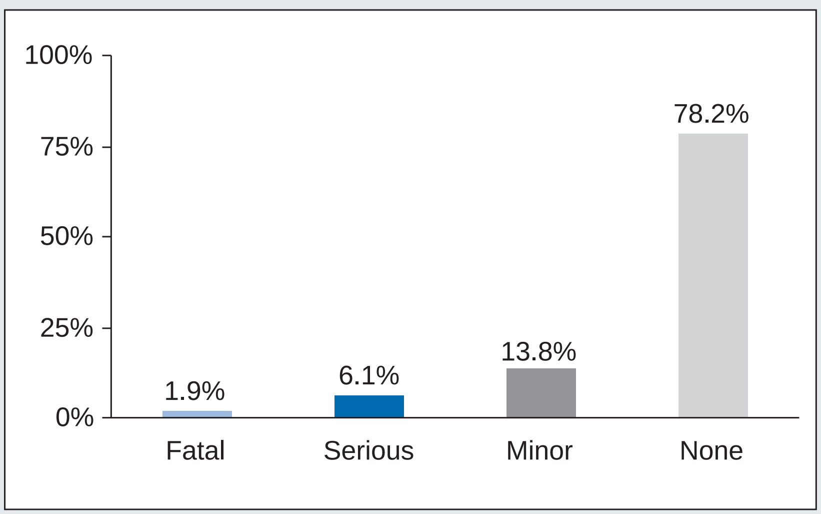


Landing Accident Severity

Although the number of landing accidents for the years 1991 through 2000 accounted for about one-quarter of the general aviation accident total, the number of reported accidents likely represented only a small portion of the total number of landing mishaps that occurred each year. As discussed previously and in Appendix B, 49 CFR 830.2 defines an aircraft accident as an event in which "any person suffers death or serious injury, or in which the aircraft receives substantial damage." Mishaps that result in less than substantial damage, minor injuries, or no injuries are categorized as incidents, which are not required to be reported to the Safety Board and are not included in this review. These mishaps can include gear-up landings, ground loops, scraped wingtips, and collisions with runway lights. Such events may be relatively commonplace, but few of them appear in the accident record because they are less likely to cause serious injury or substantial aircraft damage.

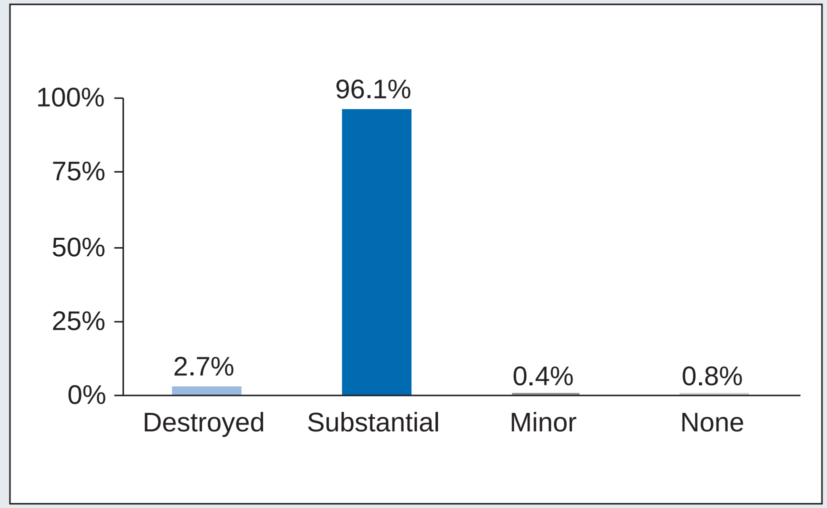
During 2000, only 9 landing accidents, or about 2% of the total, resulted in a fatal injury compared to about 19% for all accidents. Serious or fatal injuries that did occur during landing accidents were typically due to specific occurrences likely to result in severe impact forces, such as a collision with an object or structure at high speed.

Highest Level of Injury Sustained in Landing Accidents, 2000



A combined 92% of all landing accidents during 2000 resulted in minor or no injuries. These events are defined as accidents, not because of injuries but because of damage to the aircraft. In fact, nearly all aircraft involved in landing accidents in 2000 received substantial damage.

Level of Aircraft Damage in Landing Accidents, 2000



Landing Accident Occurrences

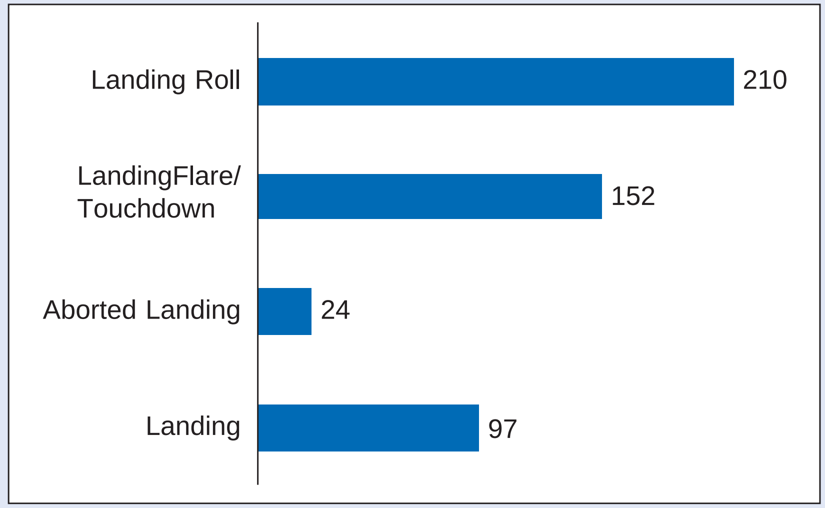
The following chart ranks, in order, first occurrences for landing accidents in 2000 by frequency. The most frequently cited first occurrence for landing accidents was "loss of control," just as it was for all general aviation accidents in 2000. For landing accidents, loss of control on ground or water indicates that most accidents occurred after the aircraft was no longer flying. The second most common occurrence, "hard landing," reflects the difficulty pilots face in judging the speed and descent rate of their aircraft and their distance from the surface as they transition from the air to the ground. Hard landings may damage the aircraft landing gear or the structure surrounding the landing gear mounting point. Noticeably few accidents in 2000 included wheels-up landings or the dragging of a wing, rotor, pod, float, or tail.

First Occurrences of Accidents During the Landing Phase of Flight, 2000

Loss of Control – On-ground/water	164
Hard Landing	88
Loss of Control – In-flight	34
Overrun	26
Nose Over	25
Airframe/Component/System Failure/Malfunction	18
On-ground/water Collision with Object	17
In-flight Collision with Object	17
In-flight Collision with Terrain/Water	15
On-ground/water Collision with Terrain/Water	14
Wheels Up Landing	12
Gear Collapsed	7
Undershoot	6
In-flight Encounter with Weather	5
Nose Gear Collapsed	5
Dragged Wing, Rotor, Pod, Float, or Tail/Skid	3
Main Gear Collapsed	3
Midair Collision	2
Gear Retraction on Ground	2
Loss of Engine Power	2
Roll Over	2
Wheels Down Landing in Water	2
Loss of Engine Power (Partial) – Mechanical Failure/Malfunction	1
Nose Down	1
On-ground/Water Encounter with Weather	1
Miscellaneous/Other	6
Total	478

Separating the broad phase of flight "landing" into more specific subcategories further illustrates the fact that most landing accidents occurred after the aircraft had already touched down. A total of 210 aircraft, or about 11% of all accident aircraft in 2000, were involved in an accident while rolling down the runway after landing.

Specific Phase of Landing Accidents by Aircraft, 2000



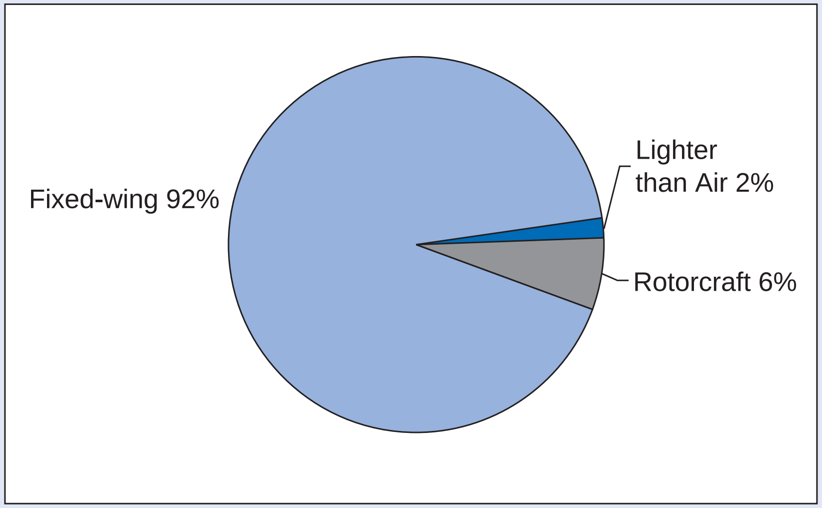
The large number of accidents that occurred during the landing roll should come as no surprise. Fixed-wing aircraft landing gear are designed to support the aircraft during taxi, takeoff, and landing, but must also be lightweight and create as little aerodynamic drag as possible while in flight. As a result, the landing gear on most general aviation aircraft are very simple in design and rely on the pilots' coordinated use of flight controls to maintain control on the ground.

For fixed-wing aircraft, directional control is typically maintained using the vertical stabilizer, commonly referred to as the "rudder." Most airplanes implement rudder control through left and right rudder pedals, requiring pilots to use their feet to make control inputs. Aircraft braking control is commonly incorporated into the rudder pedals, which pilots control by pushing on the top of the pedal. Braking controls for the left and right wheels are usually independent in these systems, giving pilots greater directional control authority through the use of differential braking. However, differential braking is typically reserved for use during low-speed taxi when the aerodynamic controls are less effective.

The large number of landing accidents that occur during and just after landing is likely related to the fact that proper control technique during landing is different from that used for surface vehicles (for example, automobiles) and other phases of flight in an airplane. The steering wheel used for directional control in an automobile is similar in operation to the yoke control used in many aircraft for control about the longitudinal or "roll" axis. During most fixed-wing aircraft flight operations, directional control is maintained by using the control yoke to bank the aircraft in the desired direction, and the rudder is used to balance the aerodynamic forces on the airplane. Depending on the aircraft design, power setting, and airspeed, very little rudder input may be required during most phases of flight compared to the amount of yoke input required.

Just prior to touchdown, however, the rudder pedals become the primary control used to align the longitudinal axis of the airplane with the runway or landing surface. At this point, the pilot uses the yoke to keep the aircraft positioned in the center of the runway by banking the aircraft into the wind. Because most pilots are much more experienced using automobile steering wheels and aircraft control yokes to maintain directional control, it is not surprising that pilots of fixed-wing aircraft have problems during landing when required to change the priority of control inputs. The potential for previously learned behaviors to negatively affect performance can be especially strong in situations that require rapid responses, like landing an aircraft. Evidence of this negative effect can be observed in the typically higher percentage of landing accidents that involve fixed-wing aircraft. For example, fixed-wing aircraft accounted for 92% percent of landing accidents in 2000 compared to 85% of the accident total. In contrast, rotorcraft accounted for 11% of the 2000 accident total but only 6% of landing accident aircraft.

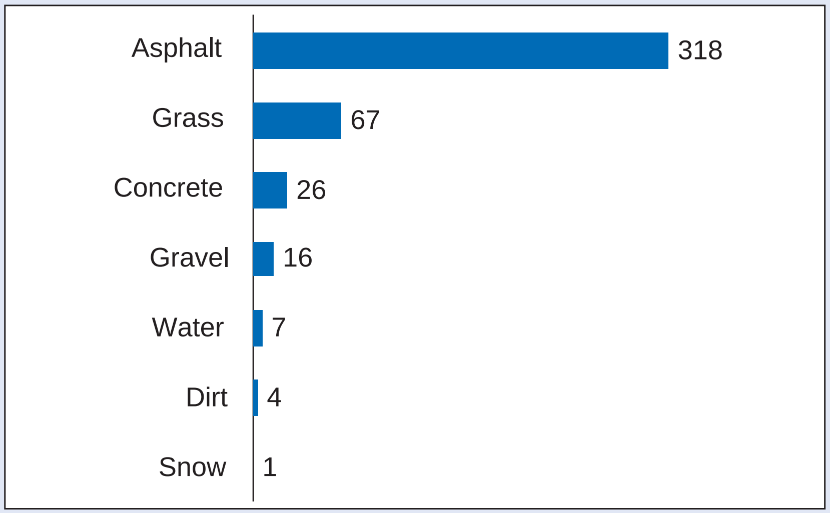
Aircraft Type Involved in Landing Accidents, 2000



Landing Surface

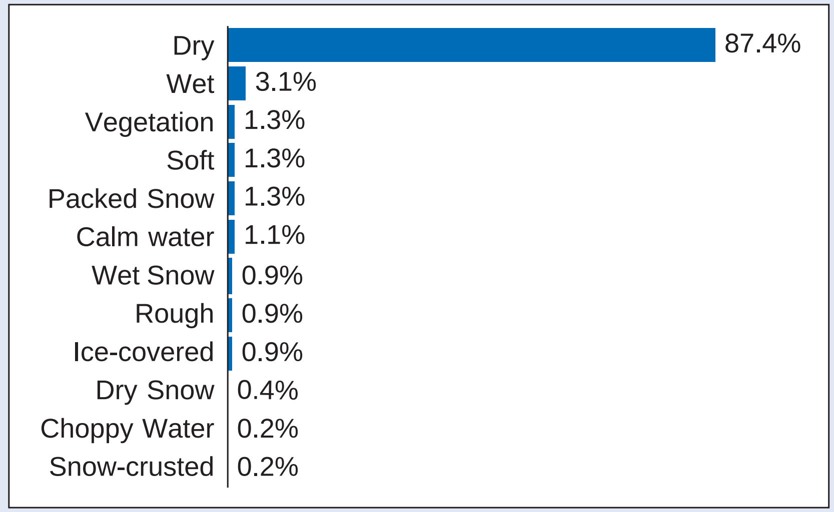
Aircraft control during landing may be complicated if the landing surface is uneven or is contaminated by snow, water, or ice. However, most landing accidents in 2000 occurred while aircraft were landing on dry, asphalt-surface runways.

Landing Surface Type for Landing Accidents, 2000



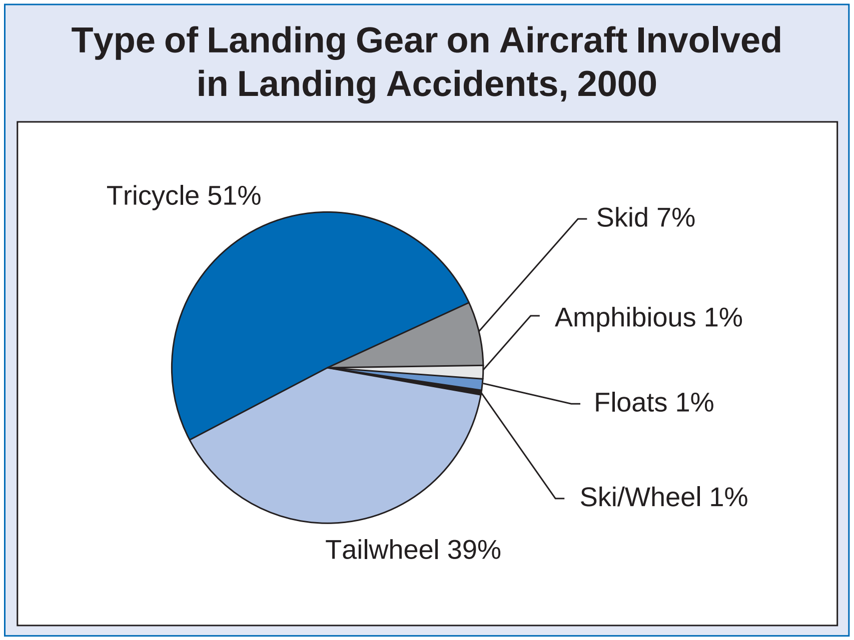
(439 landing accidents with data available)

Surface Conditions at Site of Landing Accidents, 2000



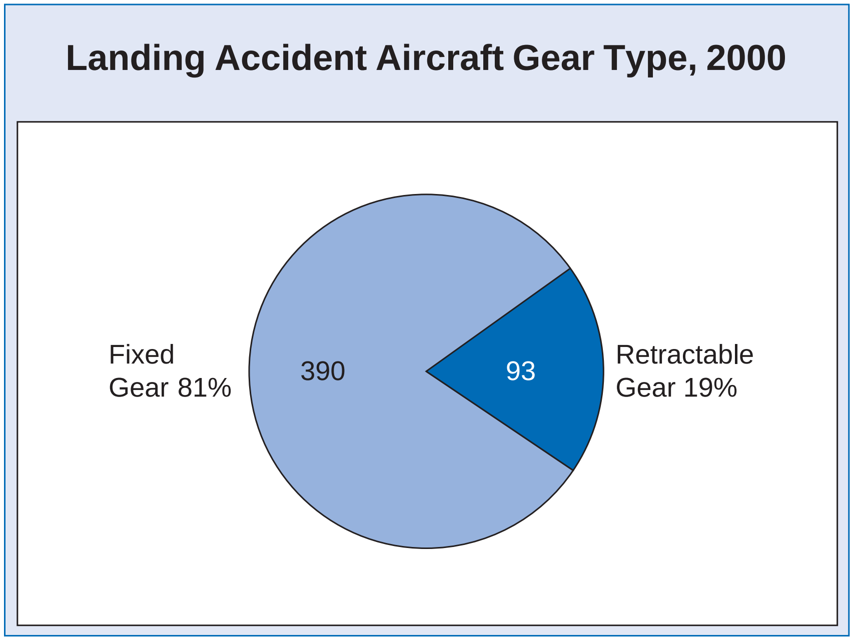
Gear Configuration

Aircraft design and landing gear configuration may pose additional risks for landing accidents. Conventional or "tailwheel" gear configuration is an example of a landing gear design that may pose additional challenges under certain circumstances. Tailwheel aircraft are susceptible to a rapid loss of directional control, commonly referred to as "ground loop," if the pilot makes abrupt rudder inputs or fails to align the longitudinal axis of the aircraft with the runway during touchdown. Tailwheel aircraft are also subject to "nose over," where the aircraft tips forward onto its nose or even flips if braking is applied too forcefully or rapidly. Specific activity data needed to compare tailwheel aircraft and those with a tricycle-gear configuration are not available. However, the large percentage of landing accidents involving tailwheel aircraft is likely the result of these potential control difficulties. The differences between tailwheel and tricycle gear aircraft prompted the FAA to require[44] pilots to obtain additional training and an instructor endorsement in order to act as pilot-in-command of a tailwheel airplane.



Despite some of the specific challenges associated with landing tailwheel aircraft, they remain popular in certain locations and for certain flight operations. For example, tailwheel airplanes are often better suited than airplanes with tricycle-gear for operation from unimproved surfaces like grass, gravel, and dirt, making them popular in locations with fewer paved runway surfaces, like Alaska. In fact, about 13% of all landing accidents involving tailwheel aircraft in 2000 occurred in Alaska, compared to only 6% of the total number of accidents.

Another aircraft configuration that might be expected to contribute to landing accidents is retractable landing gear. Failure to extend the landing gear prior to landing, whether because of mechanical malfunction or flight crew error, is an obvious risk for retractable-gear aircraft. Surprisingly, the percentage of landing accidents involving these aircraft was actually less than the percentage of total accidents involving retractable gear aircraft. Specifically, 19% of general aviation landing accidents during 2000 involved aircraft with retractable landing gear compared to about 25% of all general aviation accidents.



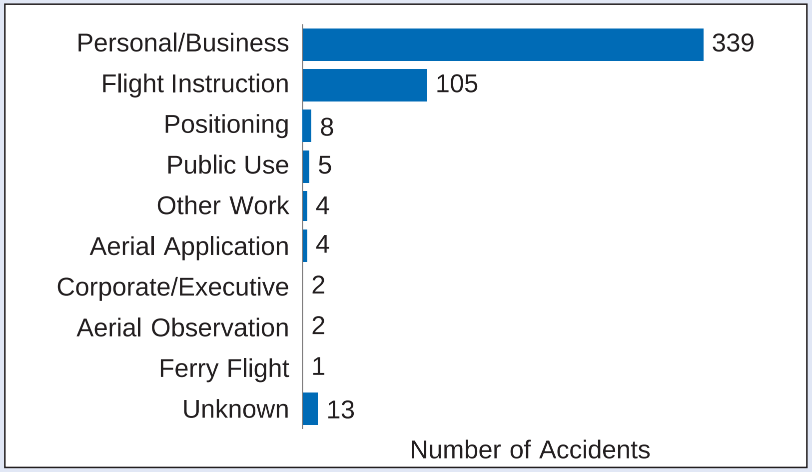
[44] See 14 CFR 61.31(h)(1).

The smaller percentage of landing accidents observed for retractable-gear aircraft may reflect the fact that mishaps specific to retractable-gear aircraft, such as wheels-up landings or gear collapses, are less likely to result in serious injury or substantial aircraft damage and are not categorized as accidents. Retractable-gear aircraft may also be less likely than fixed-gear aircraft to be used by less experienced pilots or in certain operations, such as flight instruction, that might contribute to more landing accidents.

Type of Flight Operation

A comparison of the percentage of accidents involving different flight operations shows that personal/business flights and instructional flights account for most landing accidents. However, instructional flights accounted for a disproportionate number of landing accidents overall. In 2000, about 22% of general aviation landing accidents involved instructional flight operations. In contrast, only 14% of the accident total involved instructional flights. This difference is likely explained by the combination of errors new pilots make as they learn to fly and an increased risk exposure because student pilots spend more time than other pilots practicing landings

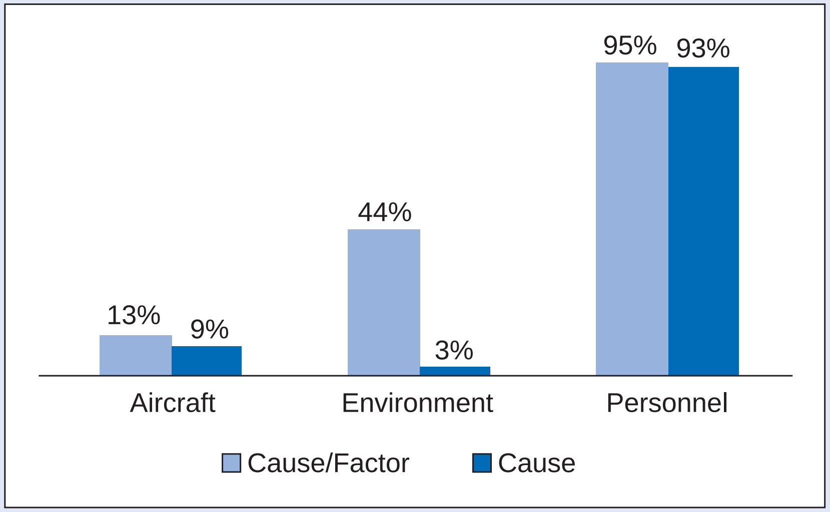
Purpose of Accident Flight for Landing Accident Aircraft, 2000



Landing Accident Causes/factors

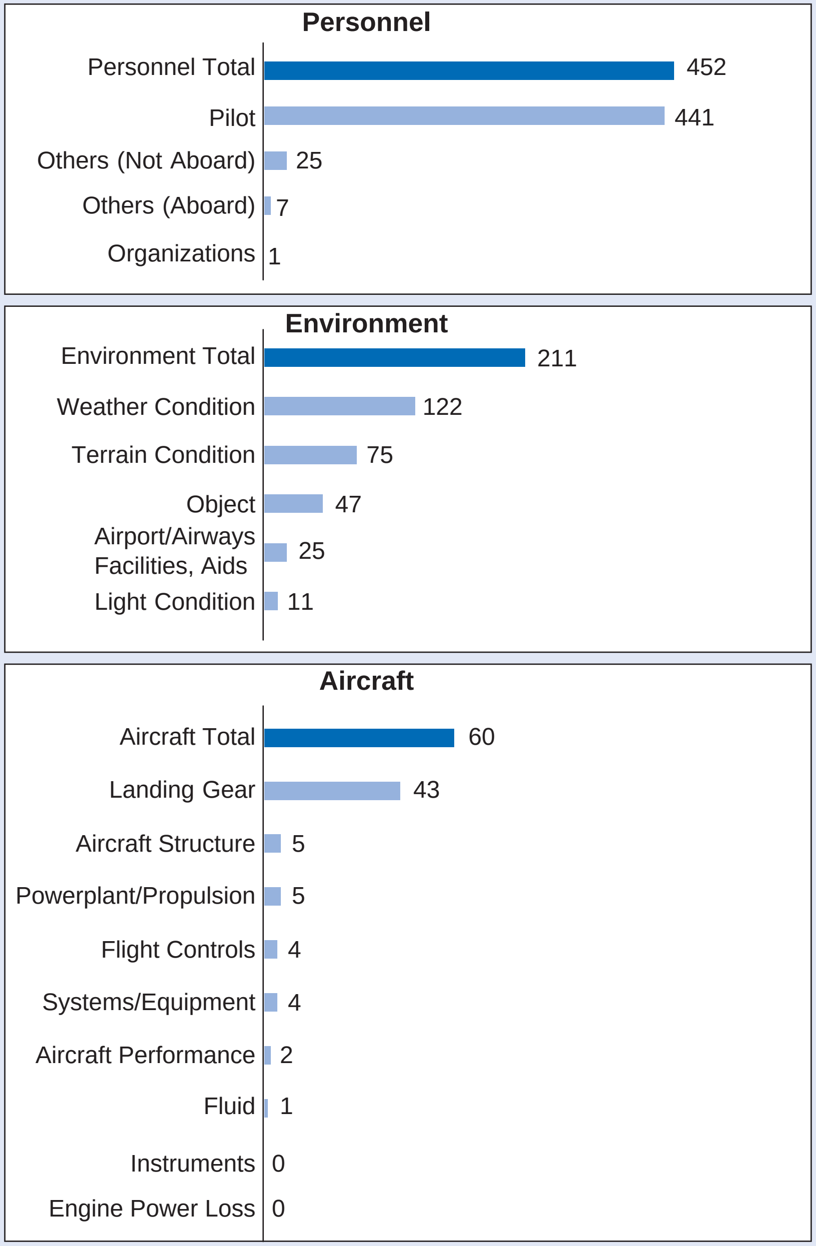
The contribution of human error to mishaps during landing is evident in the percentage of accident findings that cite personnel-related causes and/or contributing factors. Of the 477 landing accidents in 2000 for which findings are available, 95% cite personnel-related causes/factors compared to the 89% of all accidents citing similar findings. In contrast, the 13% of landing accident findings that cited aircraft-related causes and factors is considerably lower than the 29% of all accidents.

Broad Cause/Factor of Accidents During the Landing Phase, 2000



(477 landing accidents with findings available)

Summary of Findings Cited as a Cause or Factor in GA Landing Accidents, 2000



Within the broad cause/factor category of personnel, 441 of 447 accident pilots were cited as contributing to landing accidents, making them the most frequently cited individuals. In addition, 25 persons who were not aboard the accident aircraft were cited for contributing to landing accidents in 2000. For example, the driver of an airport maintenance vehicle and airport personnel were cited in the collision of a landing aircraft with a vehicle used to spray for weeds. In another example, a flight instructor was cited for failing to adequately supervise a student pilot who crashed in gusty winds during a solo flight.

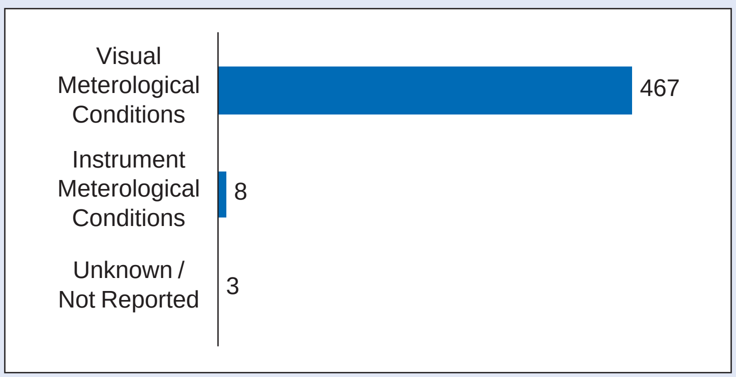
In the aircraft cause/factor category, landing gear was the most commonly cited aircraft component. The most common examples of landing gear causes or factors included brake failure and gear collapse.

Landing Accident Weather

In 2000, the proportion of landing accidents that cited environmental causes and factors was similar to the proportion for all accidents. However, the percentage of environment-related cause/factor findings citing weather conditions was noticeably higher for landing accidents. In 2000, about 58% of the environmental causes and factors cited in landing accident findings included weather conditions, compared to 46% of all general aviation accidents.

Unlike other phases of flight, cloud ceilings and visibility were less likely to contribute to landing accidents. Most likely, this was because, by the time a flight progressed to the landing phase, the greatest threat posed by low cloud ceilings had usually been avoided. With the exception of very low-surface barriers to visibility like fog and precipitation, IMC rarely poses a specific threat during the landing phase of flight. The 2000 accident record supports this suggestion, with only 8 of 478 landings accidents occurring in IMC.

Basic Weather Conditions Associated with Accidents During the Landing Phase, 2000



As illustrated in this table of weather conditions cited for landing accidents in 2000, the top seven weather causes/factors described wind conditions. The top three conditions, "crosswind," "gusts," and "tailwind," accounted for 111 of the 122 weather-related findings.

Landing Accidents Citing Weather as Cause/Factor, 2000

	Accidents
Weather Condition Total	122
Crosswind	57
Gusts	28
Tailwind	26
Downdraft	7
Variable Wind	6
High Wind	6
Unfavorable Wind	4
High Density Altitude	4
Snow	3
Dust Devil/Whirlwind	3
Low Ceiling	2
Sudden Windshift	1
Turbulence, Terrain Induced	1
Windshear	1
Updraft	1
Rain	1
Fog	1
No Thermal Lift	1

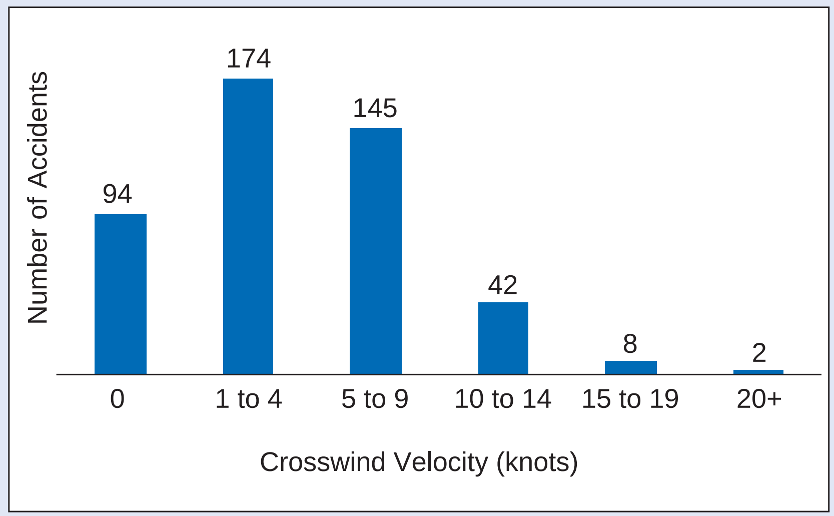
Wind

Wind orientation does not affect an aircraft's flight characteristics, but it does affect the movement of an aircraft relative to the ground. For most aircraft, the normal operating procedure during takeoffs and landings is to fly into a headwind to obtain a slower forward groundspeed while maintaining the aircraft's designed airspeed requirement. The airspeed requirements for takeoff, approach, and landing are based on the design requirements and configuration of the aircraft and do not change in relation to the wind. However, reduced groundspeed results in shorter takeoff and landing distances and reduces the forward distance traveled for a given angle of climb or descent, which is useful when attempting to clear obstacles.

Whenever possible, airports are built so that runways align with local prevailing winds, and airport traffic flow is typically directed to operate into a headwind. Larger airports may have multiple runways that are oriented in different directions to maximize the opportunity for a direct headwind. However, because local wind direction and speed may change with high and low pressure systems, fronts, and even the time of day, the wind direction will not always be aligned with the runway. As the angle between the direction of the wind and the direction of the runway increases, the headwind component decreases and the side or "crosswind" component increases. Just like a boat trying to cross a moving river, the pilot of an aircraft landing in a crosswind must angle the aircraft into the wind to follow a straight path relative to the runway centerline. During touchdown, the pilot of a fixed-wing aircraft must use the aircraft aileron (bank) and rudder (yaw) controls, as previously discussed, to align the aircraft with the runway centerline and heading: the stronger the crosswind component, the greater the control input required to maintain proper runway alignment. There is a maximum limit to the amount of crosswind that can be corrected for before the aircraft controls are no longer effective in maintaining runway alignment, and manufacturers are required[45] to provide pilots with a maximum demonstrated crosswind component value to be used as a guide. This maximum limit varies depending on the type of aircraft and the design of its controls, but a typical maximum demonstrated crosswind for a general aviation aircraft is between 15 and 20 knots.

Crosswinds were the single most common weather phenomena cited in general aviation landing accidents in 2000. However, a review of the actual crosswind component calculated from the landing runway heading and the winds reported at the time of the accidents indicates that crosswinds above 15 knots were present in only 10 of the 465 accidents for which wind information was available. This suggests that the problem was not that the crosswind exceeded the design limits of the aircraft, but that the accident pilot failed to maintain control of the aircraft and appropriately correct for the effects of the crosswind.

Reported Crosswind Velocity for Landing Accidents, 2000

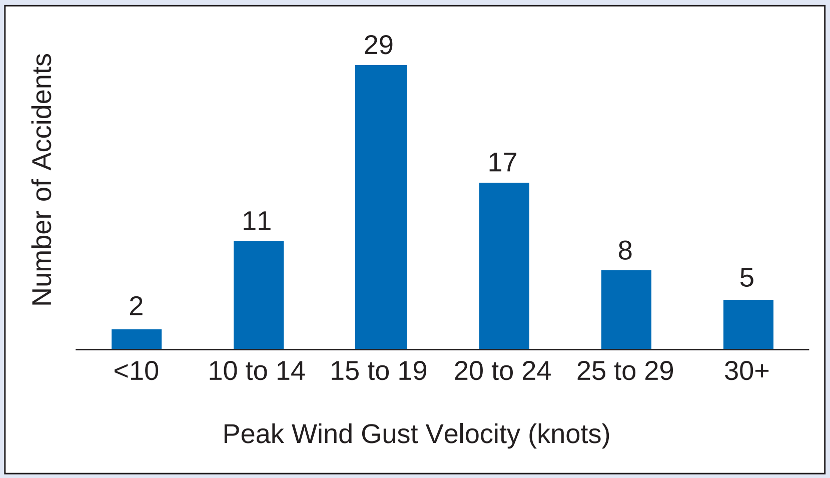


(465 of 478 landing accidents with information)

[45] See 14 CFR 23.1585 (2). See also 14 CFR 23.233(a), which requires, "A 90 degree cross-component of wind velocity, demonstrated to be safe for taxiing, takeoff, and landing must be established and must be not less than 0.2 VS0 [stall speed in the landing configuration]."

After crosswinds, the most common weather condition cited in landing accidents was "gusts."[46] Gusting winds can adversely affect landing aircraft if the wind speed or direction changes rapidly when the aircraft is at low altitude and airspeed. Pilots typically compensate for gusting wind conditions during landing by increasing approach airspeed by a percentage of the difference between the peak and lull wind speeds. In 2000, the most commonly recorded wind conditions for landing accidents that included gusts was a peak gust speed of 15-19 knots.

Maximum Reported Wind Gust Velocity for Landing Accidents, 2000



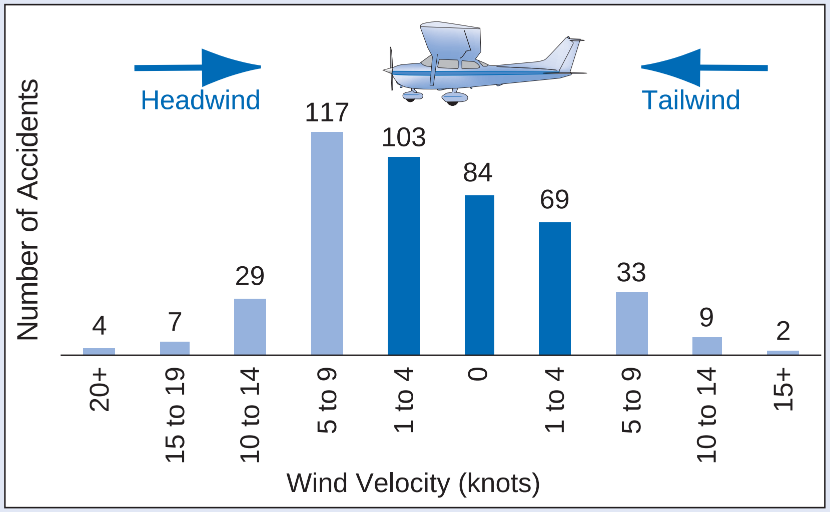
(72 of 478 landing accidents reported gusting winds)

The third most common weather condition cited in landing accidents in 2000 was "tailwind." Despite the previously mentioned reasons for landing into a headwind, some circumstances might induce a pilot to intentionally land with a tailwind. Sloping runways, terrain, or obstacles can make landing in one direction preferable to the opposite direction, even with a slight tailwind. In some cases, a pilot who fails to accurately interpret the current wind conditions may unintentionally land with a tailwind.

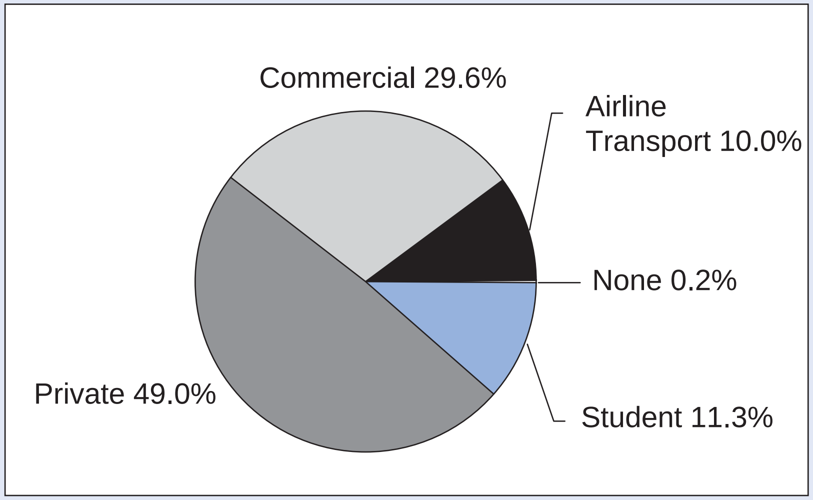
The primary result of landing with a tailwind is a higher groundspeed. To compensate, pilots of fixed-wing aircraft must use a higher rate of descent to maintain a normal approach angle, and are at risk of overshooting the runway or landing too far down the runway to stop the aircraft safely. Once on the ground, the increased groundspeed results in a longer ground roll as the pilot attempts to slow the aircraft to a stop. For a small single-engine aircraft with a normal approach speed of 55 knots, a 5-knot increase in groundspeed will typically increase the landing distance by about 20%. A 20-knot increase in groundspeed for the same aircraft can double the landing distance that would be expected with no wind. In addition to greatly increasing the likelihood that an aircraft will overrun the end of the runway during landing, landing with a tailwind also increases the risk that the landing gear, tires, and brakes will fail when exposed to the strain of higher-than-normal touchdown speeds.

[46] Gusting wind is defined in chapter 5 of the Federal Meteorological Handbook as rapid fluctuations in wind speed with a variation of 10 knots or more between peaks and lulls. (See Office of the Federal Coordinator for Meteorological Services and Supporting Research. Federal Meteorological Handbook (FCM-H1-1995),1995, available online at http://www.ofcm.gov/fmh-1/cover.htm.)

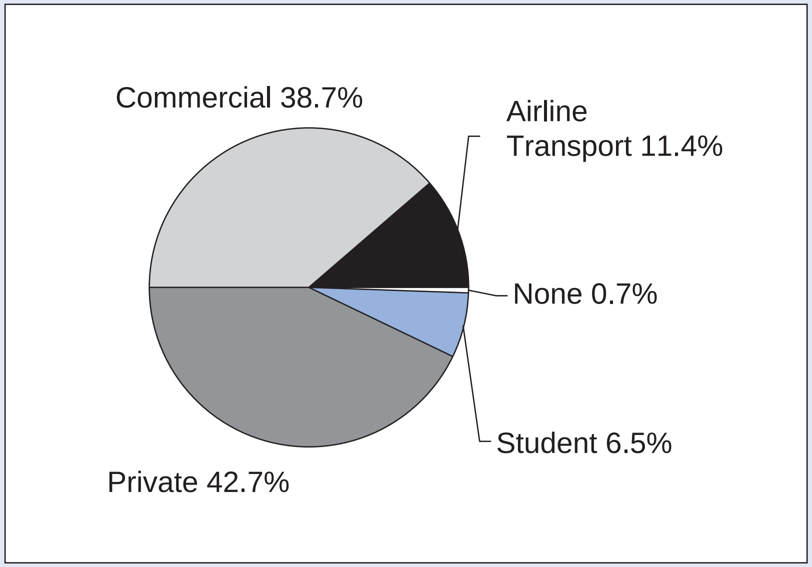
Headwind/Tailwind Velocity for Landing Accidents, 2000



Highest Certificate Held by Pilot Involved in Landing Accidents, 2000



Highest Certificate Held by All Accident Pilots, 2000

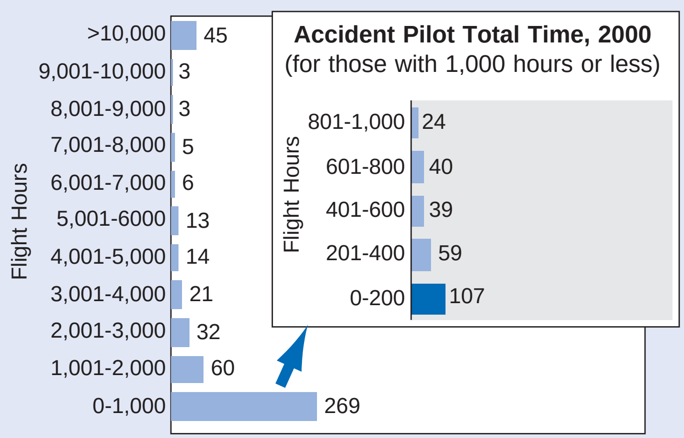


Accident Pilots

The percentage of landing accidents citing personnel-related causes and factors was noticeably larger than the percentage for total accidents in 2000. A comparison of pilots involved in landing accidents with all accident pilots shows that landing accidents included larger percentages of private and student pilots. This difference suggests that less experienced pilots were more likely to be involved in landing accidents.

An examination of total flight experience of pilots involved in landing accidents supports this suggestion. Of the 478 landing accident pilots with flight time data available, 269 (56%) had 1,000 hours of flight experience or less compared to 47% of all accident pilots in 2000. Furthermore, 107 of 269 (22%) landing accident pilots had 200 hours of total flight time or less compared to 14% of all accident pilots with less than 1,000 hours.

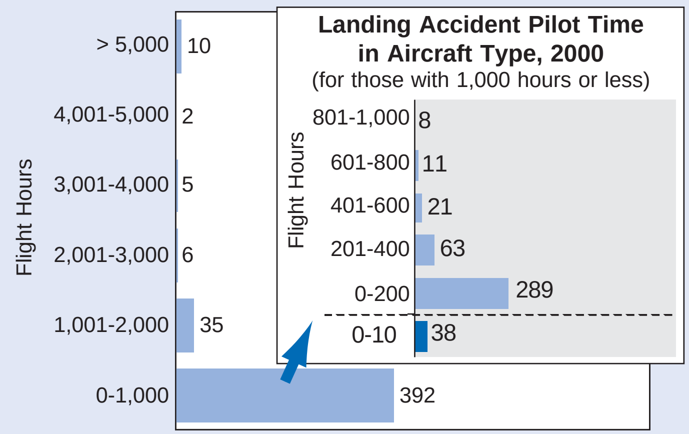
Landing Accident Pilot Total Time, 2000



(478 landing accident pilots with data available)

Lack of experience is also evident in the total flight time in accident aircraft type. Of the pilots involved in landing accidents in 2000, 38 had 10 hours or less in the accident aircraft type. As mentioned previously, a total 100 pilots involved in accidents in 2000 had 10 hours or less in type. Therefore, 38% of the landing accidents involved pilots with 10 hours or less in aircraft type. This not only supports the suggested connection between landing accidents and experience, but also illustrates the risks associated with landing when transitioning to a new aircraft type.

Landing Accident Pilot Time in Aircraft Type, 2000



(450 landing accident pilots with data available)

Summary

Transitioning an aircraft from an airborne vehicle to a ground vehicle typically requires the coordinated use of flight controls and engine power settings to reduce speed and, depending on the complexity of the aircraft, the extension of retractable landing gear and the use of additional flight surfaces such as flaps or slats. During this transition, the cognitive and perceptual demands placed on a pilot include judging aircraft height, speed, and descent rate, as well as precisely manipulating aircraft controls. It may seem as though the greatest hazards of the flight may have passed once an aircraft has reached the landing phase of flight because the flight is nearly complete. However, the accident record suggests that the opposite is true. The details of landing accidents highlight the need for instruction and repeated practice of landings, especially in crosswind conditions and when transitioning to new aircraft. In addition, wind and weather conditions associated with landing accidents suggest that pilot skill and ability may contribute more to landing accident risk than aircraft design limitations.

Appendix A

The National Transportation Safety Board Aviation Accident/Incident Database

The National Transportation Safety Board is responsible for maintaining the government's database on civil aviation accidents. The Safety Board's Accident/Incident Database is the official repository of aviation accident data and causal factors. The database was established in 1962 and about 2,000 new event records are added each year.

The Accident/Incident Database is primarily composed of aircraft accidents. An "accident" is defined in 49 CFR 830.2 as, "an occurrence associated with the operation of an aircraft which takes place between the time any person boards the aircraft with the intention of flight and all such persons have disembarked, and in which any person suffers death or serious injury, or in which the aircraft receives substantial damage." The database also contains a select number of aviation "incidents," defined in 49 CFR 830.2 as, "occurrences other than accidents that are associated with the operation of an aircraft and that affect or could affect the safety of operations."

Accident investigators use the Safety Board's Accident Data Management System (ADMS) software to enter data into the Accident/Incident Database. Shortly after the event, a preliminary report, containing a few data elements, such as date, location, aircraft operator, type of aircraft, etc., becomes available. A factual report with additional information concerning the occurrence is available within a few months. A final report, which includes a statement of the probable cause and other contributing factors, may not be completed for months until the investigation is closed.

An accident-based relational database is currently available to the public at http://www.ntsb.gov/ntsb/query.asp#query_start. It contains records of about 40,000 accidents and incidents that occurred between 1982 and the present. Each record may contain more than 650 fields of data concerning the aircraft, event, engines, injuries, sequence of accident events, and other topics. Individual data files are also available for download at ftp://www.ntsb.gov/avdata, including one complete data set for each year beginning with 1982. The data files are in Microsoft Access (.mdb) format and are updated monthly. This download site also provides weekly "change" updates and complete documentation.

Appendix B

Definitions

Definitions of Safety Board Severity Classifications

The severity of a general aviation accident or incident is classified as the combination of the highest level of injury sustained by the personnel involved (that is, fatal, serious, minor, or none) and level of damage to the aircraft involved (that is, destroyed, substantial, minor, or none). Accidents include those events in which any person suffers fatal or serious injury, or in which the aircraft receives substantial damage or is destroyed. An event that results in minor or no injuries and minor or no damage is not classified as an accident.

Definitions for Highest Level of Injury

Fatal – Any injury that results in death within 30 days of the accident.

Serious – Any injury that (1) requires the individual to be hospitalized for more than 48 hours, commencing within 7 days from the date the injury was received; (2) results in a fracture of any bone (except simple fractures of fingers, toes, or nose); (3) causes severe hemorrhages, nerve, muscle, or tendon damage; (4) involves any internal organ; or (5) involves second- or third-degree burns, or any burns affecting more than 5% of the body surface.

Minor – Any injury that is neither fatal nor serious.

None – No injury.

Definitions for Level of Aircraft Damage

Destroyed – Damage due to impact, fire, or in-flight failures to the extent that the aircraft cannot be repaired economically.[47]

Substantial Damage – Damage or failure that adversely affects the structural strength, performance, or flight characteristics of the aircraft, and that would normally require major repair or replacement of the affected component. Engine failure or damage limited to an engine if only one engine fails or is damaged, bent fairings or cowling, dented skin, small puncture holes in the skin or fabric, ground damage to rotor or propeller blades, and damage to landing gear, wheels, tires, flaps, engine accessories, brakes, or wingtips are not considered "substantial damage."[48]

Minor Damage – Any damage that neither destroys the aircraft nor causes substantial damage (see definition of substantial damage for details).

None – No damage.

[47] Title 49 CFR 830.2 does not define "destroyed." This term is difficult to define because aircraft are sometimes rebuilt even when it is not economical to do so.

[48] See 49 CFR 830.2.

Appendix C

The National Transportation Safety Board Investigative Process

The National Transportation Safety Board investigates every accident that occurs in the United States involving civil aviation and public aircraft flights that do not involve military or intelligence gathering operations. It also provides investigators to serve as U.S. Accredited Representatives as specified in international treaties for aviation accidents overseas involving U.S.-registered aircraft or involving aircraft or major components of U.S. manufacture.[49] Investigations are conducted from Safety Board Headquarters in Washington, D.C. or from one of the 10 regional offices in the United States (see Appendix D).

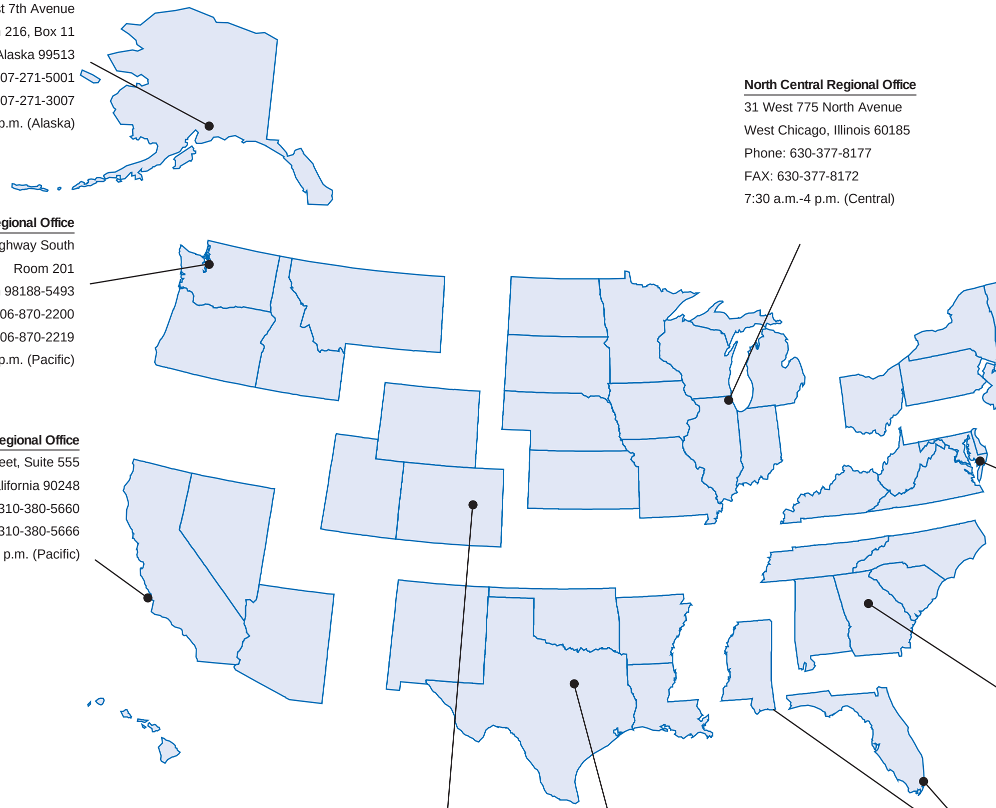
In determining probable cause(s) of a domestic accident, investigators consider the facts, conditions, and circumstances of the event. The objective is to ascertain those cause and effect relationships in the accident sequence about which something can be done to prevent recurrence of the type of accident under consideration.

Note the distinction between the population of accidents investigated by the Safety Board and those that are included in the Annual Review of Aircraft Accident Data, U.S. General Aviation. Although the Safety Board is mandated by Congress to investigate all civil aviation accidents that occur on U.S. soil (including those involving both domestic and foreign operators), the Annual Review describes accidents that occurred among U.S.-registered aircraft in all parts of the world.

[49] For more detailed information about the Safety Board's investigation of aviation accidents or incidents, see 49 CFR 831.2.

Appendix D

National Transportation Safety Board Regional Offices[50]



Alaska Regional Office
222 West 7th Avenue
Room 216, Box 11
Anchorage, Alaska 99513
Phone: 907-271-5001
FAX: 907-271-3007
8 a.m.-4:30 p.m. (Alaska)

Northwest Regional Office
19518 Pacific Highway South
Room 201
Seattle, Washington 98188-5493
Phone: 206-870-2200
FAX: 206-870-2219
8 a.m.-4:30 p.m. (Pacific)

Southwest Regional Office
1515 W. 190th Street, Suite 555
Gardena, California 90248
Phone: 310-380-5660
FAX: 310-380-5666
7 a.m.-3:30 p.m. (Pacific)

Central Mountain Regional Office
4760 Oakland Street, Suite 500
Denver, Colorado 80239
Phone: 303-361-0600
FAX: 303-361-0619
7:30 a.m.-4 p.m. (Mountain)

South Central Regional Office
624 Six Flags Drive
Suite 150
Arlington, Texas 76011
Phone: 817-652-7800
FAX: 817-652-7803
7:30 a.m.-4 p.m. (Central)

North Central Regional Office
31 West 775 North Avenue
West Chicago, Illinois 60185
Phone: 630-377-8177
FAX: 630-377-8172
7:30 a.m.-4 p.m. (Central)

Northeast Regional Office
2001 Route 46, Suite 504
Parsippany, New Jersey 07054
Phone: 973-334-6420
FAX: 973-334-6759
8:30 a.m.-5 p.m. (Eastern)

Mid-Atlantic Regional Office
490 L'Enfant Plaza, S.W.
Washington, D.C. 20594
Phone: 202-314-6320
FAX: 202-314-6329
8:30 a.m.-5 p.m. (Eastern)

Southern Regional Office
Atlanta Federal Center
60 Forsyth Street, SW
Suite 3M25
Atlanta, Georgia 30303-3104
Phone: 404-562-1666
FAX: 404-562-1674
8:00 a.m.-4:300 p.m. (Eastern)

Southeast Regional Office
8405 N.W. 53rd Street
Suite B-103
Miami, Florida 33166
Phone: 305-597-4610
FAX: 305-597-4614
8 a.m.-4:30 p.m. (Eastern)

[50] As of FY 2003