NTSB/ARG-03-02
PB2003-105847

Annual Review of Aircraft Accident Data

U.S. General Aviation, Calendar Year 1999

National Transportation Safety Board
Washington, D.C.

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NTSB/ARG-03/02
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National Transportation Safety Board
490 L'Enfant Plaza, S.W.
Washington, D.C. 20594

National Transportation Safety Board. 2003. *U.S. General Aviation, Calendar Year 1999.* Annual Review of Aircraft Accident Data NTSB/ARG-03/02. Washington, D.C.

Abstract: A total of 1,933 aircraft were involved in 1,906 accidents during calendar year 1999. The total number of general aviation accidents occurring in 1999 was virtually unchanged from calendar year 1998, with an increase of only two accidents. Of the total number of accidents, 340 were fatal, resulting in a total of 619 fatalities. The number of fatal general aviation accidents in 1999 represented a 6.6% decrease from calendar year 1998 although the number of resulting fatalities decreased by only 0.8% during that period. The circumstances of these accidents and the details related to the aircraft, pilots, and locations involved are presented throughout this report.

The National Transportation Safety Board is an independent Federal agency dedicated to promoting aviation, railroad, highway, marine, pipeline, and hazardous materials safety. Established in 1967, the agency is mandated by Congress through the Independent Safety Board Act of 1974 to investigate transportation accidents, determine the probable causes of the accidents, issue safety recommendations, study transportation safety issues, and evaluate the safety effectiveness of government agencies involved in transportation. The Safety Board makes public its actions and decisions through accident reports, safety studies, special investigation reports, safety recommendations, and statistical reviews.

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Introduction

Purpose of the *Annual Review*

The National Transportation Safety Board's *1999 Annual Review of Aircraft Accident Data for U.S. General Aviation* presents a statistical compilation and review of general aviation accidents that occurred in 1999 involving U.S.-registered aircraft. In addition to providing accident statistics for 1999, the review also includes general economic indicators that may have influenced general aviation activity for 1999 and contextual accident data from several years preceding the reporting period.

The accident data used in this review were extracted from the Safety Board's Aviation Accident/Incident Database.[1] The activity data used in this review were extracted from the *General Aviation and Air Taxi Activity Survey* (*GAATA Survey*)[2] and from *U.S. Civil Airmen Statistics,* 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 Manufacturers Association (GAMA), *General Aviation Statistical Databook*.

What is General Aviation?

General aviation (GA) 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.[3]

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 civilian public use[4] aircraft operations. Aircraft operating under Part 91 include aircraft that are flown for recreation and personal transportation, as well as certain aircraft operations that are flown with the intention of generating revenue,[5] including business flying, flight instruction, corporate/executive flights, positioning or ferry flights, pipeline/powerline patrols, and news and traffic reporting.

Which Aircraft are Included in this Review?

General aviation operations are conducted in a wide range of aircraft, including airplanes, rotorcraft, gliders, balloons and blimps, and registered ultralight, experimental, or amateur-built aircraft.

The wide range of operations and aircraft types included within the scope of general aviation must be considered when interpreting the data presented in this review. For example, the 1999 general aviation review includes accidents involving aircraft

[1] A detailed description of the Aviation Accident/Incident Database is included in Appendix C.

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

[3] For an analysis of accidents related to air carrier operations, see National Transportation Safety Board, *Annual Review of Aircraft Accident Data, U.S. Air Carrier Operations, Calendar Year 1999*, NTSB/ARC-03-01 (Washington, D.C.: 2003), available at http://www.ntsb.gov.

[4] Although the precise statutory definition has changed over the years, public aircraft operations 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.

[5] See 14 CFR 119.1.

ranging in size from 440-pound experimental aircraft to 46,500-pound business jets.

Not included in this review are any accident data associated with aircraft operating under 14 CFR Parts 121, 129, or 135, such as scheduled 121 air carrier operations, 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 involving military or non-U.S.-registered aircraft (unless the accident also involves civil aircraft), foreign-registered aircraft, unregistered ultralights, and commercial space launches. Crashes involving illegal operations or stolen aircraft are included in the accident total, but not in accident rates.

Organization of the *Annual Review*

The 1999 *Annual Review* is organized into five parts.

- The first part summarizes general aviation accident statistics for 1999, economic and industry markers related to general aviation activity in 1999, and contextual statistics from previous years.

- The second part investigates trends over the past 10 years for such factors as the types of flight, levels of aircraft damage, and level of injury.

- The third part focuses on accidents that occurred during the 1999 calendar year and their circumstances. Cause and factor findings for accidents occurring in 1999 are also listed.

- The fourth part discusses selected issues particularly relevant to general aviation safety. Topics included this year are the loss of engine power due to carburetor icing and fuel exhaustion/starvation.

- The fifth part provides in-depth coverage of a special topic important to general aviation safety. Because of the continued increase in the popularity of amateur-built aircraft, the special topic of the *1999 Annual Review* is accidents involving amateur-built aircraft.

Like the *1998 Annual Review,* the *1999 Annual Review* presents statistical data more graphically than in the years prior to 1998. Readers who wish to view the data in a tabular format or who wish to manipulate the data used in the report may access the data set online at the Safety Board's Web site, http://www.ntsb.gov. They may also contact the Safety Board's Public Inquiries Branch at 202-314-6551.

1999 General Aviation Accident Summary

A total of 1,933 aircraft were involved in 1,906 accidents during calendar year 1999.[6] The total number of general aviation accidents occurring in 1999 was virtually unchanged from calendar year 1998, with an increase of only two accidents. Of the total number of accidents, 340 were fatal, resulting in a total of 619 fatalities. The number of fatal general aviation accidents in 1999 represented a 6.6% decrease from calendar year 1998 although the number of resulting fatalities decreased by only 0.8% during that period. The circumstances of these accidents and the details related to the aircraft, pilots, and locations involved are presented throughout this report.

[6] In this report, a collision between two aircraft is counted as a single accident. The 17 midair collision accidents that occurred in 1999 involved 32 general aviation aircraft and 2 non-GA aircraft. In addition, 10 ground collision accidents involved 20 general aviation aircraft.

The General Aviation Environment in 1999

General Economic and Aviation Industry Indicators

This section presents an overview of economic and industry indicators as background for interpreting 1999 general aviation accident data. The following table provides U.S. economic indicators and measures of personal income since 1975. The table also includes U.S. economic indicators pertaining to the general aviation industry.

As the table shows, U.S. industrial and personal incomes have grown steadily since 1975. The table also shows that, between 1995 and 1999, the U.S. resident population increased by 3.8%, the gross domestic product rose by 17.4%, and disposable personal income rose by 14.2%.

Between 1975 and 1995, economic indicators for the general aviation industry were either steady or declining. Sharp declines in general aviation aircraft shipments[7] during the '70s and '80s were followed by further gradual declines during the early '90s. The total number of new aircraft sold in 1995 was less than 8% of the number sold in 1975. Factory billings for new aircraft fluctuated over the period, with 1995 billings being 2.75 times higher than 1975 net billings, primarily because an increase in the value of turbine aircraft sales compensated for losses in piston aircraft sales.

In contrast to the years between 1975 and 1995, which had modest to negative growth, general aviation industry indicators nearly tripled between 1995 and 1999, resulting from a noticeable increase in shipments after 1994. The percentage of increase in net factory billings alone between 1995 and 1999 was equal to the total increase observed between 1975 and 1995. One reason for this rapid growth, in addition to generally favorable economic conditions, was the increased production of general aviation aircraft following the 1994 passage of the General Aviation Revitalization Act[8] limiting manufacturer liability.

General Economic and Aviation Industry Indicators, 1975-1999

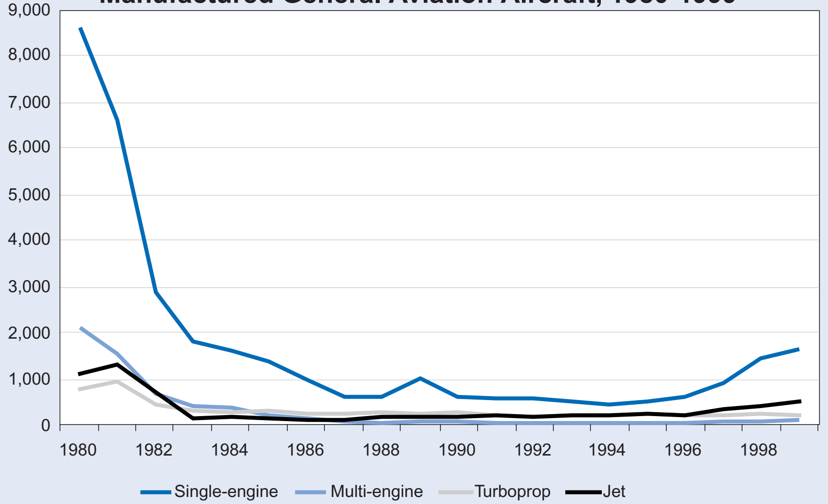
	1975	1980	1985	1990	1995	1999
Population (Millions)[a]	216.0	227.2	237.9	249.5	262.8	272.7
Gross Domestic Product (Billions)[b]	$4,084.4	$4,900.9	$5,717.1	$6,707.9	$7,543.8	$8,859.0
Disposable Personal Income (Billions)[c]	$3,108.5	$3,658.0	$4,347.8	$5,014.2	$5,539.1	$6,328.4
Disposable Personal Income Per Capita[c]	$14,393	$16,063	$18,229	$20,058	$20,795	$22,678
Number of GA Aircraft Sold[d]	14,056	11,877	2,029	1,144	1,077	2,504
Net Factory Billings for GA Aircraft (Millions)[d]	$1,032.9	$2,486.2	$1,430.6	$2,007.5	$2,841.9	$7,843.0
Value of New GA Aircraft Sold: Piston (Millions)[d]	$570	$794	$194	$92	$123	$385
Value of New GA Aircraft Sold: Turbine (Millions)[d]	$461	$1,691	$1,237	$1,916	$2,719	$7,458

a U.S. Census Bureau data, which are available at http://eire.census.gov/poptest/archives/pre1980/popclockest.txt.
b Bureau of Economic Analysis, real gross domestic product using chained 1996 dollars, available at http://www.bea.doc.gov/bea/dn/gdplev.xls.
c Bureau of Economic Analysis, chained 1996 dollars, available http://www.bea.gov/bea/dn/nipaweb/.
d General Aviation Manufacturers Association (GAMA), General Aviation Statistical Databook, 2001.

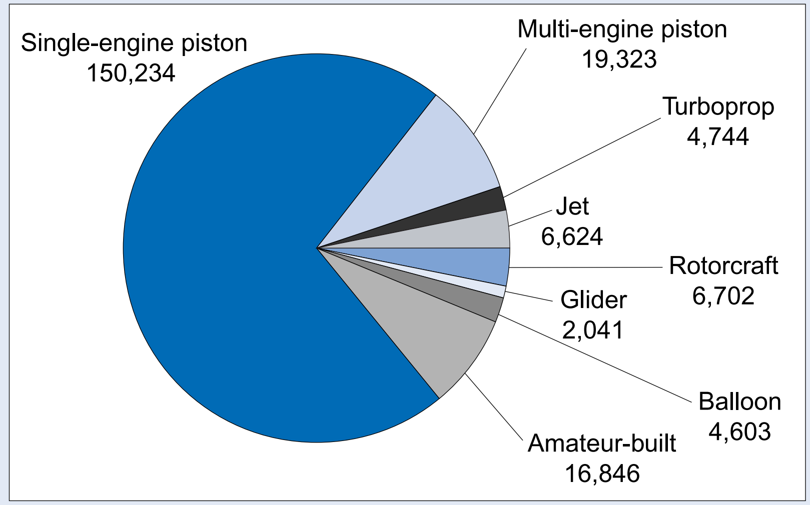
[7] *General Aviation Statistical Databook*, 2001.

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

Annual Shipments of New U.S. Manufactured General Aviation Aircraft, 1980-1999



Active Aircraft in General Aviation, 1999



Fleet Makeup

Although sales of new general aviation aircraft have increased noticeably over the last 5 years, most general aviation aircraft currently in use are more than 20 years old. U.S. manufacturers delivered 2,504 new general aviation aircraft in 1999, compared to an estimated total of 214,900 general aviation aircraft already in service. Single-engine piston aircraft have the highest average age of all types of general aviation aircraft and represent the majority of the fleet. As a consequence of this fleet makeup, changes incorporated into newly manufactured aircraft may not be reflected in the accident record for several years.

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 (1999 Data)

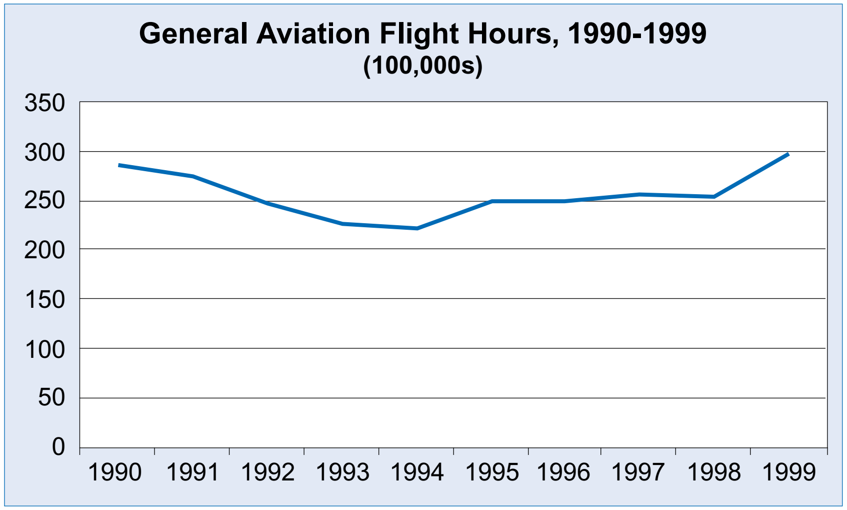
General Aviation Activity

General aviation includes a diverse group of aircraft types and operations. Because of this diversity, some measure of exposure must be considered in order 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.

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),[9] 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*.[10] 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. Because activity totals are derived from a limited sample of aircraft selected from the registry of aircraft owners and reporting is not required, activity data for general aviation are far less reliable than the data available for air carriers.

Although included in the *GAATA Survey*, nonscheduled Part 135 operations are excluded from the *1999 Annual Review of General Aviation Accidents*. Accordingly, for this review, general aviation activity was determined by subtracting those data pertaining to nonscheduled Part 135 operations from activity totals whenever possible. However, in many cases, general aviation activity data could not be calculated because the survey data represent the aggregate of all aircraft activity, including both general aviation and nonscheduled Part 135 operations. Examples of such aggregate data include the number of landings, flight hours by state or region, and flight hours by day/night or weather conditions.

The following graph illustrates the estimated total number of general aviation flight hours annually for the years 1990 to 1999.[11] General aviation flight hours began to increase in 1994 after a decline during the preceding years. The number of general aviation flight hours in 1999 was estimated to be 29.7 million, a one-third increase over the 10-year low of 22.2 million hours, estimated in 1994.

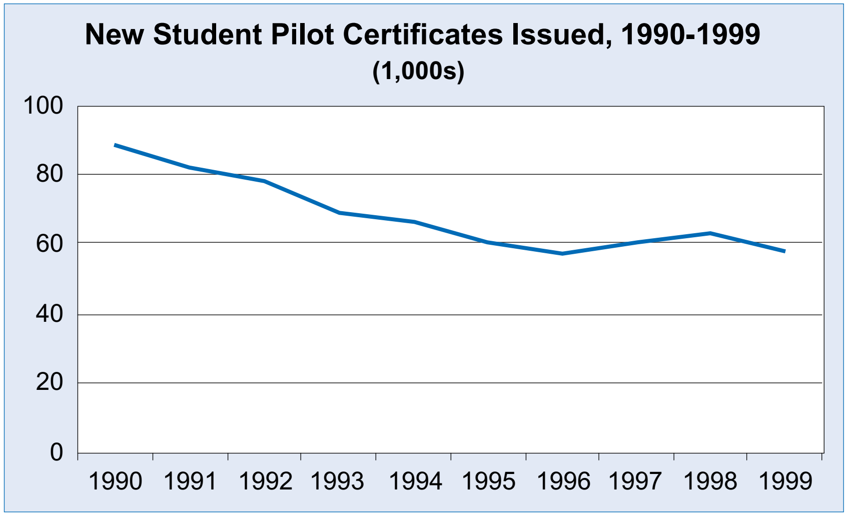


[9] Part 121 operators report activity on a monthly basis, and scheduled Part 135 operators report quarterly.

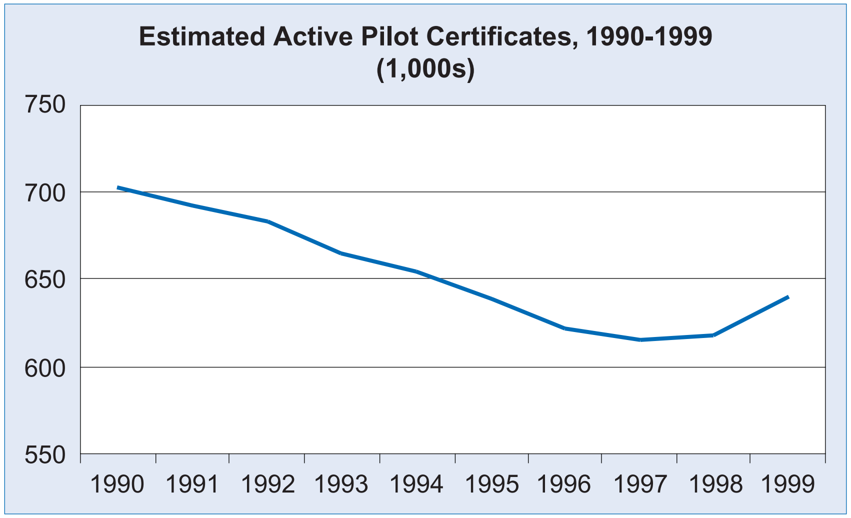
[10] Available at http://api.hq.faa.gov/pubsarchive.asp

[11] FAA, *GAATA Survey 1999*, available at http://www.api.faa.gov/GA2001/tab_1-6.pdf (GA flight hour total excludes air taxi and air tour activity).

Two indirect indicators of general aviation activity are the number of new pilot certificates issued and the number of active pilots. The number of new student pilot certificates issued is particularly meaningful because it represents positive growth in the pilot population. The number of new student pilot certificates issued[12] decreased steadily each year from 88,586 in 1990 to 56,653 in 1996.[13] Between 1996 and 1998, the number of new student pilot certificates issued annually increased slightly to a total of 63,037, but dropped again in 1999 to 58,278.



The total number of active pilots decreased steadily throughout the early and mid '90s, from 702,659 in 1990 to 622,261 in 1996. Between 1997 and 1999, the number of active pilots fluctuated, with an estimated total of 635,472 U.S. pilots active in 1999.



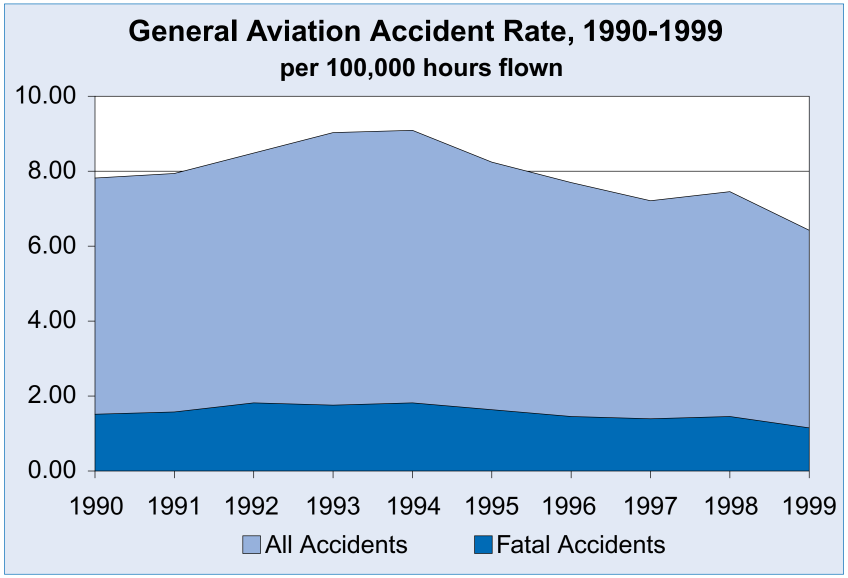
In summary, the indicators of general aviation activity–flight hours and the total number of active new and current pilot certificates issued–decreased annually between 1990 and approximately 1996. Since then, these indicators have generally begun to increase. This noticeable change in activity over the period should be considered when attempting to interpret the general aviation accident record for 1999.

[12] FAA, *U.S. Civil Airmen Statistics*, available at http://api.hq.faa.gov/CivilAir/docs/air22-99.XLS.
[13] Based on medical certificates issued.

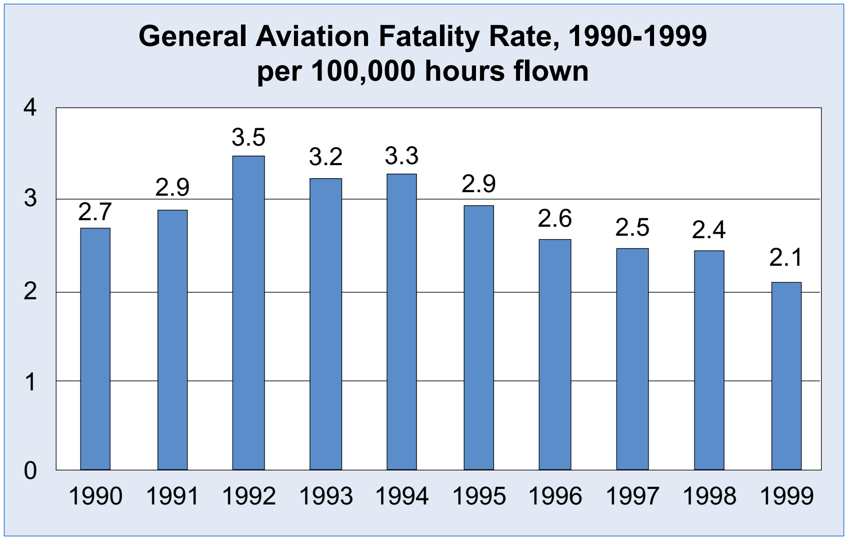
Historical and Current Accident Data

Accident Rates

The general aviation accident rate fluctuated between 1990 and 1999 with 6.41 accidents per 100,000 hours flown in 1999, which was substantially lower than the 1994 high of 9.09 accidents per 100,000 hours. Although the accident rate in 1999 appears to be part of a general downward trend since 1994, the fatal accident rate remained fairly constant from 1990 through 1999, at 18 to 21% of the total accident rate. The 1999 rate of 1.14 fatal accidents per 100,000 flight hours was the lowest for the 10-year period.



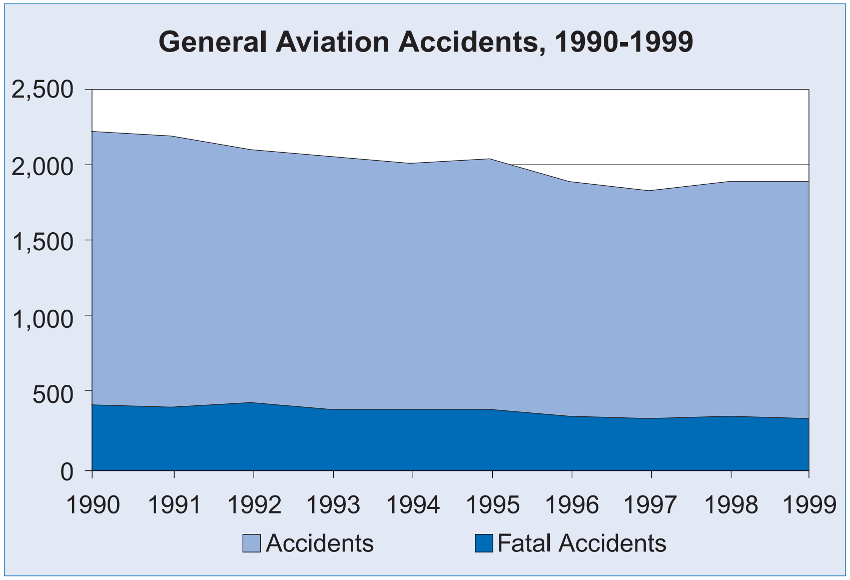
In 1999, the fatality rate, or number of accident-related deaths per flight hour, was 2.1 fatalities per 100,000 hours flown, the lowest rate of the 10-year period between 1990 and 1999. The highest annual rate for this period occurred in 1992 with 3.5 deaths per 100,000 hours flown.



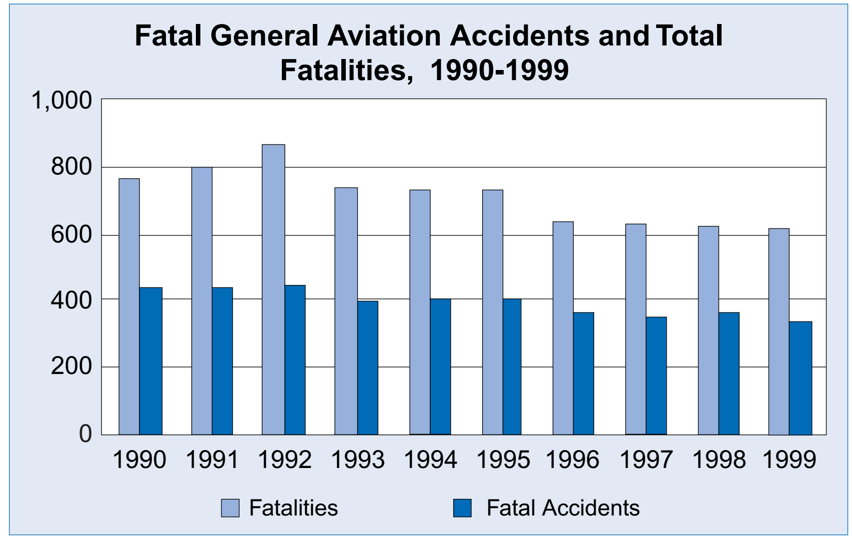
Because rate calculations require the use of activity data extrapolated from a relatively small sample of aircraft owners, the resulting values are accurate only to the extent that the sample represents the larger population of general aviation operators. For this reason, accident rate data presented in this report will include raw frequency data for comparison.

Number of Accidents

There was a slightly downward trend in the number of accidents that occurred annually between 1990 and 1997. The number of general aviation accidents has leveled off or increased slightly since then, with the number of accidents in 1999 (1,906) being slightly higher than the 10-year low of 1,845 accidents in 1997. The number of fatal accidents decreased to 340 in 1999, the lowest number for the 10-year period. Fluctuations in accident frequency in recent years occurred during a period that also saw changes in the numbers of new aircraft sales, total general aviation flight hours, and new student pilot starts.



The total number of fatalities resulting from general aviation accidents between 1990 and 1999 reached a high of 867 in 1992 and then began a general downward trend to a low of 619 in 1999. The observed decline in fatalities is consistent with trends in both the level of activity and the number of fatal accidents for those years.



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. Because the flight data collected in the *GAATA Survey* allows for only a coarse representation of all general aviation operations, the operations data presented here include only four operational categories, which were selected as typical of general aviation activity: personal/business flying,[14] corporate flying, aerial application, and instructional flights.

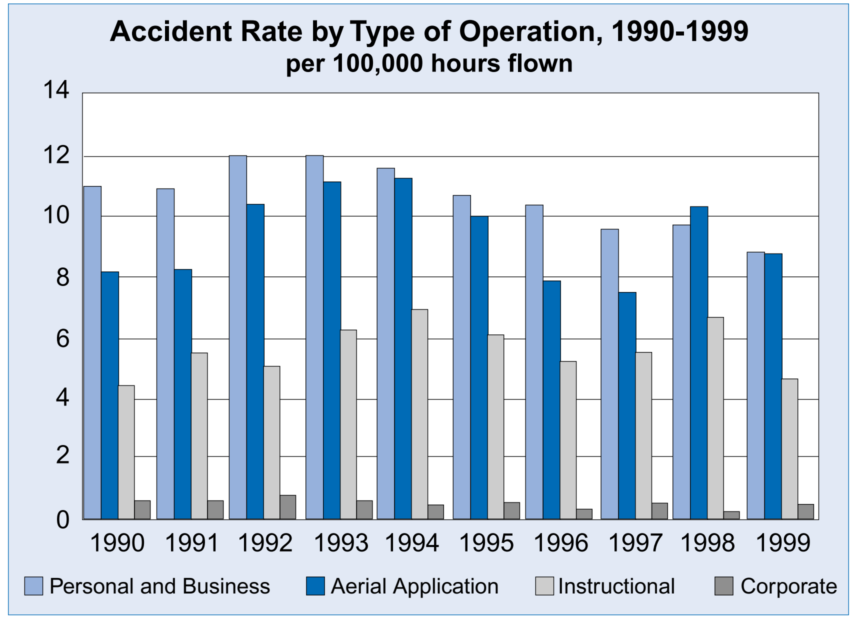
- Personal flying makes up the largest portion of general aviation activity and includes all flying for pleasure and/or personal transportation. Although similar to personal flying, business flying includes the use of an aircraft for business transportation without a paid, professional crew. Personal and business flights are typically conducted in

[14] 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 report is calculated using combined exposure data (hours flown).

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.[15] Aircraft used for instructional flights are often similar to those used for personal flying, but instructional operations are unique because they often involve the repeated practice of takeoffs and landings, flight maneuvers, and emergency procedures.

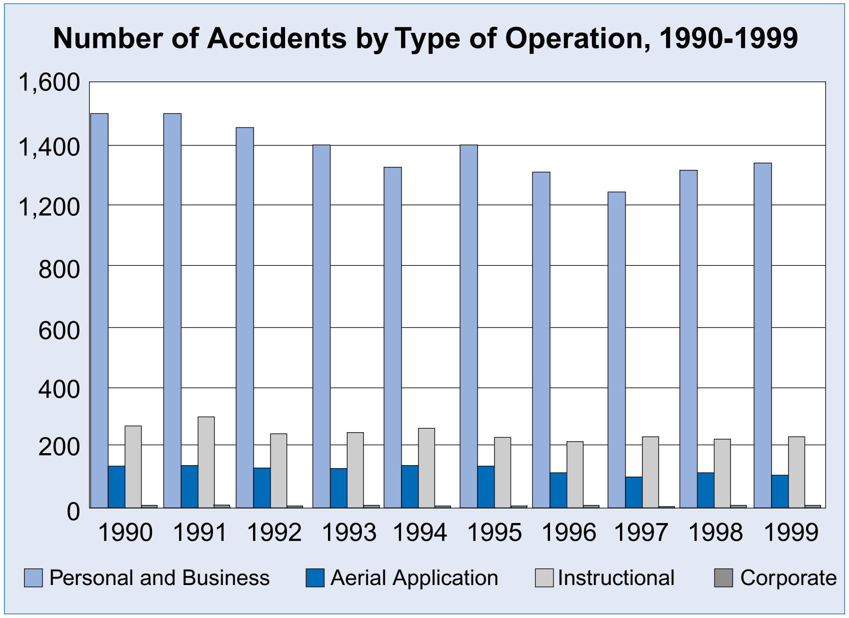
Between 1990 and 1999, personal and business flying had the highest average accident rate, followed by aerial application and instructional flights. The accident rate for corporate/executive transportation was consistently the lowest overall, averaging less than one-tenth of the next-lowest rate (that is, the rate that was observed for instructional flying).

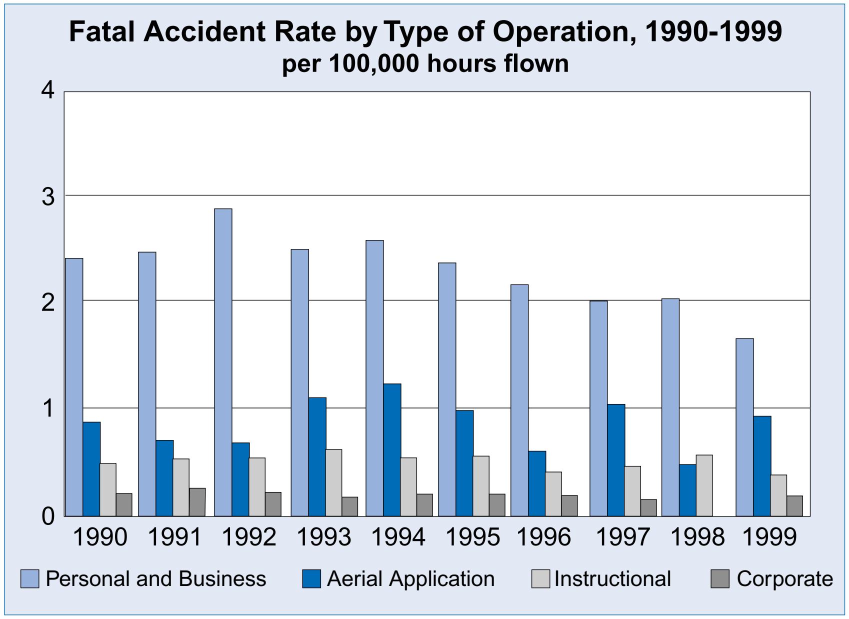


[15] See 14 CFR Subpart H for flight instructor certificate and rating requirements.

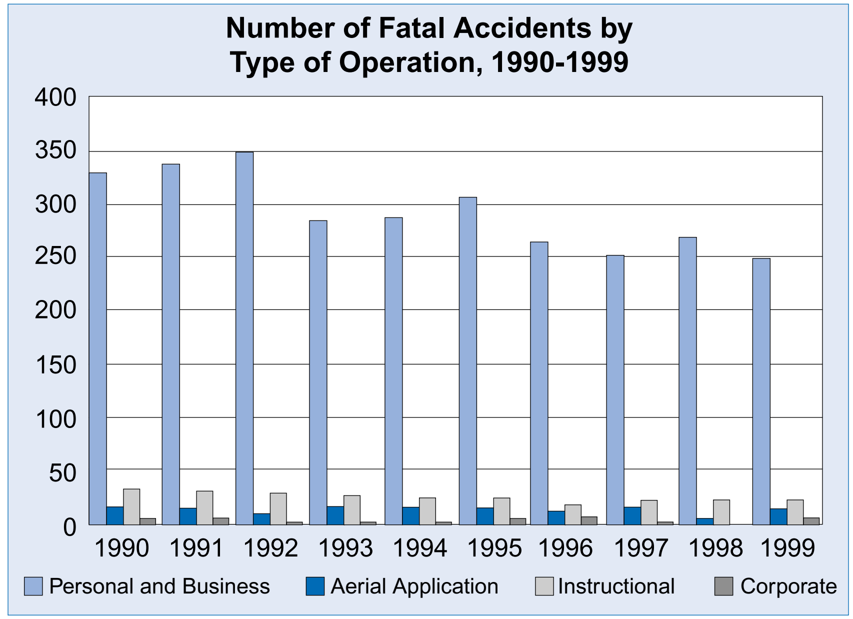
The vast majority of general aviation accidents involved personal and business operations. Between 1990 and 1999, personal/business flying accounted for an average 67% of all general aviation accidents. Instructional flying has historically accounted for the next highest number, with an average 14% of all general aviation accidents.

The combined category of personal/business flying also had the highest fatal accident rate, which was typically more than double the rate for any other type of flying. These differences are probably related to the type of aircraft and equipment, the level of pilot training, and the operating environments unique to each type of operation.





Between 1990 and 1999, personal/business flying accounted for an average 74% of fatal general aviation accidents and 75% of all fatal general aviation injuries. An average 533 fatal injuries per year between 1990 and 1999 were associated with personal/business flying, compared to the average 47 deaths per year related to instructional flying.



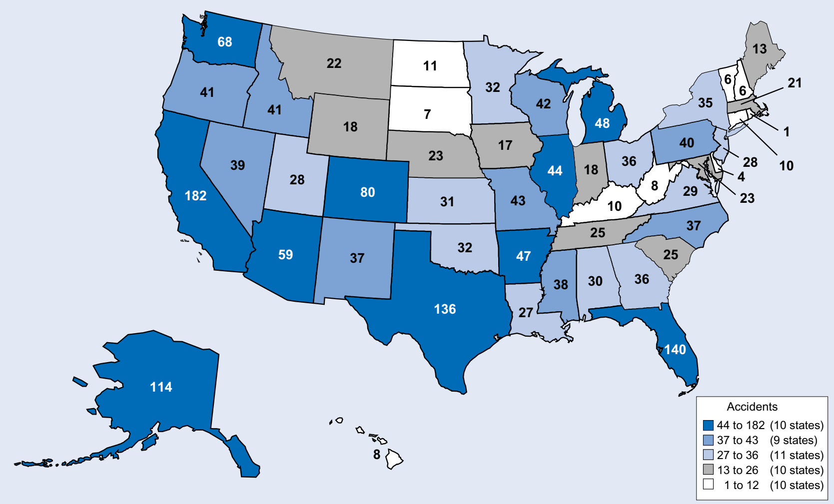
1999 In Depth

Location of General Aviation Accidents in 1999

United States Aircraft Accidents

This map depicts the number of general aviation accidents that occurred in each state during 1999. The states are also coded from light to dark, qualitatively signifying (from low to high) the relative number of accidents. 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 were not available for 1999, some assumptions can be made about general aviation activity level based on the population of each state. For example, California,[16] Florida,[17] and Texas had the greatest number of accidents in 1999; U.S. Census Bureau data[18] indicate that California had the highest state population in 1999, 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 additional general aviation traffic from other states. These states also had the largest numbers of active pilots[19] and active aircraft,[20] suggesting that the high number of accidents in these states may be primarily related to a high level of activity.

General Aviation Accidents per State, 1999



Regional differences that affect general aviation accident numbers may also include hazards unique to the local terrain and/or weather. For example, Alaska had the fourth-highest number of general aviation accidents with 114, which was 3.3 times more than New York, a state estimated to have a similar number of active aircraft and pilots in 1999.[21] However, the operating environment, infrastructure, and travel requirements in Alaska provide unique challenges[22] to aviation, and these challenges are reflected in the general aviation accident record.

[16] The total of 182 accidents for California includes one accident off the coast in the Pacific Ocean.

[17] The total of 140 accidents for Florida includes one accident off the coast in the Gulf of Mexico.

[18] U.S. Census Bureau; data are available at http://eire.census.gov/popest/archives/state/st-99-1.txt.

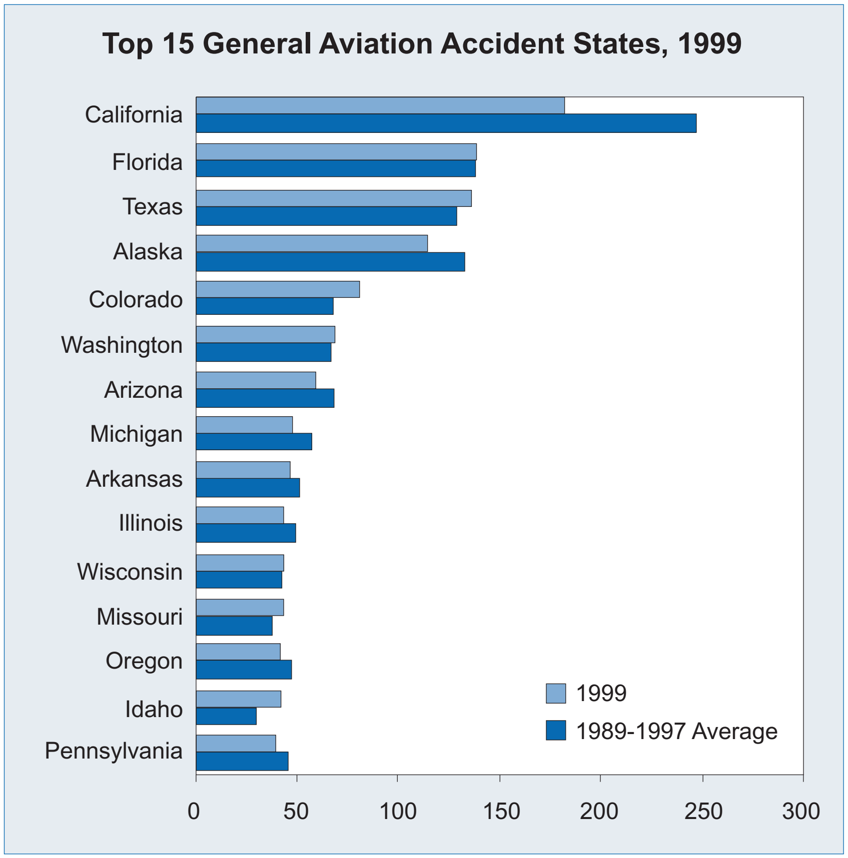
[19] FAA, *U.S. Civil Airmen Statistics*, 1999, available at http://apo.faa.gov/CivilAir/docs/air5-99.XLS.

[20] FAA, *GAATA Survey 1999*, available at http://www.api.faa.gov/GA2001/tab_2-3.pdf.

[21] Because the *GAATA Survey* cannot accurately separate air taxi operations (unscheduled Part 135) from general aviation operations, the comparison between these estimates is included only as a demonstration of similar activity.

[22] 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 following graph shows the top 15 states by number of general aviation accidents in 1999, along with the average numbers of accidents occurring in each of those states over the 10 years preceding 1999. The graph illustrates that, except for a noticeable drop for California, the distribution of accidents was similar to state historical averages.



Foreign Aircraft Accidents

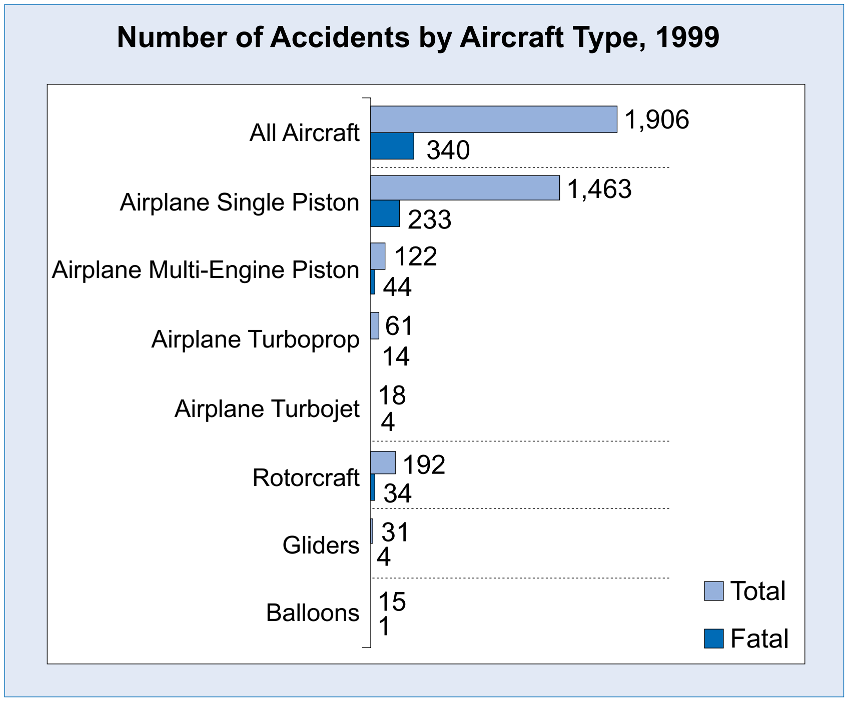
U.S.-registered aircraft were involved in 35 accidents in locations outside the 50 United States in 1999. These accidents occurred in 15 different countries and territories, and in both the Atlantic and Pacific Oceans. Of those accidents, 14 were fatal, resulting in 33 deaths and 3 serious injuries. The largest number of accidents outside the 50 states occurred in Canada, with 7 accidents, followed next by the Bahamas 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 1999 accident record also includes accidents that occurred as far away as Germany, Saudi Arabia, and Thailand.

Accidents Involving U.S.-Registered General Aviation Aircraft Outside the 50 United States, 1999

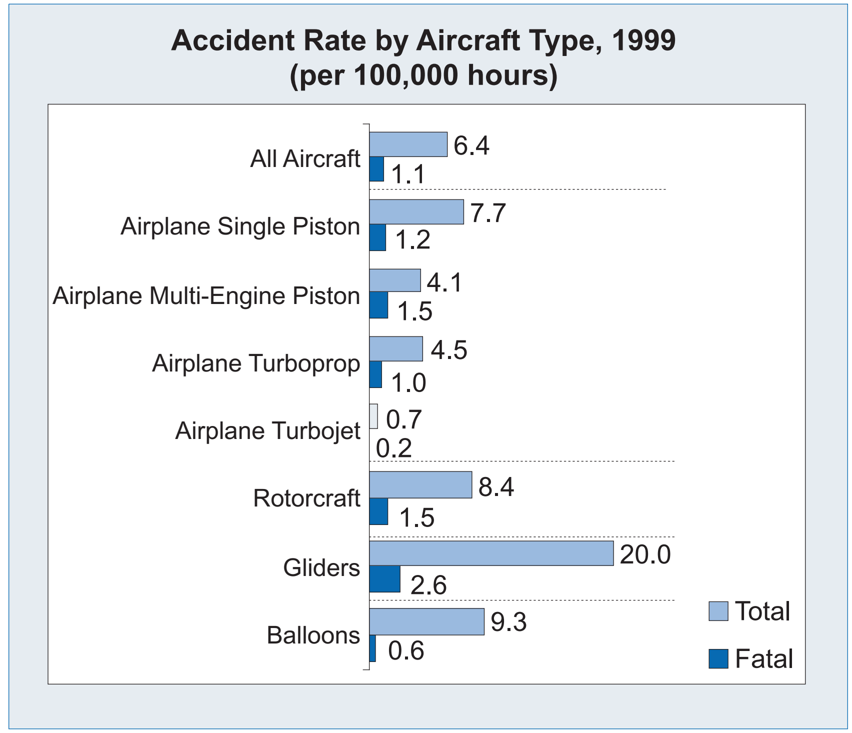
	Accidents	Fatal Accidents	Fatalities
Pacific Ocean	3	1	2
Off Guam (1)			
Off Marshall Islands (1)			
Off Micronesia (1)			
Atlantic Ocean	2	1	1
Off Bahamas (2)			
Other Countries/Territories	30	12	30
Bahamas (4)			
Canada (7)			
Dominican Republic (1)			
Ethiopia (1)			
French West Indies (1)			
Germany (2)			
Guam (3)			
Kenya (1)			
Marshall Islands (1)			
Mexico (2)			
Puerto Rico (3)			
Saudi Arabia/Arabian Gulf (1)			
Thailand (1)			
Venezuela (1)			
Virgin Islands (1)			
Total	**35**	**14**	**33**

Aircraft Type

The following graphs illustrate the total number of accidents and the number of fatal accidents occurring in 1999 by type of aircraft. Most notable is the large number of accidents involving single-engine piston aircraft, accounting for 76.8% of all general aviation accidents and 68.5% of all fatal accidents.



The general aviation accident rate for all aircraft was 6.40 accidents per 100,000 hours flown, and 1.14 fatal accidents per 100,000 hours flown. Among fixed-wing powered aircraft, the accident rate was highest for single-engine piston aircraft with 7.70 accidents and 1.22 fatal accidents per 100,000 hours flown. Among all powered aircraft, the accident rate was highest for rotorcraft, with 8.36 accidents and 1.48 fatal accidents per 100,000 hours flown. Glider operations had the highest accident rate of all aircraft types, with 20.04 accidents and 2.59 fatal accidents per 100,000 hours flown.



Purpose of Flight

Purpose of flight can be defined as the reason a flight was initiated. As previously mentioned, general aviation includes a wide range of operations, 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 normalized across operations using flight hours as a measure of activity.

Activity data by purpose of flight are derived from the FAA's *General Aviation Air Taxi Activity (GAATA) Survey*. The *GAATA Survey* includes 14 purpose/use categories; 2 of these, "Air Taxi" 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 mentioned categories of "personal," "business," "instructional," "corporate," and "aerial application," which together account for more than 85% of general aviation operations, as well as other, more specific categories, such as "external load" and "medical use." A limitation of the activity data is that these 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.

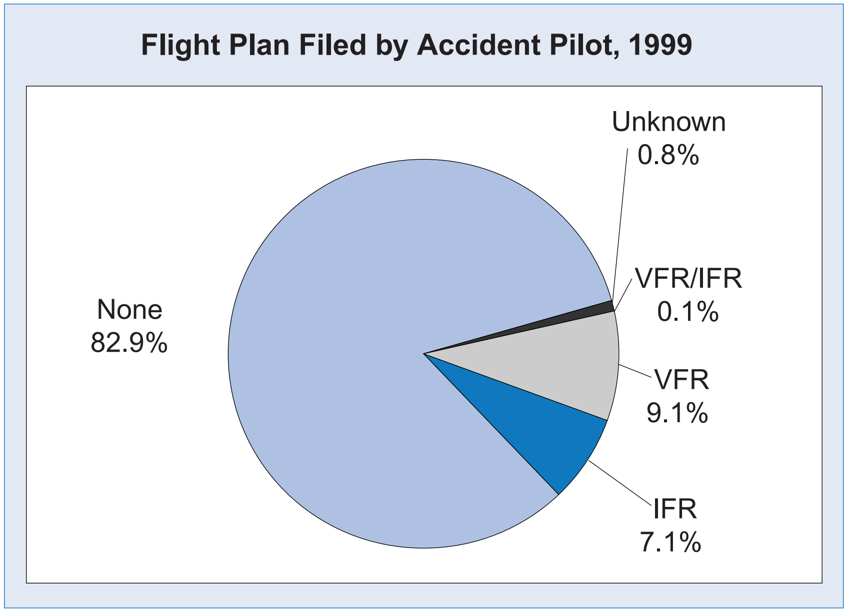
According to the *GAATA Survey*, most general aviation operations are conducted for personal and/or business purposes. Of the 29.7 million general aviation hours flown in 1999, approximately half–14.9 million–were conducted for personal or business reasons.[23] A result of this level of activity is that a large percentage of general aviation accidents involve personal/business flying. However, personal/business flying is actually over-represented in the accident record considering that this segment included approximately half of the activity but accounted for 69% (1,307) of all general aviation accidents and 74% (249) of all fatal general aviation accidents in 1999.

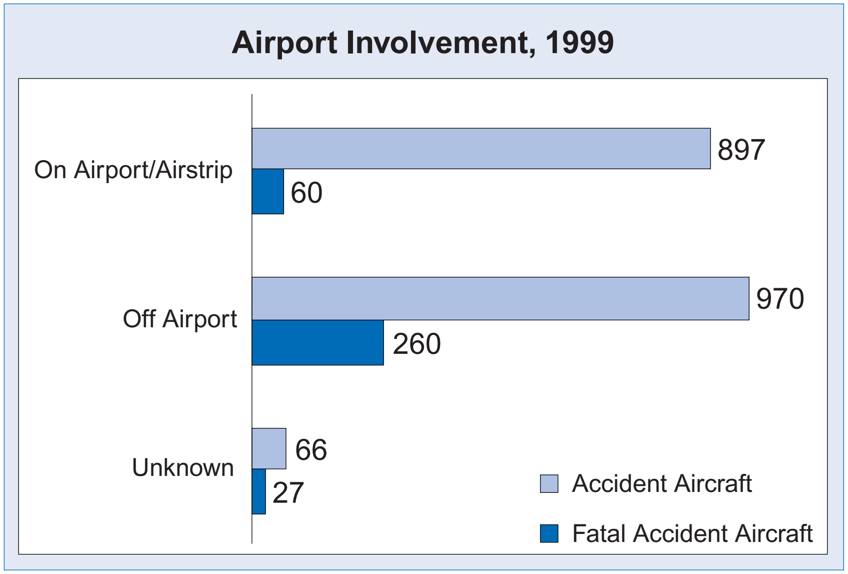
Although personal/business flying has historically had the highest accident rate, aerial application had a similar accident rate in 1999, with 8.78 and 8.69 accidents per 100,000 hours, respectively. Aerial application accidents typically involve contact with the ground, power lines, or other obstacles that would likely result in high levels of occupant injury and damage for most aircraft. However, the aircraft used in aerial application operations are often designed with these risks in mind. Aircraft designed for aerial application often include safety features such as "roll" cages and 5-point safety harnesses, and pilots often wear helmets. As a result of these operation-specific factors, aerial application accidents are less likely than other general aviation accidents to result in fatal injury. Only 10.6% of the aerial application accidents that occurred in 1999 resulted in fatalities, compared to 19.1% of personal/business flying accidents. When compared with the number of hours flown, the fatal accident rate for aerial application operations is 0.92 fatal accidents per 100,000 hours flown. The fatal accident rate remains highest for personal and business flying, with 1.67 fatal accidents per 100,000 hours flown.

Flight Plan

Of the 1,933 pilots involved in accidents in 1999, 1,602 (82.9%) 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 can also file a flight plan to aid search and rescue efforts if they fail to arrive at their intended destination.

[23] FAA, *GAATA Survey* 1999, available at http://apo.faa.gov/GA2001/tab_1-6.pdf.





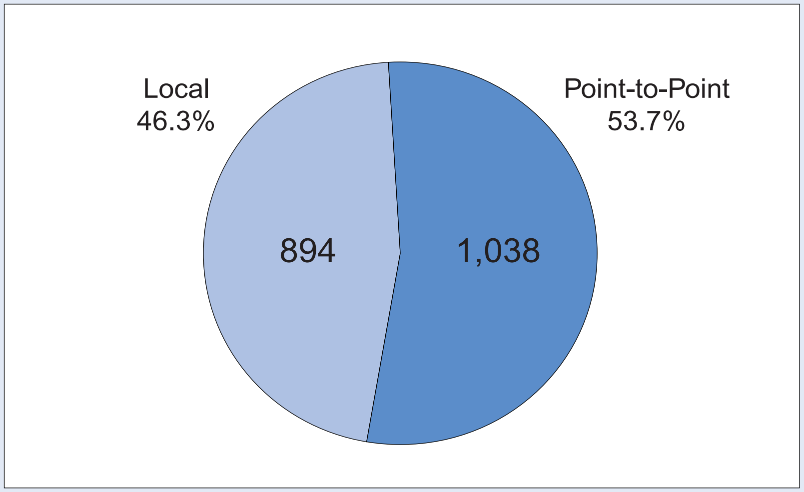
Airport Involvement

In 1999, accident aircraft locations were closely split between those occurring away from an airport (50.2%) and those occurring on an airport or airstrip (46.4% combined); however, it is difficult to compare accident risk based on location because of exposure differences. Accidents that occur on or near an airport or airstrip typically involve aircraft at relatively low altitudes and airspeeds that are taking off, landing, or maneuvering to land. Accidents that occur away from an airport typically include aircraft in the climb, cruise, maneuvering, and descent phases of flight. They are typically at higher altitudes and higher airspeeds than aircraft in the immediate vicinity of an airport. Because of these differences, accidents that occur away from an airport are more likely to result in higher levels of injury and aircraft damage. As the graph below shows, most aircraft involved in fatal accidents (74.9%) were located away from an airport or airstrip.

Another distinction in flight profiles is between local and point-to-point flights. 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. Local flights include sightseeing, flight instruction, proficiency, and pleasure flights, as well as many aerial observation and aerial application flights. Conversely, point-to-point flights include any operation with the goal of moving people, cargo, or equipment from one place to another. Examples include corporate executive transportation, personal and business travel, and aircraft repositioning flights.

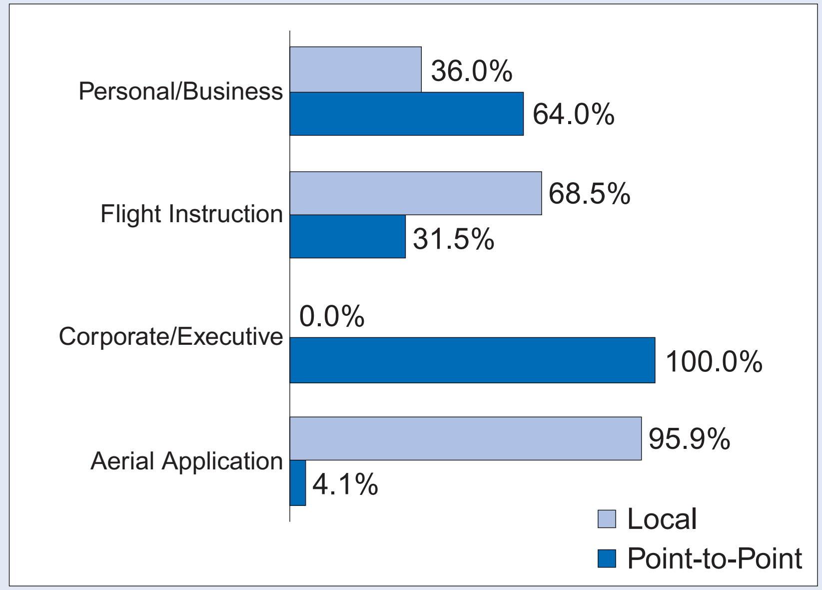
The following graph depicts a comparison of accident aircraft on local flights to those on point-to-point flights. As the graph shows, the percentages of aircraft on each type of flight were similar, with point-to-point flights accounting for slightly more accident aircraft.

Local and Point-to-Point Flights, 1999



The activity data necessary to compare local and point-to-point accidents rates 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 (64%) were point-to-point, while most instructional flights (68.5%) were local. Corporate executive transportation and aerial application operations were also inversely proportionate, with 100% of corporate flights being point-to-point and 95.9% of aerial application flights being local.

Local and Point-to-Point Flight Comparison by Type of Operation, 1999

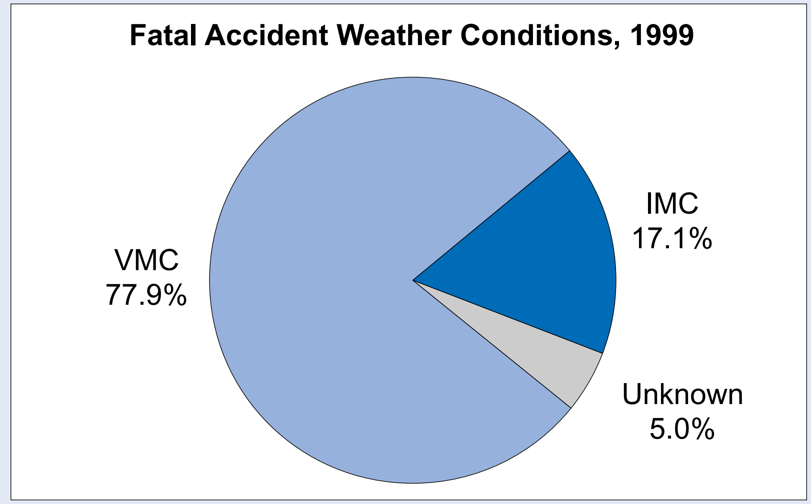


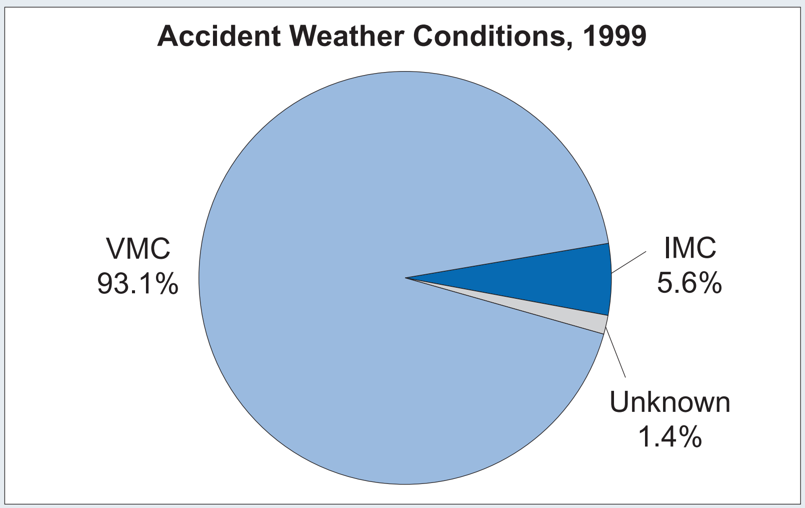
Environmental Conditions

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 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 to provide the necessary information. Because of the difficulties associated with flying an aircraft solely by reference to instruments, the FAA has established specific pilot, aircraft, and procedural requirements[24] for flight in instrument meteorological conditions (IMC).

[24] Title 14 CFR 61.579(c), 91.167-193, 91.205(d).

According to the FAA Pilot/Controller Glossary, "instrument meteorological conditions" are defined as "Meteorological conditions expressed in terms of visibility, distance from cloud, and ceiling less than the minima[25] 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 graphs illustrate the percentage of accidents and fatal accidents that occurred in VMC and IMC. Although instrument conditions account for only 5.6% of all accidents, 17.1% of fatal accidents occurred in IMC.



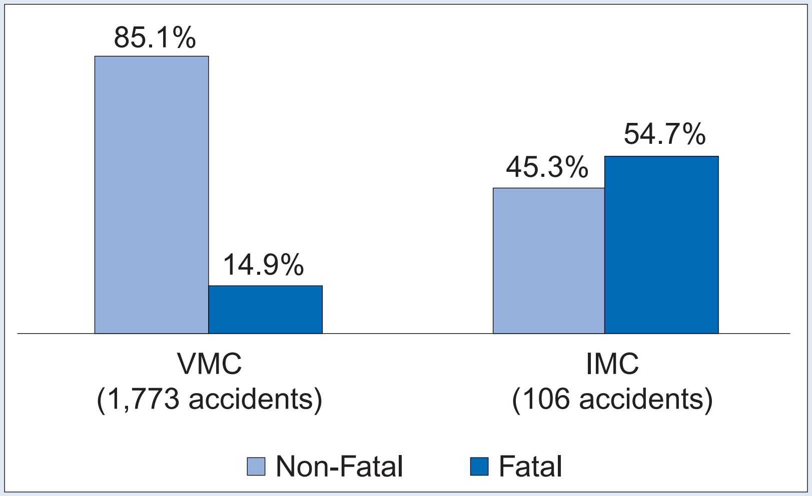


Considering the percentage of accidents in each weather condition that resulted in a fatality illustrates the hazards associated with flight in IMC. Only 14.9% of accidents in visual conditions resulted in a fatality, but 54.7% of accidents in instrument conditions were fatal. One reason for the disproportionate number of fatal accidents in IMC is that accidents that occur during instrument flight 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

[25] Minima for visual meteorological conditions are specified in 14 CFR 91.155.

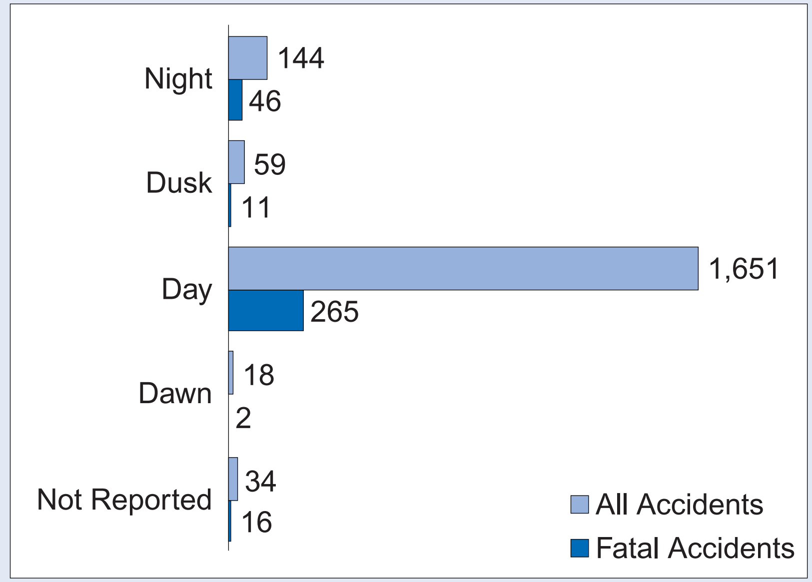
conditions because reduced visibility would make the selection of a suitable landing location more difficult.

Percentage of Fatal and Non-Fatal Accidents in Visual and Instrument Meteorological Conditions, 1999

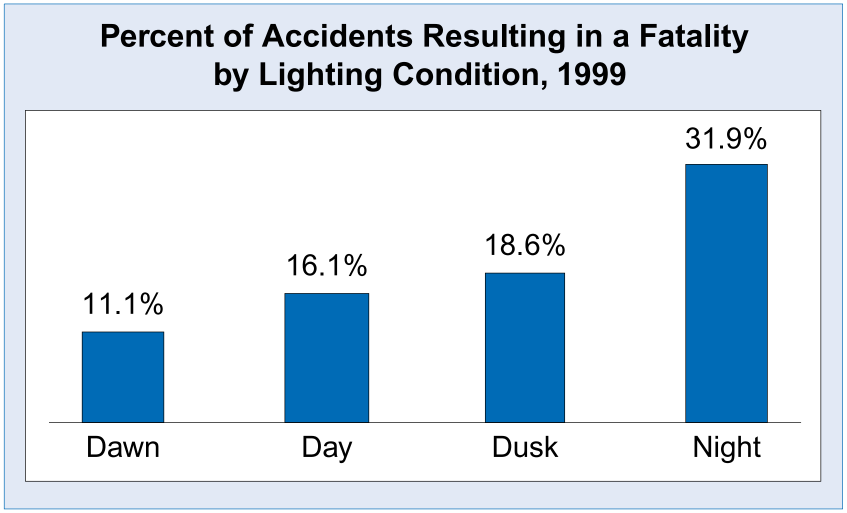


Lighting conditions can present a similar hazard to pilots because of physiological factors related to night vision, difficulties in seeing potential hazards such as mountains, terrain, and unlighted obstructions, and perceptual illusions associated with having fewer visual cues. The data presented in 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.

Lighting Conditions of All Accidents and Fatal Accidents, 1999



In fact, the following chart shows that accidents that occur at night are twice as likely as 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.

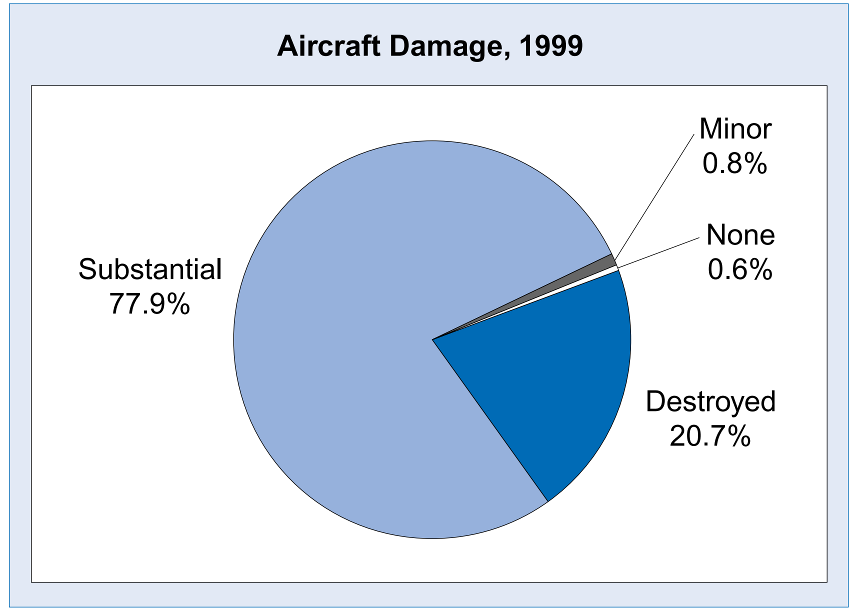


Injuries and Damage for 1999

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 defined as any damage in which repair cost would exceed the value of the aircraft,[26] and "minor" damage as any damage that is not classified as either "destroyed" or "substantial."

Most aircraft involved in accidents during 1999 sustained substantial damage (77.9%), and approximately one in five accident aircraft (20.7%) were destroyed. "Minor" and "no damage" classifications included less than 1% each of accident aircraft.



Accident Injuries

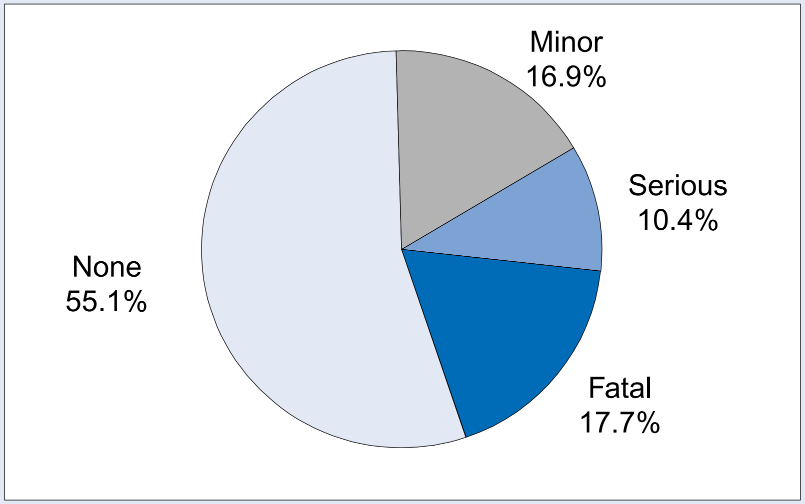
Safety Board investigators categorize injuries resulting from general aviation accidents as "fatal," "serious," or "minor." Title 49 CFR 830.2 defines a fatal injury as "any injury which results in death within 30 days of the accident." Title 49 CFR 830.2 also outlines several qualifications[27] of serious injury that include, but are not limited to, hospitalization for more than 48 hours,

[26] Missing or unrecoverable aircraft are also considered "destroyed."

[27] See Appendix A for the complete definition of injury categories.

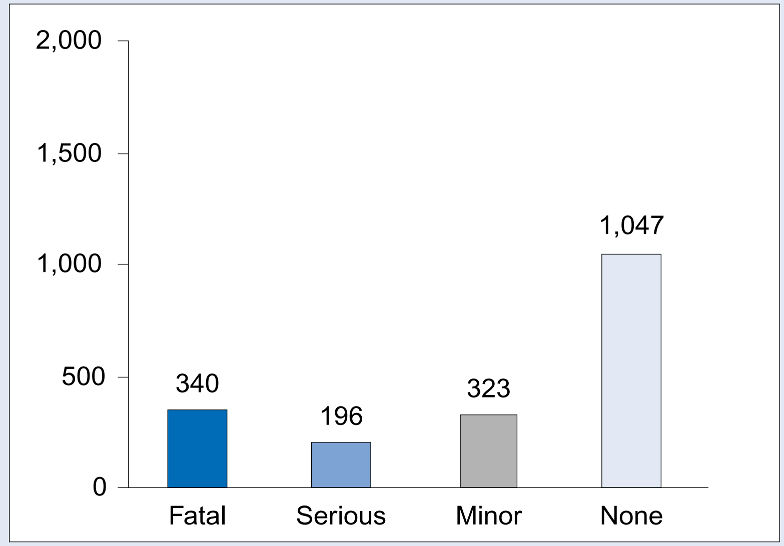
bone fracture, internal organ damage, or second- or third-degree burns. The following graph depicts the percentage of general aviation accidents resulting in each level of injury during 1999. Most notable is the fact that more than half (54%) of general aviation accidents do not result in injury.

Highest Level of Injury per Accident Aircraft, 1999

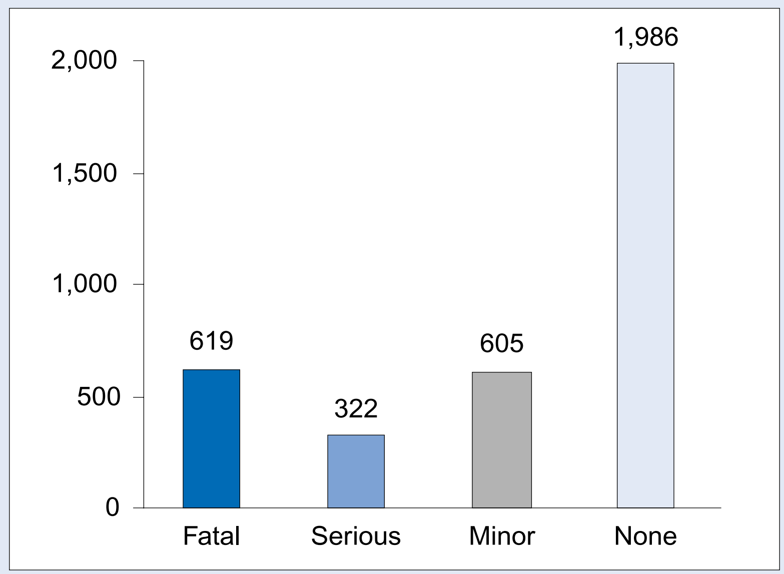


The following graphs illustrate both the number of accident aircraft in each injury category and the corresponding number of persons aboard those aircraft who sustained injuries in each category. Aircraft injury level is equal to the highest level of injury sustained by an occupant of that aircraft.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

Number of Accident Aircraft by Highest Level of Injury, 1999



Injuries Sustained by Persons Aboard Accident Aircraft, 1999



Injuries by Role for 1999

Personal Injuries	Fatal	Serious	Minor	None	Total
Pilot	317	187	300	1,129	1,933
Copilot	21	12	14	70	117
Flight Engineer	1	0	0	1	2
Flight Instructor	1	0	0	0	1
Dual Student	15	6	18	80	119
Check Pilot	1	1	0	4	6
Other Crew	10	8	2	13	33
Flight Attendant	0	0	0	2	2
Passenger	249	103	223	687	1,262
Total Aboard	615	317	557	1,986	3,475
On Ground	3	5	48	0	56
Other Aircraft	1	0	0	0	1
Total	**619**	**322**	**605**	**1,986**	

The following table presents detailed information about the types of injuries incurred by all persons involved in general aviation accidents in 1999. 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 exposure risk. For example, all aircraft have a pilot, but not all aircraft have passengers on board. In 1999, 575 passengers suffered some level of injury in general aviation accidents, compared to the 804 pilots who were injured. Despite the apparent difference, the injury rate for passengers was similar to that of pilots, considering that only 1,262 of 1,933 accident aircraft had passengers on board. 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 1999, suffering 51.2% of all fatalities, 58.1% of all serious injuries, and 49.6% of all minor injuries.

In addition to injuries sustained by persons on board the accident aircraft, 56 persons who were not aboard accident aircraft also sustained injuries. Examples of accidents in 1999 that resulted in injuries to persons not aboard an aircraft include a ground service employee killed after contact with an aircraft propeller and two persons seriously injured when an airplane struck their home.

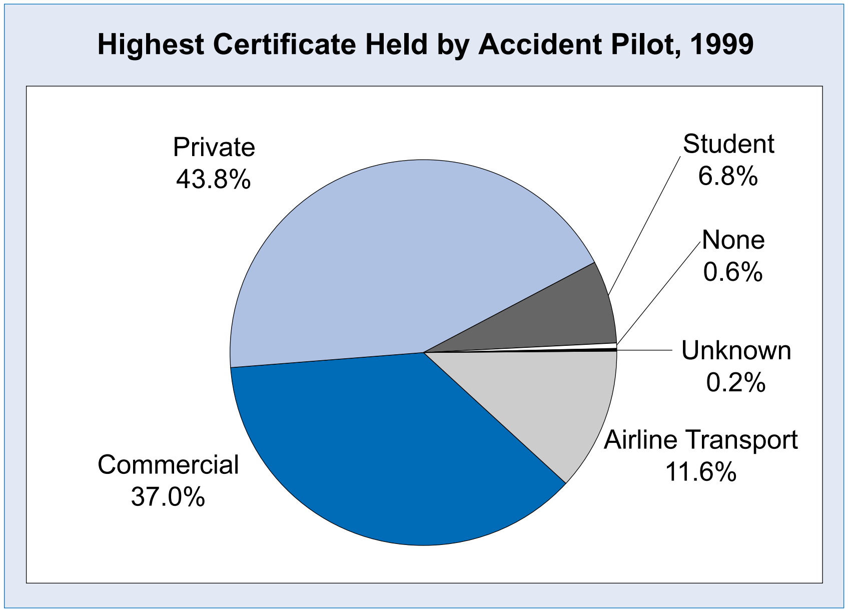
Accident Pilots

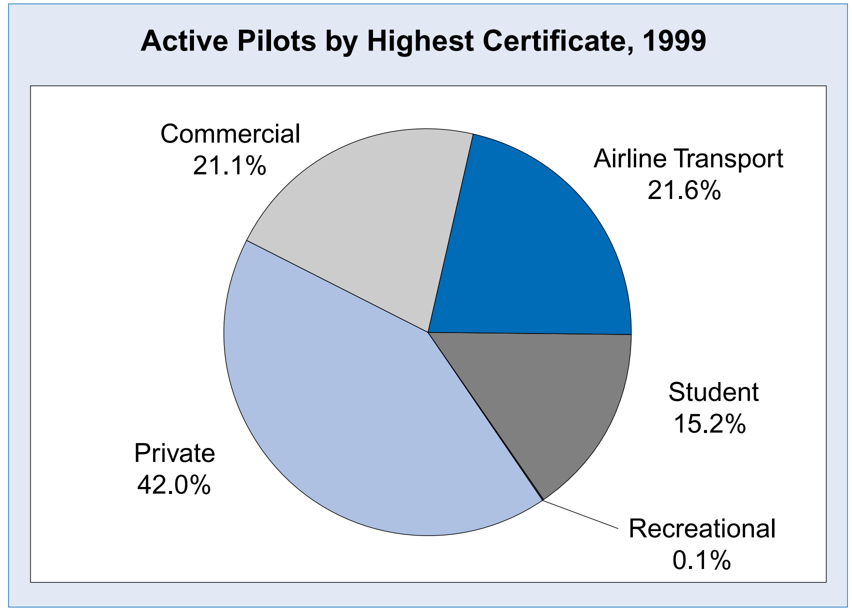
Rating

Of the 1,933 pilots involved in general aviation accidents in 1999, the largest percentage (43.8%) held a private pilot certificate.[28] The second-largest percentage (37.0%) held a commercial pilot certificate, which is required in order for any person to act as pilot-in-command of an aircraft for compensation or hire.[29]

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

[29] See 14 CFR 61.133 for the privileges granted by a commercial pilot certificate.





When compared to the number of active pilots in 1999 holding each type of pilot certificate, commercial pilot certificate holders were over-represented in general aviation accidents. The 21.1% of active pilots with commercial pilot certificates accounted for 37.0% of accidents.

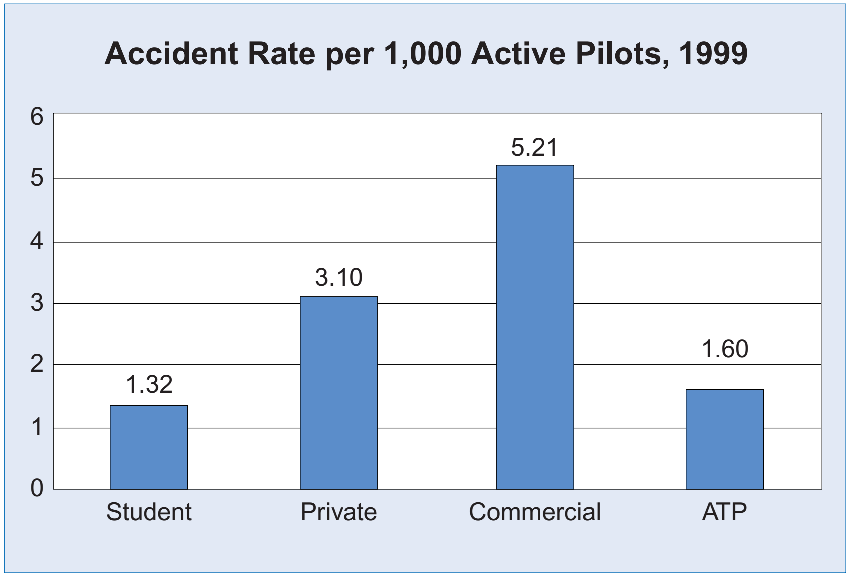
As depicted in the following graph, the accident rate per 1,000 active pilots was highest for commercial pilot certificate holders, who can be employed as pilots and are likely to fly more hours annually than student or private pilots. Annual flight-hour data for pilots holding each type of certificate are not available to confirm this conclusion. The *U.S. Civil Airmen Statistics* compiled by the FAA[30] also do not include information about the type of operation that certificate holders engage in, but examples of commercial operations include corporate executive transportation, flight instruction, sightseeing flights, banner towing, and aerial application. The largest percentage of commercial pilots involved in accidents during 1999 (42.3%) were conducting personal flights

[30] FAA, *U.S. Civil Airmen Statistics*, 1999, available online at http://api.hq.faa.gov/CivilAir/index.htm.

[31] Refer to 14 CFR 61, Subpart G, for the privileges and limitations of the airline transport pilot certificate.

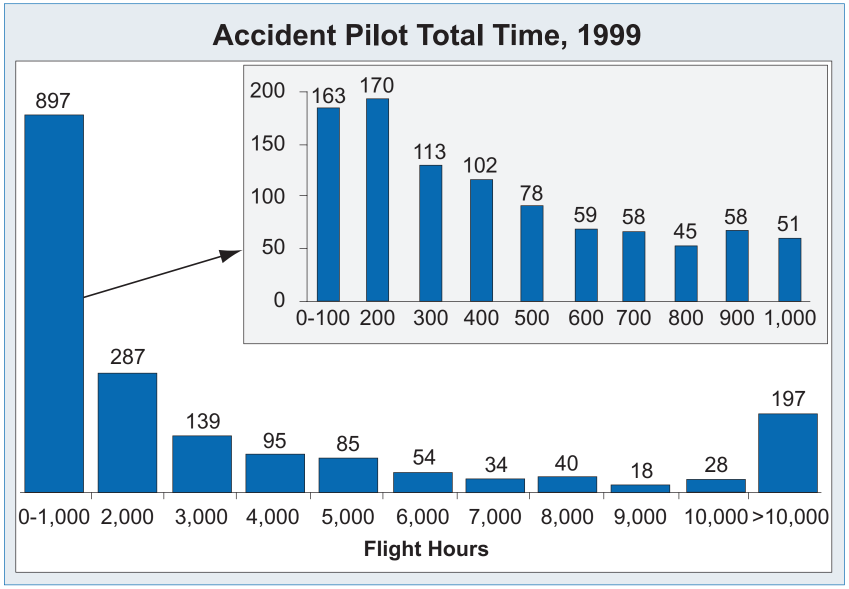
[32] Title 14 CFR 121.437

and were not involved in a commercial operation at the time of the accident. Airline transport pilot (ATP) certificate holders, in addition to being employed as pilots,[31] can engage in air carrier operations,[32] 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.



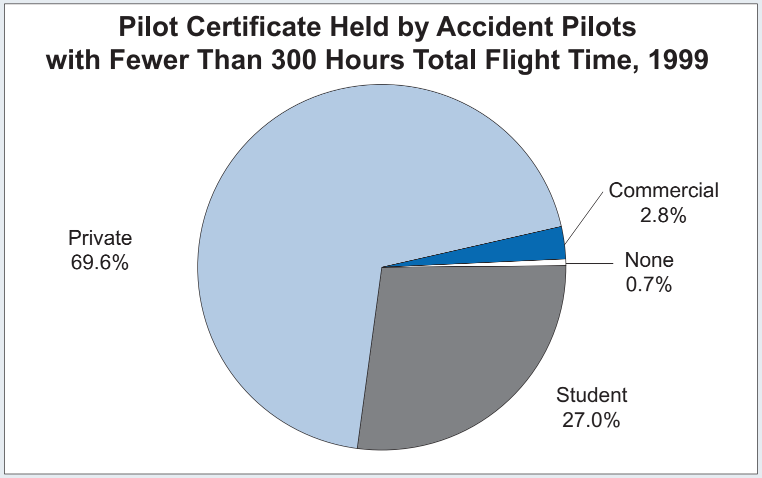
Total Time

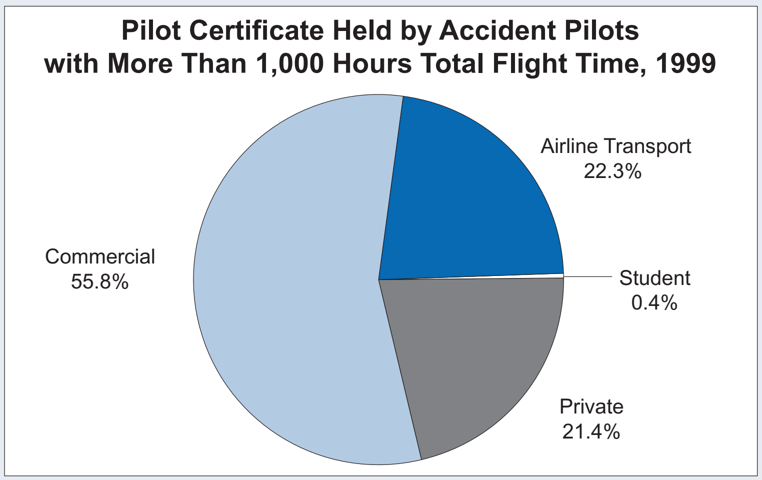
Of the 1,874 accidents in 1999 for which pilot total flight experience data are available, 47.9% involved pilots with fewer than 1,000 hours of flight time. The following chart depicts the distribution of experience among accident pilots; the inset focuses on those pilots with fewer than 1,000 hours. The largest percentage of accident pilots in this group had between 100 and 200 hours of total flight time, and a total of 446 pilots had 300 hours or fewer. When compared to all accident pilots with available data, approximately 24% of accident pilots had 300 hours of flight experience or fewer.

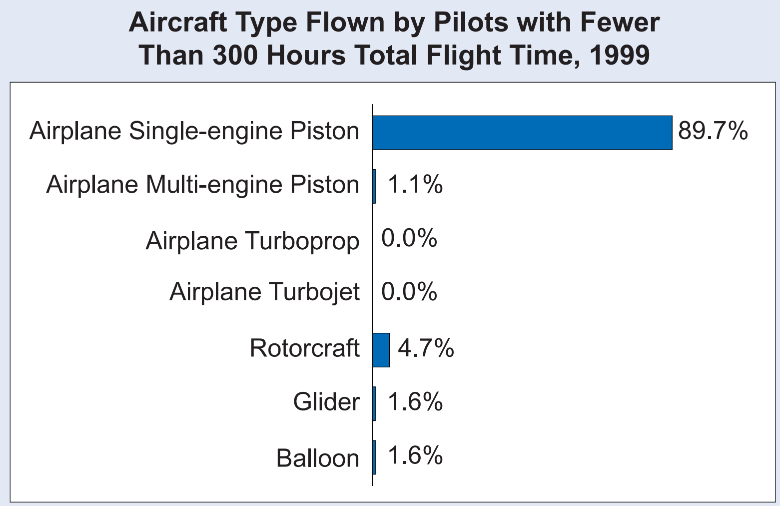


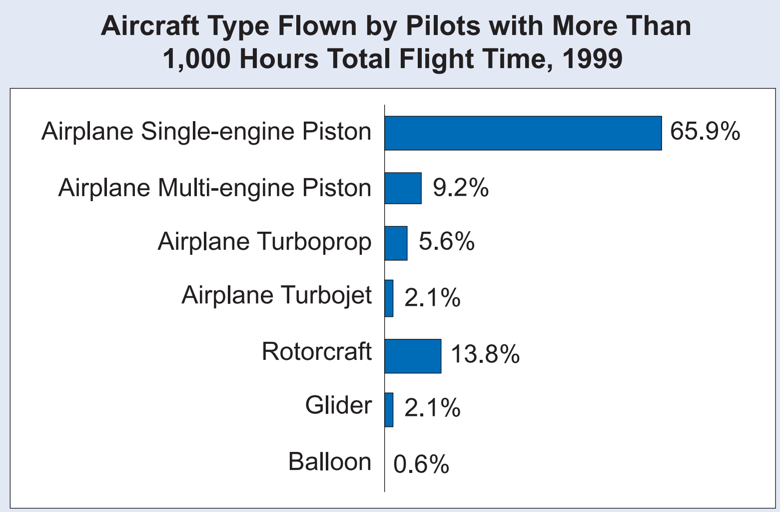
Because of the minimum hour requirements[33] for obtaining commercial and airline transport pilot certificates, it is not surprising that most accident pilots with 300 or fewer total hours of flight time held either private pilot certificates (69.6%), or student pilot certificates (27.0%). Most pilots with more than 1,000 total hours of flight time held commercial pilot certificates (55.8%), followed next by those with ATP certificates, and then by those with private pilot certificates.

[33] Refer to 14 CFR Part 61 for the requirements of each type of pilot certificate and to 14 CFR 141 for changes to those requirements for training conducted at approved flight schools.





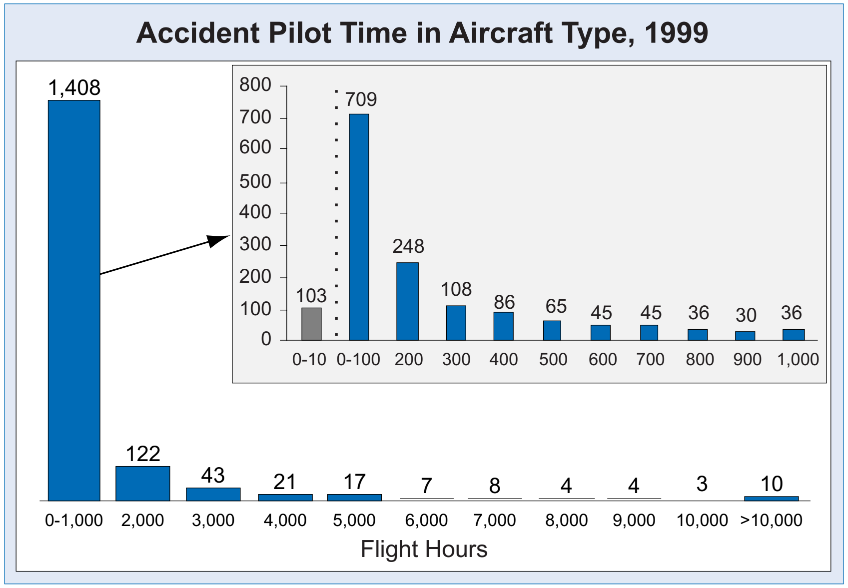




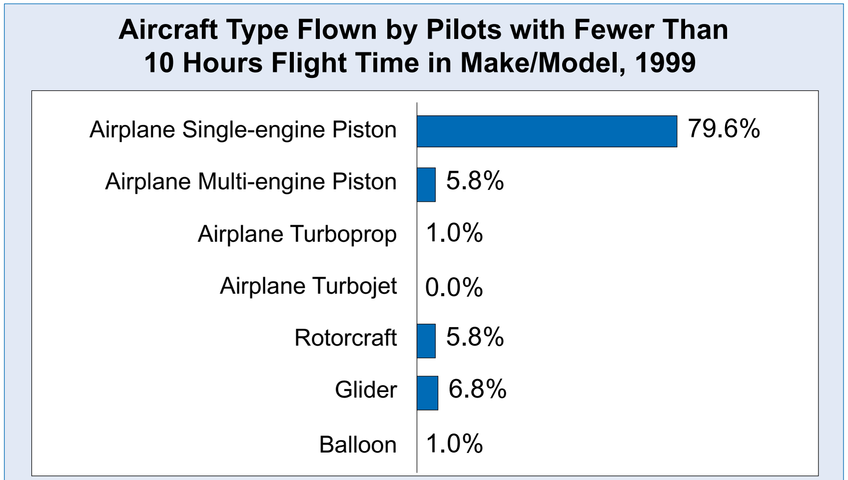
It is also not surprising that most accident pilots with 300 or fewer hours total flight time were flying single-engine piston airplanes when the accidents occurred. Accident pilots with more than 1,000 hours were flying a more diverse selection of aircraft, including 9.2% who were flying multi-engine airplanes, 5.6% who were flying turboprop airplanes, and 13.8% who were flying helicopters.

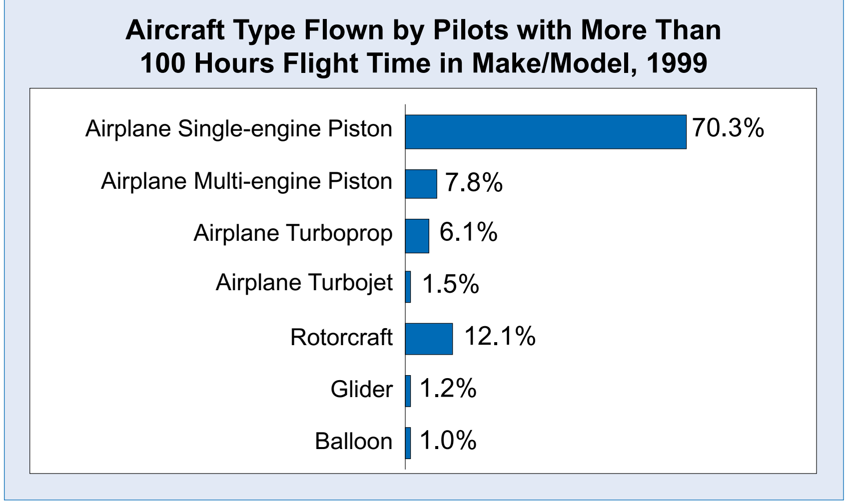
Time in Type of Aircraft

Of the 1,647 accidents in 1999 for which data are available about pilot experience in the accident aircraft make and model, 85.5% involved pilots with 1,000 or fewer hours of time in the accident aircraft make and model. The inset chart below depicts the distribution of experience among those accident pilots with fewer than 1,000 hours in type. The largest percentage of accident pilots in this group (50.8%) had fewer than 100 hours of total flight time in the accident aircraft type, and a total of 103 pilots (6.3% of all accident pilots for whom data are available) had fewer than 10 hours in type. Most accident pilots with fewer than 10 hours of flight time in make and model were flying single-engine piston aircraft.

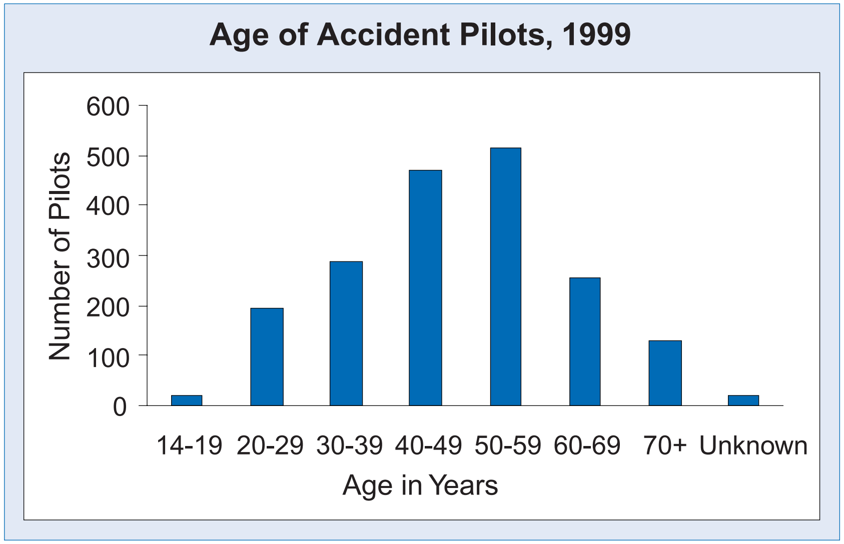


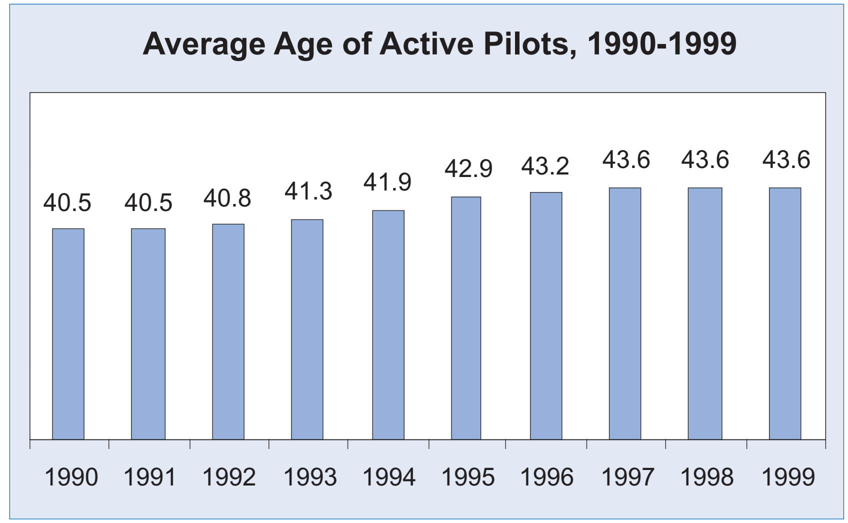
The percentage of accident pilots with low time in make and model who were flying gliders is also worth noting and is probably due to the shorter durations typical of glider flights compared to those of powered aircraft. Comparison of the two graphs shows that pilots with more than 100 hours in make and model were more likely than pilots with fewer hours in type to be flying rotorcraft or multi-engine piston, jet, or turboprop airplanes.





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 types 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.

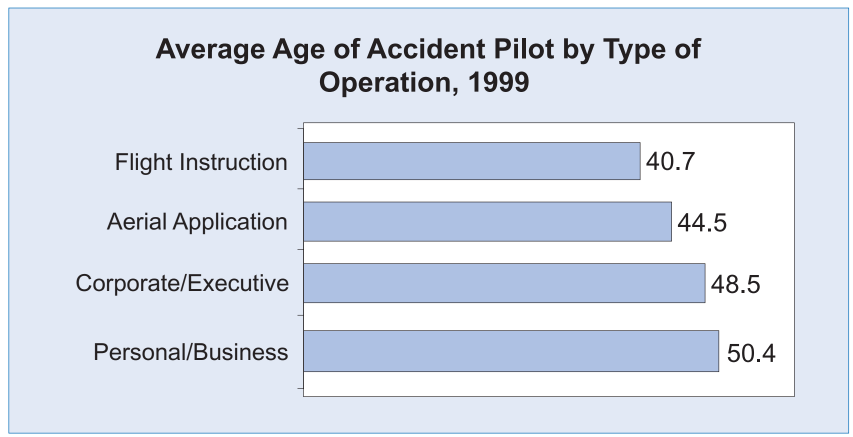




Age

The following graph illustrates the age distribution of pilots involved in accidents during 1999. Most accident pilots were between the ages of 50 and 59. The average age of all active pilots in the U.S. has been increasing steadily over the last decade and was equal to 43.6[34] years in 1999, while the average age of general aviation accident pilots was 48.1 years. No meaningful inferences can be made regarding specific age-related accident risk because FAA flight hour activity numbers are not available for each age group, but it is likely that opportunities for recreational flying may increase with age.

Accident pilots conducting flight instruction operations, which include both student pilots and flight instructors, had the lowest average age of all pilots. Accident pilots conducting personal/business flights had the highest average age at 50.4 years.



[34] FAA, *U.S. Civil Airmen Statistics*, 1999, available at http://apo.faa.gov/CivilAir/docs/air13-99.xls.

Accident Occurrences for 1999

The circumstances of an accident are documented in the Safety Board's accident report as accident "occurrences" and "sequence of events." The occurrence data can be defined as *what* happened during the accident. A total of 54[35] occurrence codes are available to describe the events for any given accident. Because aviation accidents are rarely limited to a single event, each accident is coded as a sequence (that is, occurrence 1, occurrence 2, etc.), with as many as five different occurrence codes. For accidents that involve more than one aircraft, the list of occurrences may be unique to each aircraft. Of the 1,896 accident aircraft in 1999 with data available, 1,422 had 2 or more occurrences, 664 had 3 or more, 86 had 4 or more, and 4 had a total of 5 occurrences (each) coded in the accident sequence of events. Each accident event includes information about the sequential order of its occurrence. For example, one accident in 1999 involved an airplane that experienced a loss of engine power. As a result of the engine failure, the aircraft made an emergency descent and forced landing. During the landing roll, the aircraft contacted vegetation and the landing gear collapsed. Each of these occurrences was coded; the first occurrence, for example, was coded "loss of engine power-mechanical failure." An excerpt from the brief report for this accident is included here as an example of how occurrences are coded.

Occurrence #1: LOSS OF ENGINE POWER (TOTAL) MECH FAILURE/MALF
Phase of Operation: CRUISE

Findings
1. (C) FUEL SYSTEM, CARBURETOR EXCESSIVE FLOW/OUTPUT
2. (C) MAINTENANCE, INSTALLATION IMPROPER UNKNOWN

Occurrence #2: FORCED LANDING
Phase of Operation: EMERGENCY DESCENT/LANDING

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

Findings
3. TERRAIN CONDITION HIGH VEGETATION
4. GROUND LOOP/SWERVE ENCOUNTERED PILOT IN COMMAND

Occurrence #4: GEAR COLLAPSED
Phase of Operation: LANDING-ROLL

Findings
5. LANDING GEAR-OVERLOAD

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

The National Transportation Safety Board determines the probable cause(s) of this accident as follows.
An improperly installed and maintained float needle in the carburetor, which would not seat sufficiently to stop fuel flow and caused the engine to run excessively rich, resulting in a complete loss of engine power.

Occurrence data do not include any 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 the first occurrences for all of the 1999 general aviation accident aircraft with sequence of events data available. To simplify the presentation of accident occurrence data, similar occurrences have been grouped into eight major categories.

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

1999 Accident First Occurrences

	Total	Fatal
Collision - Inflight	**308**	**109**
In Flight Collision With Object	151	48
In Flight Collision with Terrain/Water	106	46
Midair Collision	31	15
Undershoot	20	0
Near Collision Between Aircraft	0	0
Noncollision - Inflight	**447**	**155**
Loss of Control - In Flight	252	104
Airframe/Component/System Failure/Malfunction	104	20
In Flight Encounter with Weather	77	29
Abrupt Maneuver	3	2
Forced Landing	8	0
Vortex Turbulence Encountered	2	0
Altitude Deviation, Uncontrolled	1	0
Decompression	0	0
Collision - On-Ground or Water	**108**	**3**
On Ground/Water Collision with Object	51	0
On Ground/Water Encounter with Terrain/Water	35	2
Collision Between Aircraft (Other than Midair)	14	0
Dragged Wing, Rotor, Pod, Float, or Tail/Skid	8	1
Noncollision - On-Ground or Water	**442**	**5**
Loss of Control - On Ground	238	1
Hard Landing	120	1
Overrun	45	1
Nose Over	15	0
Roll Over	5	0
Propeller/Rotor Contact to Person	2	2
On Ground Encounter with Weather	14	0
Nose Down	3	0
Propeller Blast or Jet Exhaust/Suction	0	0
Ditching	0	0

	Total	Fatal
Power Related	**505**	**48**
Loss of Engine Power	190	20
Loss of Engine Power (Total) - Nonmechanical	156	12
Loss of Engine Power (Total) - Mech Failure/Malfunction	77	5
Loss of Engine Power (Partial) - Mech Failure/Malfunction	35	5
Loss of Engine Power (Partial) - Nonmechanical	34	3
Rotor Failure/Malfunction	2	1
Propeller Failure/Malfunction	10	2
Engine Tearaway	1	0
Landing Gear	**51**	**0**
Wheels Up Landing	17	0
Gear Collapsed	19	0
Main Gear Collapsed	10	0
Gear Retraction on Ground	0	0
Nose Gear Collapsed	3	0
Complete Gear Collapsed	0	0
Wheels Down Landing in Water	1	0
Tail Gear Collapsed	1	0
Other Gear Collapsed	0	0
Gear Not Extended	0	0
Gear Not Retracted	0	0
Miscellaneous	**32**	**5**
Miscellaneous/Other	21	3
Fire	8	1
Explosion	1	0
Fire/Explosion	2	1
Hazardous Materials Leak/Spill	0	0
Cargo Shift	0	0
Undetermined	**3**	**3**
Missing Aircraft	2	2
Undetermined	1	1

Among the eight major categories of first occurrences, the largest portion of accidents (26.6%) included occurrences related to aircraft power. Among the individual occurrences, the most common involved a loss of control either in flight (13.3%) or on the ground (12.6%). Although loss-of-aircraft-control-on-the-ground occurrences resulted in only 1 fatal accident, loss-of-control-in-flight occurrences resulted in a total of 104 fatal accidents, which was nearly one-third of all fatal accidents and more than twice as many as for any other single occurrence.

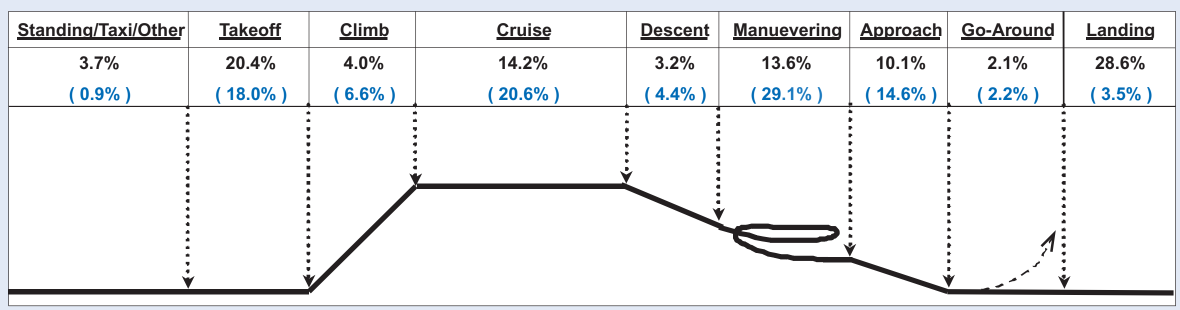
Phase of Flight

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 have been grouped into eight broad phase categories for 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 fatal accidents.

As depicted in the illustration, most accidents occurred during landing and takeoff, despite the relatively short duration of these phases in comparison to the entire profile of a normal flight. The high number of accidents that occur during takeoff and landing reflects the increased workload placed on both the flight crew and the aircraft during these phases. During takeoff and landing, the flight crew must control the aircraft while changing altitude and speed, communicating with air traffic control (ATC) and/or other aircraft, and maintaining separation from obstacles and other aircraft. Aircraft systems are also stressed during takeoff and landing with changes in 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 largest percentage of total accident first occurrences (28.6%) happened during the landing phase of flight, but only 3.5% of fatal accident first occurrences happened during this phase. The largest percentage of fatal accident first occurrences (29.1%) occurred during the maneuvering phase of flight, but only 13.6% of all accident first occurrences occurred during this phase. These statistics reflect the relative severity of the types of accidents that are likely to occur during each of these phases. Accidents 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.

Accident Aircraft Phase of Flight During First Occurrence, 1999



1,877 Accident Aircraft with Phase of Flight Data in 1999

The likelihood of an aircraft accident first occurrence during each phase of flight varies with different aircraft types and types of flying. For example, single-engine piston aircraft used for instructional flights fly more takeoffs and landings because new pilots must practice these skills. As a result, 43.2% of all first occurrences for 1999 accidents involving single-engine aircraft on instructional flights occurred during the landing phase and 21.0% occurred during takeoff. In contrast, the largest percentage of first occurrences for accidents involving helicopter flights occurred while maneuvering or hovering (37.4%), reflecting the hazards unique to helicopter operations.

Most Prevalent Causes/Factors for 1999

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 this determination is to discern the cause-and-effect relationships in the accident sequence. This could be described as *why* the accident happened. In determining probable cause of an accident, the Safety Board considers all facts, conditions, and circumstances. Within each accident occurrence, any information that contributes to the explanation of that event 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 may be the combination of multiple causes and factors. For this reason, a single accident report can include multiple cause and factor codes.

Details of a 1999 accident are included here as an example. The accident sequence began when a single-engine airplane lost electrical power in flight due to an alternator failure. Because the retractable landing gear on the aircraft relied on an electrically driven hydraulic pump, the gear would not automatically extend and the pilot attempted to lower the gear manually. The pilot did not follow the recommended procedure for alternate gear extension, and the landing gear failed to fully extend. Because it was not fully extended, the gear collapsed during landing and the aircraft sustained substantial damage. In the findings of this accident, the pilot's failure to follow the proper gear extension procedures was cited as a cause, and both the alternator failure and the failure of the landing gear to fully extend were cited as factors. An excerpt of the brief for that accident is included as an example of how those findings were recorded.

Occurrence #1: AIRFRAME/COMPONENT/SYSTEM FAILURE/MALFUNCTION
Phase of Operation: CRUISE

Findings
1. (F) ELECTRICAL SYSTEM,ALTERNATOR-FAILURE,TOTAL

Occurrence #2: FORCED LANDING
Phase of Operation: EMERGENCY DESCENT/LANDING

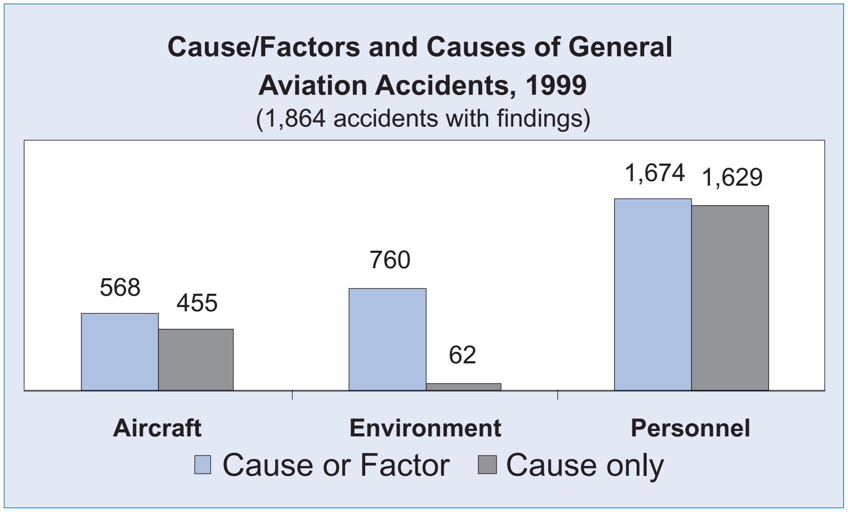
Findings
2. (F) LANDING GEAR OTHER
3. (C) PROCEDURES/DIRECTIVES NOT FOLLOWED PILOT IN COMMAND

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

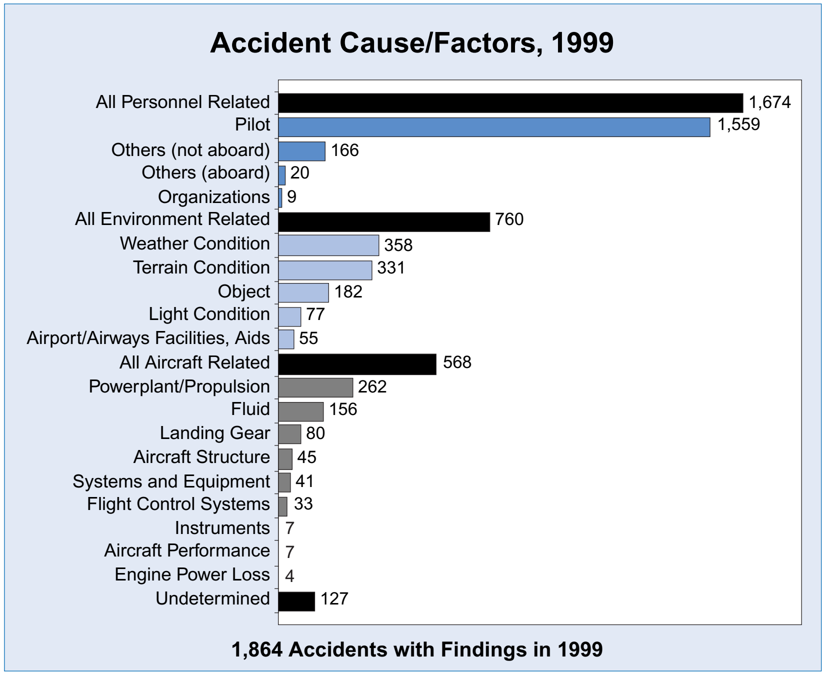
The National Transportation Safety Board determines the probable cause(s) of this accident as follows.
The pilot's failure to follow alternate landing gear extension procedures. Factors were the main landing gear failure to extend and a loss of electrical power.

To simplify the presentation of probable cause information, the hundreds of unique codes have been 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 depicts the number of general aviation accidents that fall into each broad cause/factor classification. Personnel-related causes or factors were cited in 89.8% of all general aviation accident reports for

1999 for which cause/factor data were available (N=1,864). Environmental causes/factors were cited in 40.8% of these accident reports, and aircraft-related causes/factors were cited in 30.5% of reports.[36] Environmental conditions are rarely cited as an accident cause but are more likely to be cited as a contributing factor. In 1999, only 62 of 760 environmental citations (8.2% of all environmental cause/factors) were listed as a cause, with the remainder listed as contributing factors.



The following graph displays the cause/factors of the 1999 accidents with available information. As mentioned previously, several hundred unique codes are available to document causes/factors; however, this graph summarizes those codes by the broad cause and factor categories of personnel, environment, and aircraft and by the next-lower-level subcategory.

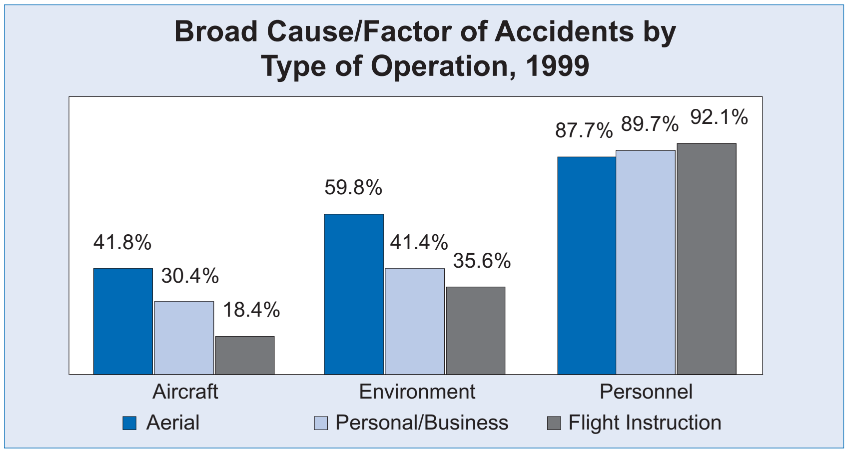


The preceding graph clearly shows that most causes and factors attributed to general aviation accidents are personnel related. The pilot is the most frequently cited individual in the personnel category; however, other persons not aboard the aircraft are cited as a cause or factor in 166 accidents. Examples of accident-related personnel not aboard the aircraft could include an air traffic controller, a maintenance technician, or airport personnel. In the broad category of environmental factors, weather conditions were cited in a total of 358 (19.2%) accidents. Powerplant-related[37] causes/factors were the most commonly cited factors within the broad category of aircraft and were cited in 262 (14.1%) of the general aviation accidents in 1999.

[36] 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.

[37] "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, while "engine power loss" refers only to the total loss of engine power.

The following graph shows that specific accident causes and factors can vary for different types of flight operations. For example, aircraft causes and factors were cited in 41.8% of aerial application accidents, compared to only 30.4% of personal/business and 18.4% of flight instruction accidents. The high percentage of aircraft cause/factors for aerial application accidents may be due to the flight profile of aerial application operations. Because they operate at low altitudes, pilots engaged in aerial application operations have less time and fewer options for dealing with mechanical difficulties. Any difficulties that do arise may therefore be more likely to lead to an accident.



Environmental causes and factors were cited in 59.8% of accidents involving aerial application operations, compared to 41.4% and 35.6%, respectively, for personal/business and flight instruction operations. Because of the low altitudes typical of aerial application operations, environmental factors like terrain and obstacles pose a greater hazard than to other types of flying. Accidents that involve landing on unsuitable terrain are also more common because pilots have fewer options in the event of a forced landing. Support for these suggestions comes from the fact that terrain conditions and objects account for 77% of all environmental causes/factors cited in aerial application accidents.

Flight instruction accidents were presumably less likely to cite environmental causes and factors because solo student pilots and flight instructors chose not to fly in marginal weather conditions, but were more likely to cite personnel cause/factors due to an increase in aircraft control and decision-making errors associated with individuals learning to fly.

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 became disoriented and lost control of an aircraft after continuing a visual flight into instrument flight conditions, the pilot would be cited as "cause" in the personnel category, and planning/decision-making would likely also be cited in the human performance issues category.

Of the 1,549 accidents for which the cause or factor was attributed to human performance, the most frequently cited cause/factor was aircraft handling and control (64.3%), followed by planning and decision-making (38.8%) and use of aircraft equipment (11.4%). Issues related to personnel qualification were cited in 42.4% of the 224 accidents with underlying explanatory factors related to human performance. Examples of qualification issues that were cited in the 1999 accident record include lack of experience, improper training, and lack of certification.

	Cause / Factor	Cause
Human performance issues	**1,549**	**1,497**
Aircraft handling/control	996	943
Planning/decision	601	526
Use of aircraft equipment	177	151
Maintenance	115	92
Communications/information/ATC	69	51
Meteorological service	14	8
Airport	3	2
Dispatch	0	0
Underlying explanatory factors	**224**	**55**
Qualification	95	5
Physiological condition	52	20
Psychological condition	48	9
Aircraft/equipment inadequate	12	5
Material inadequate	11	10
Institutional factors	9	1
Information	6	1
Procedure inadequate	6	4
Facility inadequate	1	1

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 causes/factors cited in general aviation accidents in 1999, three were related to wind. Because aircraft are most susceptible to the effects of wind during takeoffs and landings, the effect of adverse wind is reflected in the high percentage of general aviation accidents that occur during those phases of flight.

Weather as a Cause/Factor, 1999

All Accidents		Fatal Accidents	
Total	**358**	**Total**	**66**
Crosswind	78	Low Ceiling	23
Gusts	74	Clouds	11
High Density Altitude	48	Fog	9
Tailwind	46	High Density Altitude	9
Low Ceiling	34	Obscuration	8
Downdraft	23	Icing Conditions	6
Carburetor Icing Conditions	18	Thunderstorm	6
Clouds	16	Rain	5
Fog	16	Turbulence	4
Icing Conditions	13	Drizzle/Mist	3
Turbulence	13	Downdraft	2
High Wind	12	Gusts	2
Sudden Windshift	12	Snow	2
Obscuration	10	Tailwind	2
Dust Devil/Whirlwind	9	Below Approach/Landing Minimums	1
Rain	9	Crosswind	1
Variable Wind	9	Hail	1
Windshear	8	High Wind	1
Snow	7	Lightning	1
Thunderstorm	7	Mountain Wave	1
Unfavorable Wind	6	Turbulence in Clouds	1
No Thermal Lift	5	Turbulence, Terrain Induced	1
Drizzle/Mist	3	Variable Wind	1
Below Approach/Landing Minimums	2	Carburetor Icing Conditions	0
Temperature	2	Dust Devil/Whirlwind	0
Hail	1	Haze/Smoke	0
Haze/Smoke	1	Microburst/Dry	0
Lightning	1	No Thermal Lift	0
Microburst/Dry	1	Sudden Windshift	0
Mountain Wave	1	Temperature, High	0
Turbulence in Clouds	1	Unfavorable Wind	0
Turbulence, Terrain Induced	1	Updraft	0
Updraft	1	Whiteout	0
Whiteout	1	Windshear	0

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

Just as most landing accidents do not result in fatal injuries, 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 198 accidents, but only 5 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 may include pilot disorientation, loss of control, or collision with obscured obstacles or terrain, all of which are likely to result in severe injuries and aircraft damage.

General Aviation Safety Issues

The following section discusses several issues particularly relevant to general aviation safety. This section is not meant to be an exhaustive discussion of all safety concerns, but rather a sample of the issues important to general aviation. Because of the high number of accident occurrences each year involving a partial or total loss of aircraft engine power, two power-related problems, carburetor icing and fuel starvation, have been selected for discussion.

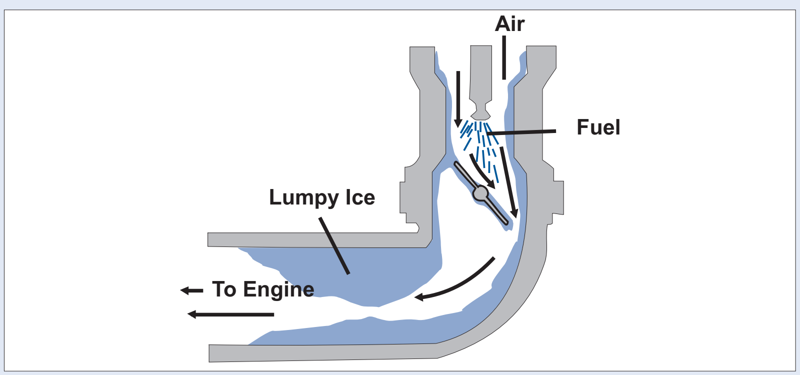
Carburetor Icing

Single-engine piston airplanes accounted for approximately 70% of the general aviation fleet in 1999. Many of these single-engine piston airplanes, and many piston helicopters, use a carbureted fuel system. In this type of fuel system, a carburetor is used to regulate the flow of air and fuel into the engine. Intake air is drawn into the carburetor through a venturi, or narrow passage, in the carburetor. The venturi is designed to create a low-pressure area when the air flows through the passage. The low pressure then draws fuel through a jet located in the passage, where it is mixed with the intake air, and then drawn through the intake manifold into the engine for combustion.

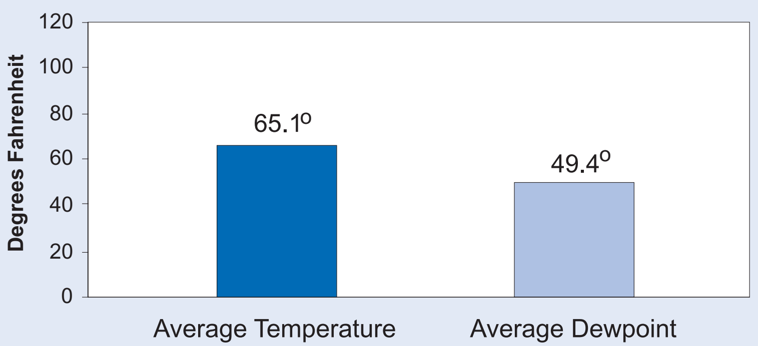
The combination of the adiabatic expansion of air as it flows through the carburetor, and the vaporization of fuel, causes a sudden cooling of the fuel/air mixture. Any water vapor in the air, or water suspended in the fuel, may condense as a result of this cooling. If the temperature inside the carburetor is at or below freezing, condensed water vapor may form ice inside the carburetor. Even a slight accumulation of carburetor ice can reduce power, and may eventually lead to a complete engine failure if the accumulation continues. Some carburetor designs and fuel types, such as automotive gasoline, are more likely to encounter carburetor icing than others, but all carbureted engines are susceptible.

Because the inside of the carburetor is much colder than the ambient air temperature, carburetor icing is usually not associated with cold weather. In fact, carburetor icing is most likely when the outside temperature is between 20° F and 70° F, in conditions of visible moisture or high humidity. In 1999, 19 general aviation accidents cited carburetor icing as either a cause or factor. The average air temperature during these accidents was 65.1°, with an average dewpoint of 49.4°, equating to an approximate average relative humidity of 76%.

Carburetor Icing Illustration

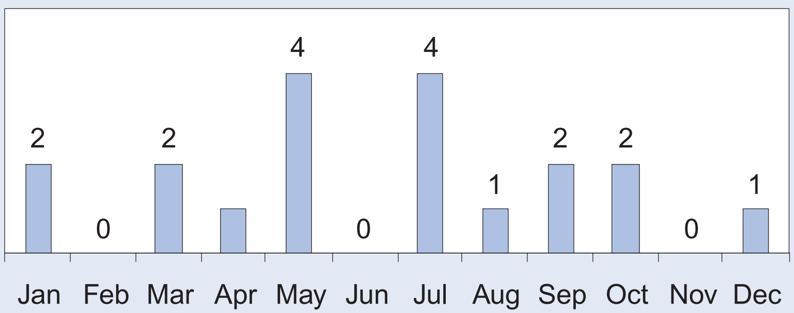


Average Temperature and Dewpoint Conditions of Accidents with Carburetor Icing Cause/Factor, 1999



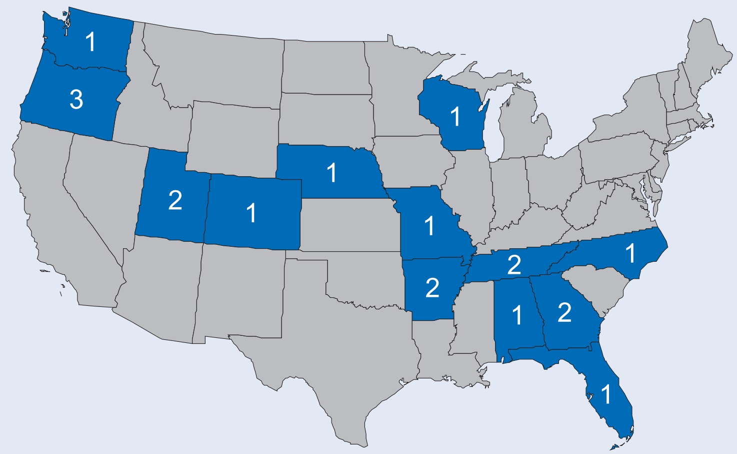
Because carburetor icing conditions are more likely to occur during periods of warm, humid weather, accidents associated with carburetor icing may also be more likely during the spring and summer months, but can occur any time during the year. The following graph illustrates the number of accidents per month citing engine failure due to carburetor icing as a cause/factor.

Number of Accidents per Month Citing Carburetor Icing as a Cause / Factor, 1999

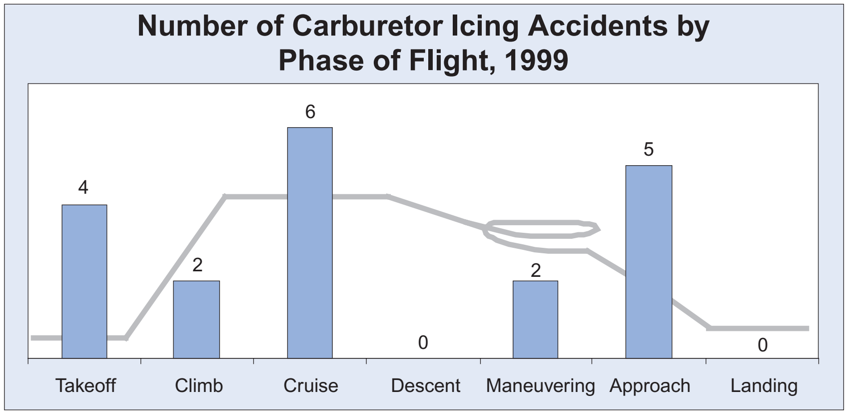


Because the likelihood of carburetor icing is related to specific weather conditions, the climate in certain locations is more conducive to carburetor icing accidents than in others. This map shows the number of accidents per state citing carburetor icing as a cause or factor during 1999. Some of these accidents were in states not normally associated with warm, humid weather, but most of the accidents took place in areas of the country like the Southeast and Northwest, where conditions of high relative humidity are common.

Location of Accidents with Carburetor Icing as a Cause/Factor, 1999



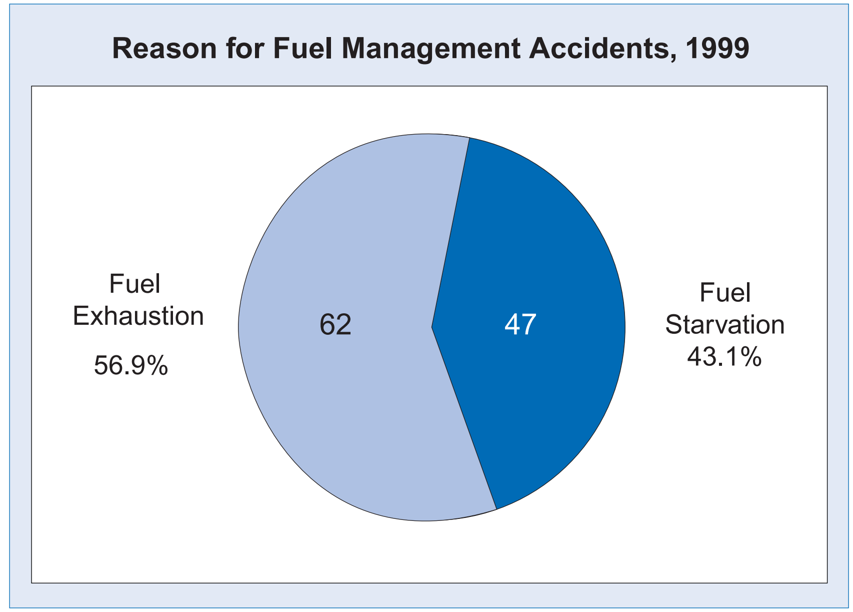
Carburetor icing is remedied through the use of carburetor heat, which directs air heated by hot engine exhaust into the carburetor. Operating procedures for aircraft with carbureted engines typically recommend the use of carburetor heat whenever carburetor ice is suspected or as a precaution whenever operating with reduced power, such as during landing. Although carbureted engines are most susceptible to icing during reduced power settings, carburetor icing can occur during any phase of flight. The following graph illustrates the number of accident aircraft in each phase of flight citing carburetor icing as a cause/factor. Most accidents citing a loss of engine power due to carburetor icing occurred during cruise flight. The only phases of flight that carburetor icing-related engine failures did not occur were descent and landing.



Some aircraft have a carburetor air temperature gauge that can be used to identify potential icing conditions before a problem develops. Without a carburetor air temperature gauge, the first indication of a problem may be a reduction in engine RPM or manifold pressure and/or a rough-running engine. In these cases, ice has already begun to form in the engine. Because carburetor icing can be prevented or eliminated through the proper use of carburetor heat, the ability to identify potential icing conditions and recognize the onset of ice is key to avoiding engine problems related to carburetor icing.

Fuel Management

Although carburetor-icing accidents are related to environmental conditions, engine failure resulting from fuel exhaustion or fuel starvation is typically attributed to the actions and/or planning of personnel. In 1999, 109 general aviation accidents, 11 of which were fatal, involved engine failure due to fuel exhaustion/starvation related to such human performance issues as miscalculating fuel burn or failing to operate fuel system controls correctly. Although the more common type of fuel management problem is fuel exhaustion, or a lack of fuel in the aircraft fuel tanks (approximately 57%), approximately 43% of fuel management accidents in 1999 involved fuel starvation.

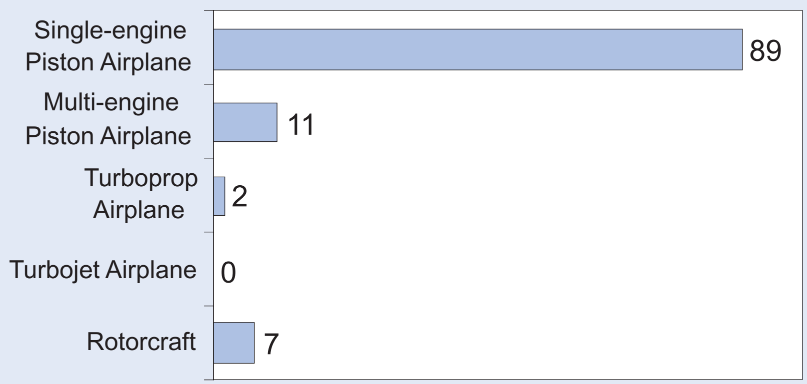


In cases of fuel starvation, the amount of fuel in the tanks may have been sufficient, but the fuel system was operated in such a way that fuel did not get to the engine. Examples of actions that might result in fuel starvation include the improper operation of fuel tank selector or fuel cutoff valve(s), improper operation of fuel boost pump(s), or the inadvertent selection of an empty fuel tank. Conversely, fuel exhaustion problems may result from an incorrect measurement of fuel onboard, a failure to calculate fuel burn properly, or the decision to fly past known fuel range limits.

An example of an accident in 1999 with a fuel management cause/factor related to fuel starvation was the forced landing of a multi-engine airplane on an instructional flight that was unable to maintain altitude after the training pilot inadvertently turned the fuel selector valve off on one of the engines. Another example was the forced landing of a single-engine aircraft by a pilot who was unable to restart the engine after running the auxiliary tanks dry before switching to the main tanks.

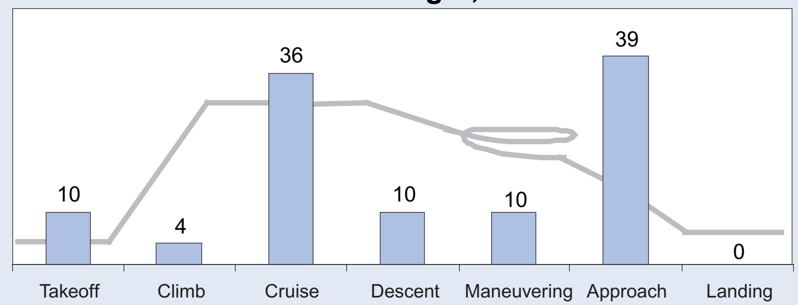
The following graph illustrates the type of aircraft involved in fuel management accidents in 1999. Most of these aircraft were single-engine piston airplanes. However, when compared to the number of each type of powered aircraft active in general aviation, single-engine piston airplanes are only slightly more likely than other types of aircraft to be involved in fuel management accidents. Aircraft-related factors such as the fuel capacity, fuel burn rate, and fuel system complexity can all contribute to fuel management accidents.

Type of Accident Aircraft With Fuel Management Cause/Factor, 1999

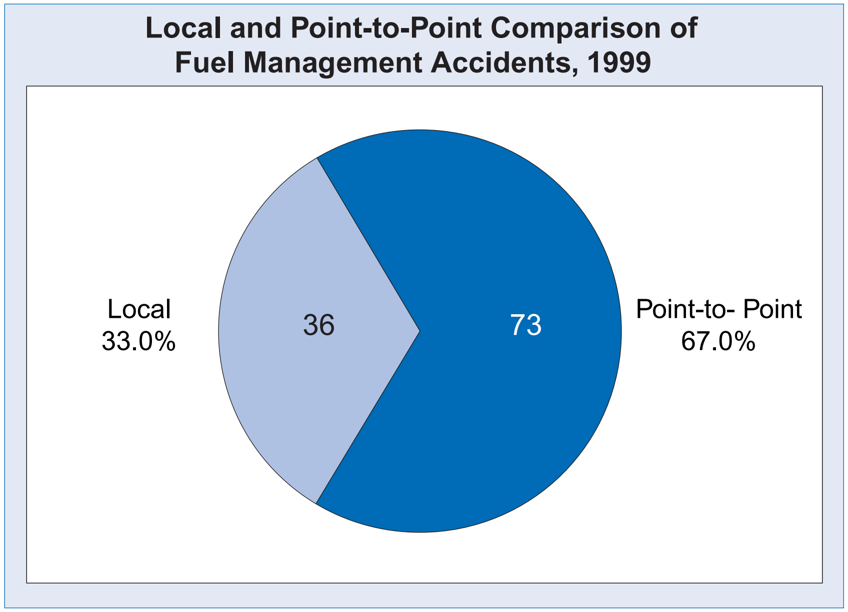


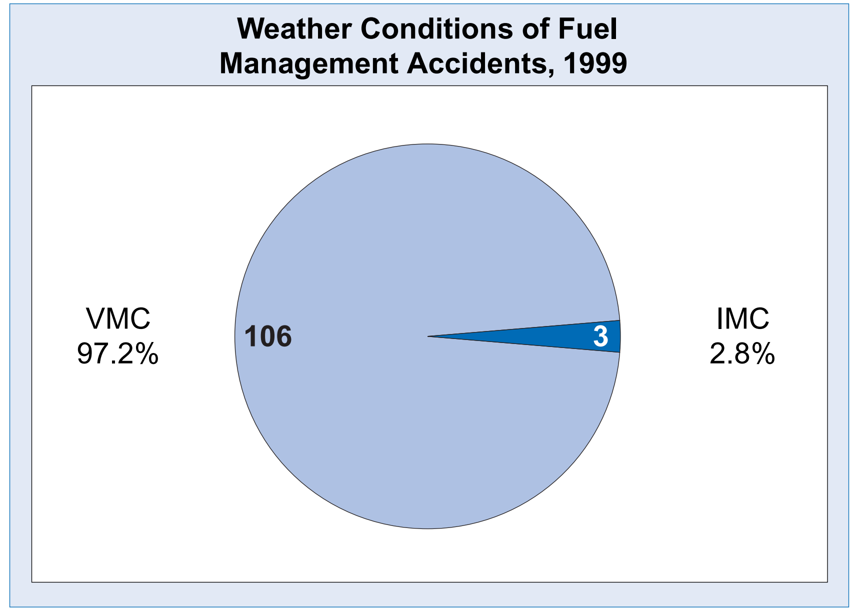
As previously discussed, most general aviation accidents occur during the takeoff and landing phases of flight. However, most fuel management accidents in 1999 occurred during approach and cruise. The number of fuel management accidents involving aircraft on approach to landing suggests that pilots may have been attempting to extend their flights just beyond the maximum range of the aircraft with the fuel available.

Number of Fuel Management Accidents by Phase of Flight, 1999



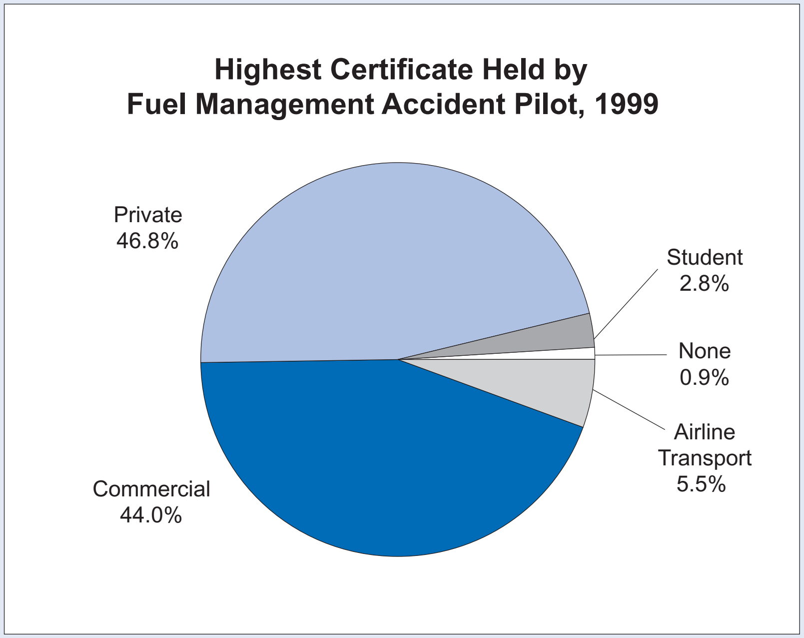
A comparison of flight profiles for fuel management accidents is presented in the following graph, showing that 67.0% of aircraft involved in fuel management accidents were on point-to-point flights. In comparison to the 53.8% of all accident aircraft in 1999 on point-to-point flights, these flights were over-represented in fuel management related accidents. Point-to-point flights are more likely to encounter fuel management problems because they are typically of longer duration than local flights. What is not known is whether the accident pilots knowingly pushed the limits of aircraft range or were simply unaware that they may have calculated fuel requirements incorrectly. The fact that several of the accident narratives in 1999 included quotes from pilots stating that they did not trust aircraft fuel quantity gauges that were indicating low fuel, even though they had flown for several hours, suggests that many of these accidents may have resulted from a combination of planning and decision-making errors related to fuel management. Pilot decision-making may also have been influenced by a general mistrust of aircraft fuel indicators that are typically not as accurate as those in automobiles, for example.

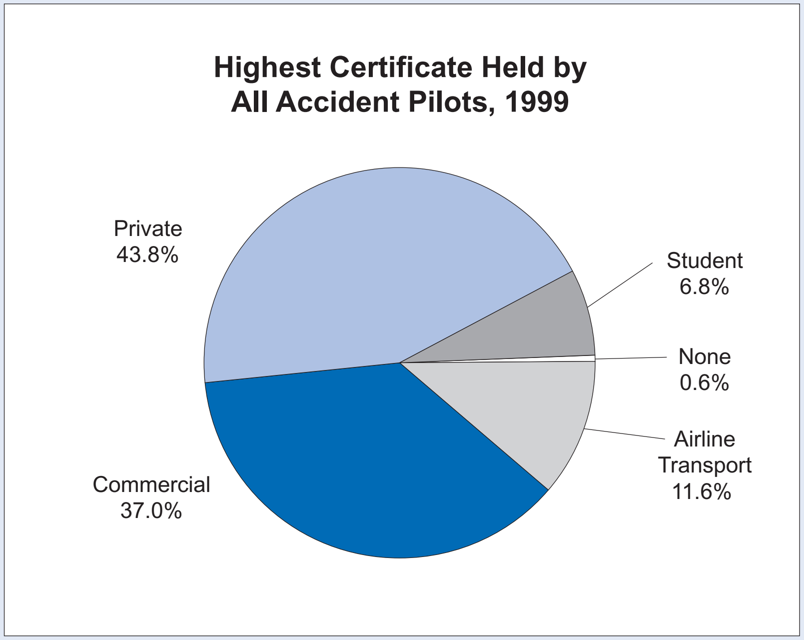




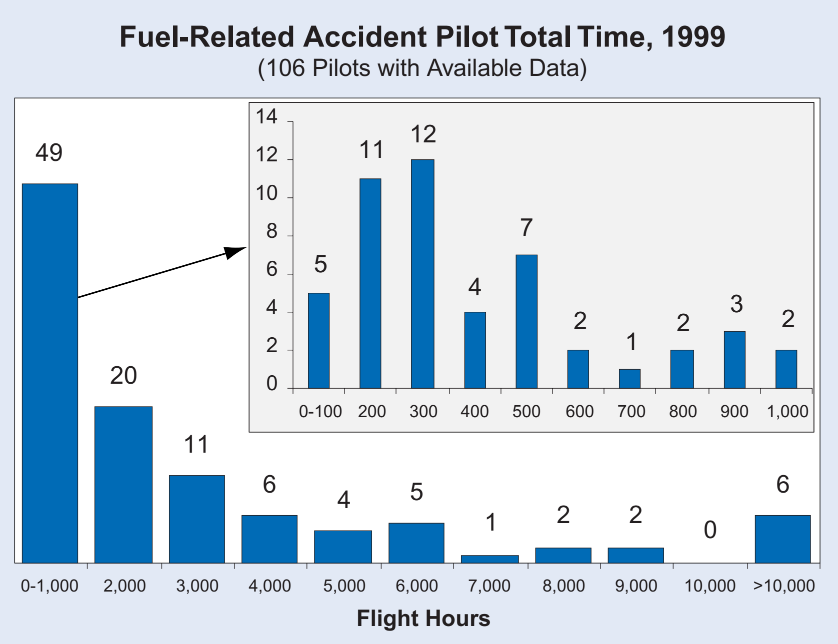
A comparison of fuel management accidents in visual and instrument meteorological conditions indicates that about 97% of fuel management accidents occurred in visual meteorological conditions. The percentage of fuel management accidents occurring in instrument conditions was half that of all accidents in IMC during 1999. The smaller percentage of fuel management accidents occurring in IMC may be related to the higher degree of planning typically required for instrument flights.

Because fuel management requires planning and decision-making, one might also expect that less experienced or lesser-trained pilots would be more likely to run out of fuel than more experienced or more highly trained pilots due to their knowledge of aircraft systems and experience calculating aircraft performance. The following graph illustrates that this is not the case. Most pilots involved in fuel management accidents in 1999 held a private pilot certificate, followed closely by those holding commercial pilot certificates. When compared to all accident pilots, a slightly higher percentage of private and commercial pilots were involved in fuel management accidents, while the percentages of student and airline transport pilots were half of those observed for all accidents.

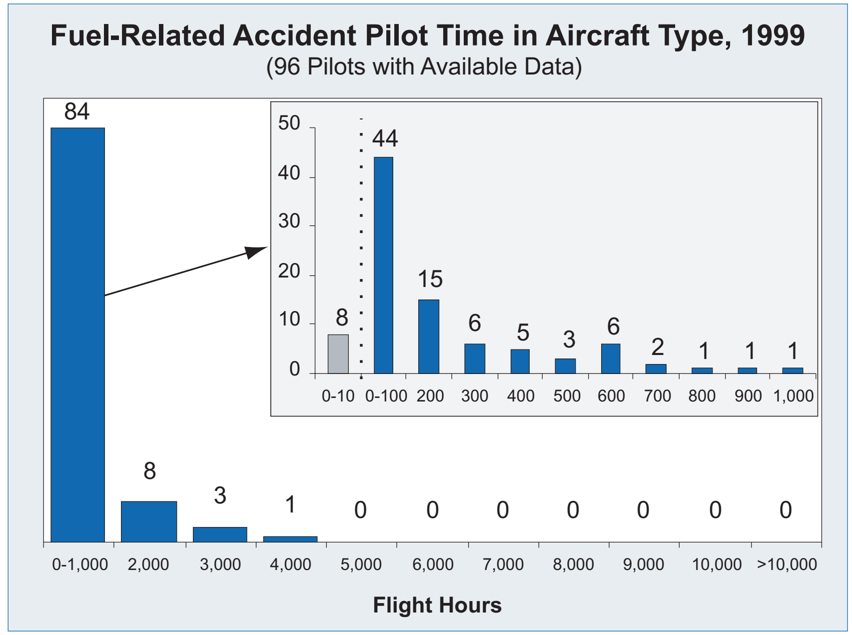




Fuel management errors also do not appear to be directly related to total flight experience. The flight experience of pilots involved in fuel management accidents in 1999 ranged from student pilots with a median of 61 total hours to airline transport pilots with a median of 5,398 hours. The following graph illustrates that, although 26.4% of pilots involved in fuel management accidents had 300 or fewer hours of total flight time, the percentage of pilots with more than 1,000 hours (53.8%) was larger than the percentage of accident pilots with fewer than 1,000 hours.



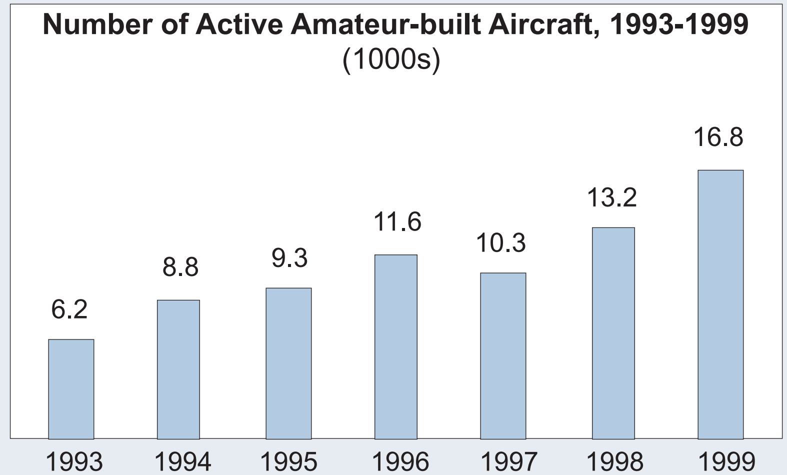
One explanation for these statistics may be that accident pilots were transitioning to new aircraft and lacked an adequate understanding of the fuel system operation and/or the real-world fuel consumption of the engines. However, the data do not directly support this assumption. Among pilots involved in fuel management accidents, 45.8% had 100 hours or fewer in the accident aircraft type, and 8.3% had 10 or fewer hours in type; these percentages are similar to those for other accident pilots in 1999.

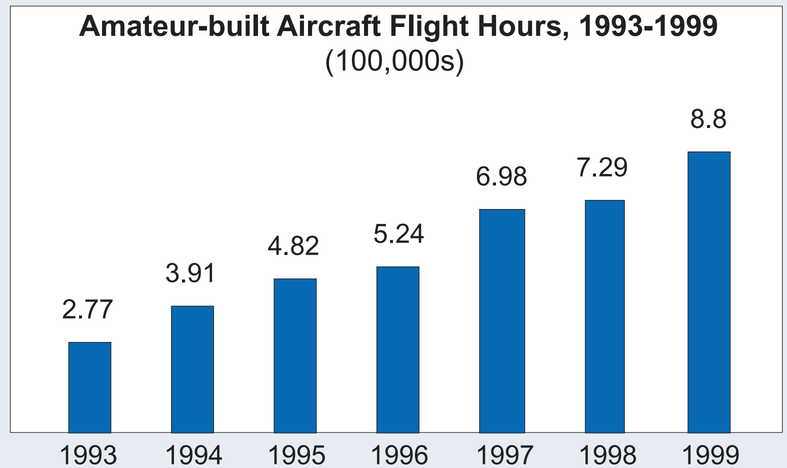


Accidents Involving Amateur-Built Aircraft

Amateur-built Aircraft

A segment of general aviation that continues to increase in popularity is that of amateur-built aircraft. Title 14 CFR Part 21[38] 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). Personal challenge, educational experience, aircraft performance, and lower cost have all been used as reasons[39] for choosing to build rather than buy an aircraft. Evidence of the increasing popularity of these aircraft can be observed in the 585% increase in the estimated number of active amateur-built aircraft and the 218% increase in the estimated number of annual flight hours for these aircraft since the FAA began reporting[40] amateur-built data in 1993.



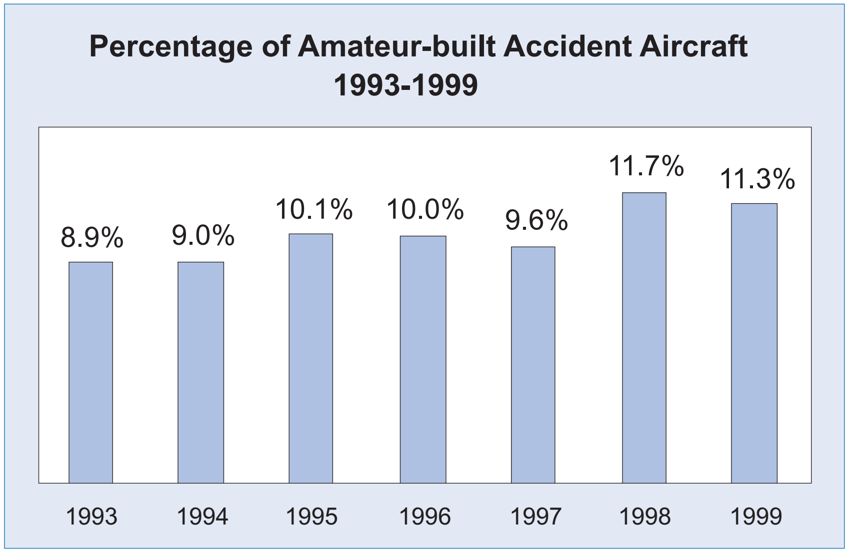


[38] Section 21.191(g) defines an amateur-built aircraft as an aircraft, the major portion of which has been fabricated and assembled by person(s) who undertook the construction project solely for their own education or recreation. Commercially produced components and parts normally purchased for use in aircraft may be used including engines and engine accessories, propellers, tires, spring steel landing gear, main and tail rotor blades, rotor hubs, wheel and brake assemblies, forgings, castings, extrusions, and standard aircraft hardware such as pulleys, bellcranks, rod ends, bearings, bolts, rivets, etc.

[39] Experimental Aircraft Association, frequently asked questions, at http://www.eaa.org/education/homebuilt_faq.html.

[40] FAA, *GAATA Survey 1999*, available at http://http://api.hq.faa.gov/GA2001/tab_1-5.pdf

Increased activity has resulted in amateur-built aircraft representing a larger percentage of general aviation accident aircraft. The percentage of amateur-built aircraft in the accident aircraft total increased from 8.9% to 11.3% between 1993 and 1999.



Because 14 CFR 91.319 prohibits all experimental aircraft, including amateur-built, from carrying persons or property for compensation or hire, most of the activity involving these aircraft is conducted for recreational purposes. In 1999, an estimated 828,535 of 879,549[41] hours (94.2%) flown in amateur-built aircraft were for personal / business purposes.

Amateur-built Aircraft Accident Conditions

Being certified as experimental aircraft, amateur-built aircraft also have specific operating restrictions[42] related to the conditions in which they can be flown. One of these restrictions is that amateur-built aircraft are prohibited from flying at night or in IMC without specific authorization from the FAA. Many amateur-built aircraft are able to meet this requirement by installing the flight instruments and equipment required[43] for instrument flight, but the percentages of aircraft certified for IFR or night flight appear to be smaller for amateur-built than for manufactured aircraft. Although exact numbers of VFR-only and day-only aircraft are not available, avionics data[44] from the *GAATA Survey* indicate that an estimated 17.4% of amateur-built aircraft have no electrical system in contrast to only 9.5% of single-engine piston airplanes and 8.5% of piston rotorcraft.[45] Amateur-built aircraft are also less likely to have equipment necessary for IFR navigation; for example, 78.6% do not have instrument approach equipment installed compared to only 33.3% of similar manufactured airplanes.[46] The effect of these differences can be observed in the weather and lighting conditions of accidents involving amateur-built aircraft. With very few exceptions, accidents involving amateur-built aircraft occurred in day, VFR conditions.

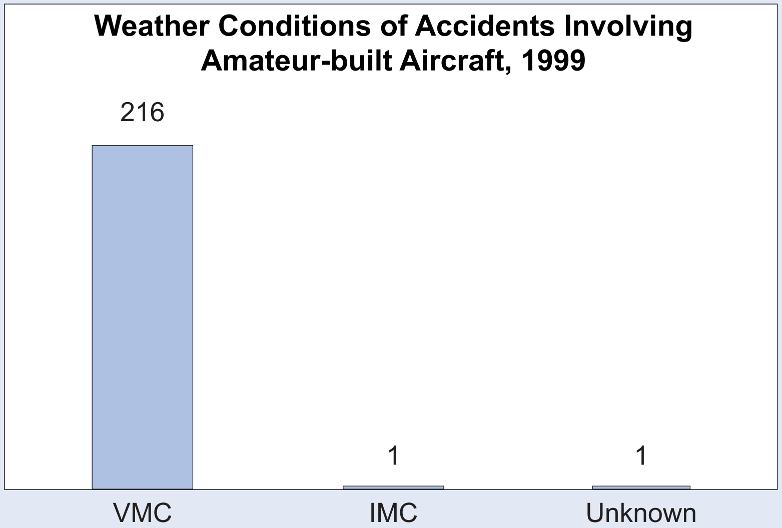
[41] This total includes only hours associated with *amateur-built* aircraft and not all *experimental* aircraft. This also excludes 340 hours reported in the *GAATA Survey* 1999 as resulting from *air taxi* and *air tour* operations although amateur-built aircraft are prohibited from engaging in these activities.

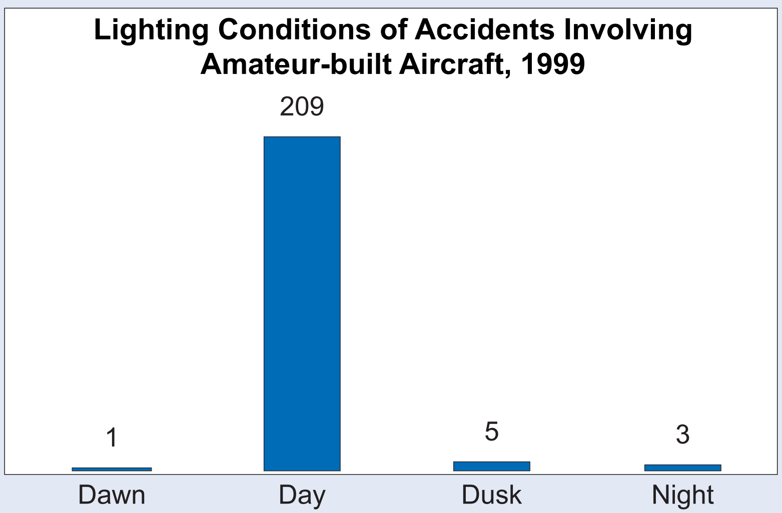
[42] Title 14 CFR 91.319 includes operating limitations for experimental category aircraft.

[43] Title 14 CFR 91.205 includes equipment requirements.

[44] The *GAATA Survey* includes avionics installation data on a biennial basis. Avionics data from the 2000 *GAATA Survey* were used in this section because those data were not available for 1999.

[46] FAA, *GAATA Survey 2000*, available at http://api.hq.faa.gov/GASurvey/docs/2000%20GA%20avtab_8-1.pdf.



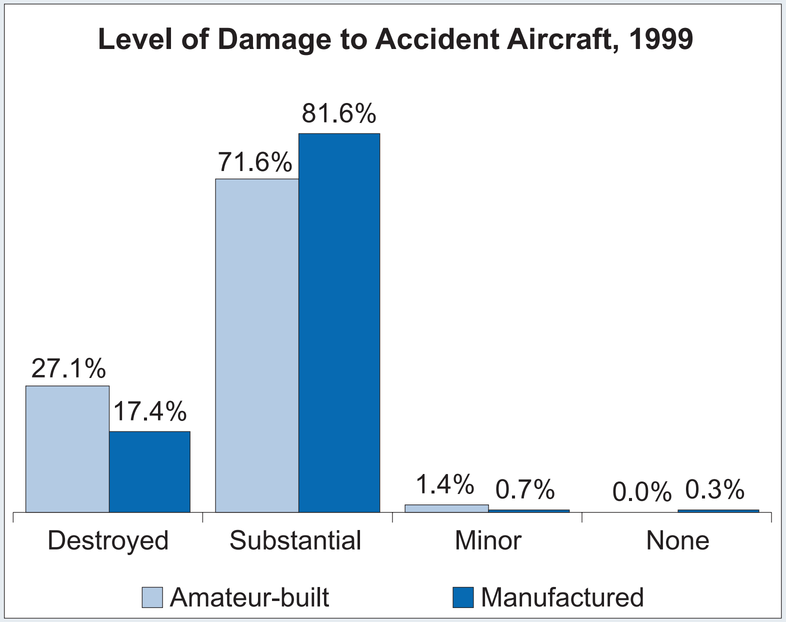


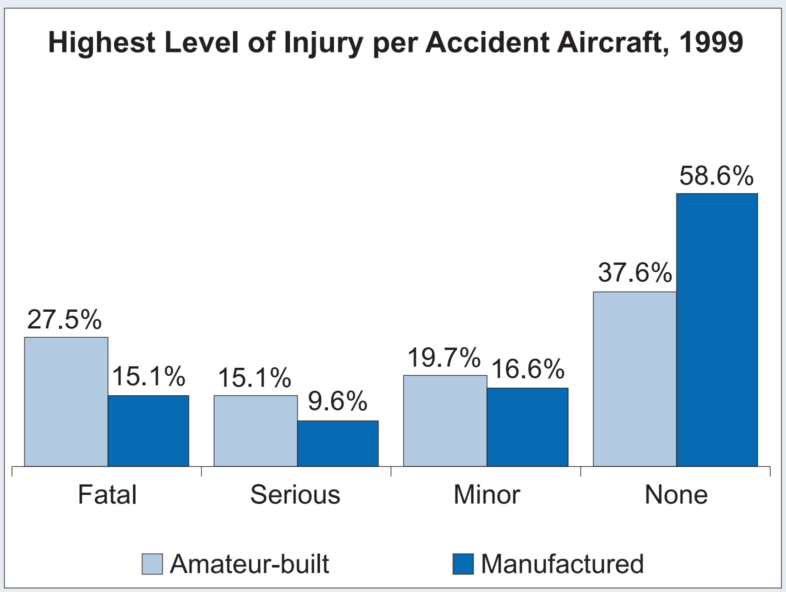
As previously mentioned, a disproportionate number of all fatal general aviation accidents occur at night and/or in instrument conditions. Because many amateur-built aircraft are prohibited from flying in these conditions, it would be reasonable to expect that a smaller percentage of amateur-built aircraft accidents might be fatal.

Amateur-built and Manufactured Aircraft Comparisons

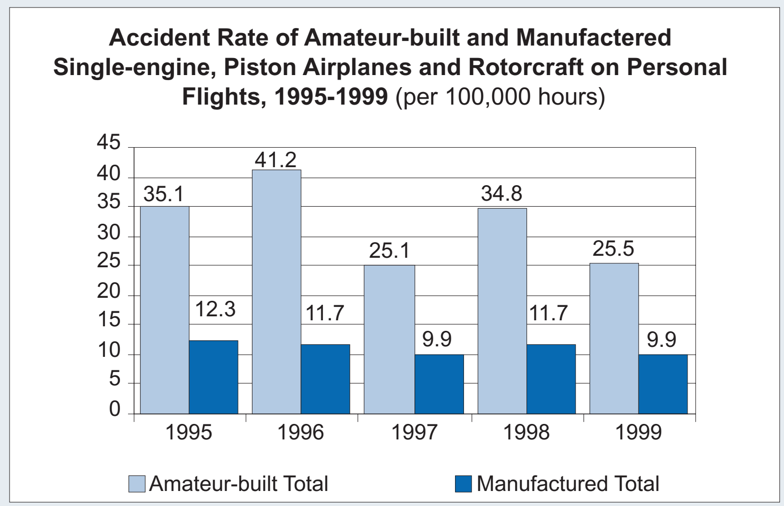
Before attempting to compare amateur-built and manufactured aircraft, it is again necessary to acknowledge the diverse range of aircraft and operations included in general aviation. In order to make meaningful comparisons, the population of manufactured aircraft must be limited to a sample of similar aircraft conducting similar operations. For example, it would be inappropriate to compare accident statistics for amateur-built aircraft with those of manufactured business jets on corporate flights. For this reason, all comparisons between amateur-built and manufactured aircraft in this section include only single-engine piston airplanes and rotorcraft conducting personal/business flights. In 1999, 218 accidents, 60 of which were fatal, involved amateur-built aircraft, and 877 accidents, 134 fatal, involved manufactured single-engine piston airplanes and rotorcraft on personal/business flights.

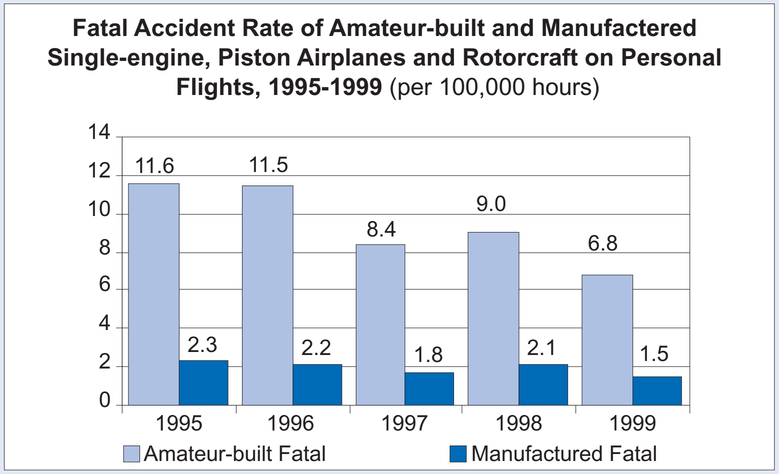
Even with the additional operating limitations placed on amateur-built aircraft, the percentage of fatal accidents for amateur-built aircraft was almost twice as high as for similar manufactured aircraft in 1999 (27.5% versus 15.1%, respectively). The percentage of accidents in which the aircraft was destroyed is also noticeably higher for amateur-built than for manufactured aircraft (27.1% versus 17.4%, respectively). However, because the criteria for an aircraft being “destroyed” is based on the cost of repair exceeding the cost of the aircraft, a direct comparison between damage to amateur-built and damage to manufactured aircraft could be misleading. Amateur-built aircraft often cost less than similar manufactured aircraft, and many use composite or fiberglass construction materials that can be more difficult and/or costly to repair.





A comparison of the accident rate per 100,000 hours flown indicates that the rate is considerably higher for amateur-built than for manufactured aircraft. The amateur-built accident rate ranged from 41.2 to 25.1 accidents per 100,000 hours between 1995 and 1999, and was equal to 25.5 accidents per 100,000 hours in 1999. The accident rate for manufactured, single-engine piston airplanes and rotorcraft remained between 12.3 and 9.9 per 100,000 hours during the same period. The fatal accident rate for amateur-built aircraft decreased from a high of 11.6 fatal accidents per 100,000 flight hours in 1995, to 6.8 fatal accidents per 100,000 flight hours in 1999. The fatal accident rate for similar manufactured aircraft was only one-fourth that of amateur-built aircraft during the same period, ranging between 2.3 accidents per 100,000 hours in 1995 and 1.5 fatal accidents per 100,000 hours in 1999.





The observed differences in accident rate, damage, and injury suggest that amateur-built aircraft are not only more likely than manufactured aircraft to be involved in an accident, but those accidents are also more likely to result in higher levels of aircraft damage and occupant injury. It is not clear whether these injury and damage differences are related to amateur-built aircraft being involved in types of accidents that result in higher levels of injury, or differences in crashworthiness resulting in more severe injuries and damage than would result from similar accidents involving manufactured aircraft.

Occurrences

A comparison of the first occurrences for accidents involving amateur-built and manufactured aircraft supports the suggestion that the percentage of fatal amateur-built accidents is due in part to the types of accidents in which those aircraft are involved. The following table lists the 10 most frequent first occurrences of accidents involving amateur-built aircraft. The percentages of accidents involving those occurrences are listed for all accidents and fatal accidents. The corresponding percentages of manufactured accidents and fatal accidents involving those occurrences are included for comparison.

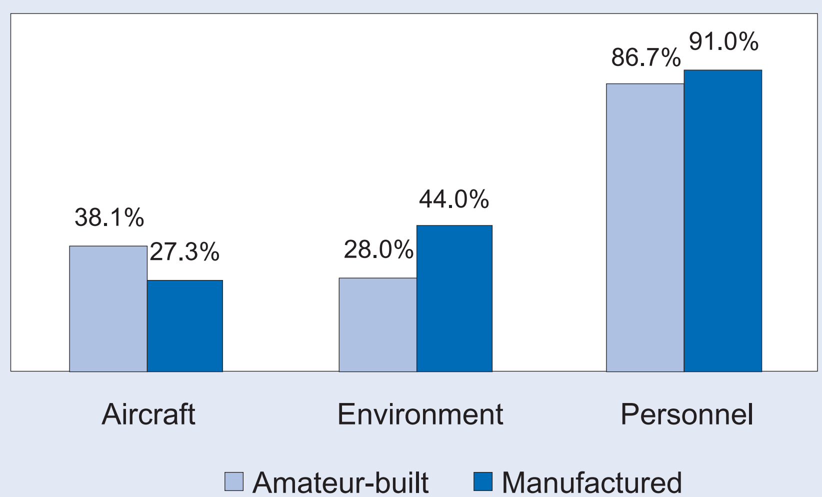
Accident First Occurrences, 1999	Amateur-built		Manufactured	
	Total	Fatal	Total	Fatal
Loss of Control - In Flight	25.7%	45.0%	10.7%	30.8%
Loss of Engine Power	15.6%	8.3%	10.2%	4.5%
Airframe/Component/System Failure/ Malfunction	8.7%	11.7%	4.0%	2.3%
Loss of Control - On Ground	8.3%	0.0%	15.2%	0.0%
Loss of Engine Power (Total) - Mech Failure/Malfunction	6.4%	1.7%	3.0%	1.5%
Loss of Engine Power (Total) - Nonmechanical	6.0%	0.0%	9.8%	4.5%
In Flight Collision With Object	4.6%	10.0%	7.6%	15.8%
In Flight Collision With Terrain/Water	4.6%	10.0%	5.3%	15.0%
Hard Landing	2.8%	0.0%	4.5%	0.0%
On Ground/Water Encounter with Terrain/Water	2.3%	0.0%	2.4%	0.0%

The most common first occurrence among amateur-built aircraft accidents during 1999 was a loss of control in flight. In-flight loss of control accounted for slightly more than 25% of all amateur-built aircraft accidents, compared to approximately 11% of manufactured aircraft accidents. The percentages of amateur-built aircraft accident occurrences related to *airframe, component, or system malfunction/failure* and *total loss of engine power due to mechanical malfunction/failure* were also more than double those for similar manufactured aircraft (8.7% versus 4.0% and 6.4% versus 3.0%).

Broad Cause/Factor

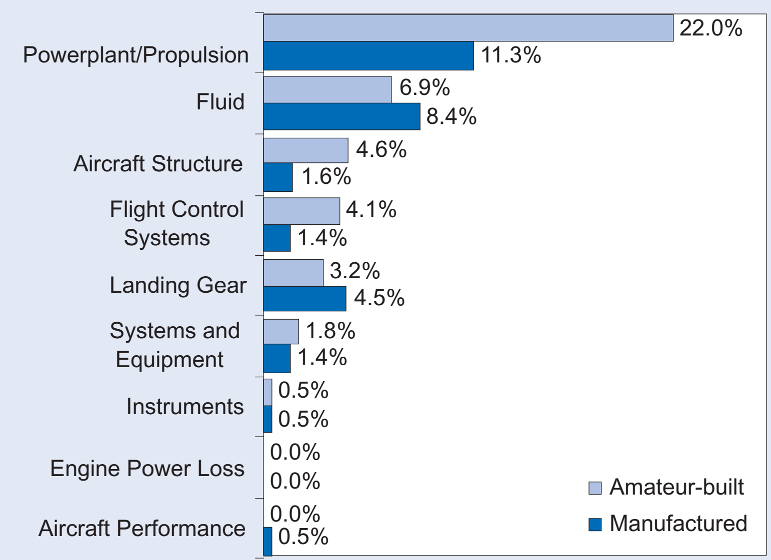
Comparisons of accident causes/factors indicate an unequal proportion of aircraft-related findings among amateur-built accidents. The following graph illustrates the broad causes/factors cited in amateur-built accidents during 1999. Data for similar manufactured aircraft are included for comparison. The percentages of accidents citing personnel causes/factors are similar for both types of aircraft, with a smaller percentage being cited for amateur-built aircraft accidents. Environmental causes/factors were cited in only 28% of amateur-built accidents compared to 44% of accidents involving manufactured aircraft. The large disparity in the percentage of environmental causes/factors between manufactured and amateur-built aircraft is no doubt due to the fact that more amateur-built than manufactured aircraft are restricted from flying in instrument weather conditions, which are associated with a large percentage of fatal accidents in general aviation. Because fewer amateur-built aircraft fly in IMC, the range of exposure to weather-related hazards is smaller. If the exposure to weather-related risk were similar for both amateur-built aircraft and manufactured aircraft operations, the disparity between the accident and fatal accident rates for the two types of aircraft would likely be even greater.

Cause/Factor of Amateur-built and Manufactured Aircraft Accidents, 1999



Other than the difference in causes and factors related to specific operating limitations placed on some amateur-built aircraft, the most meaningful difference between manufactured and amateur-built aircraft accidents is the percentage of causes and factors attributed to the aircraft. Aircraft related causes/factors were cited in 38.1% of amateur-built accidents, but only 27.3% of manufactured aircraft accidents. To further illustrate those differences, the following graph includes a comparison of aircraft causes and factors by the next level of subcategories.[47]

Aircraft-related Cause/Factors of Accidents Involving Amateur-built and Manufactured Aircraft, 1999



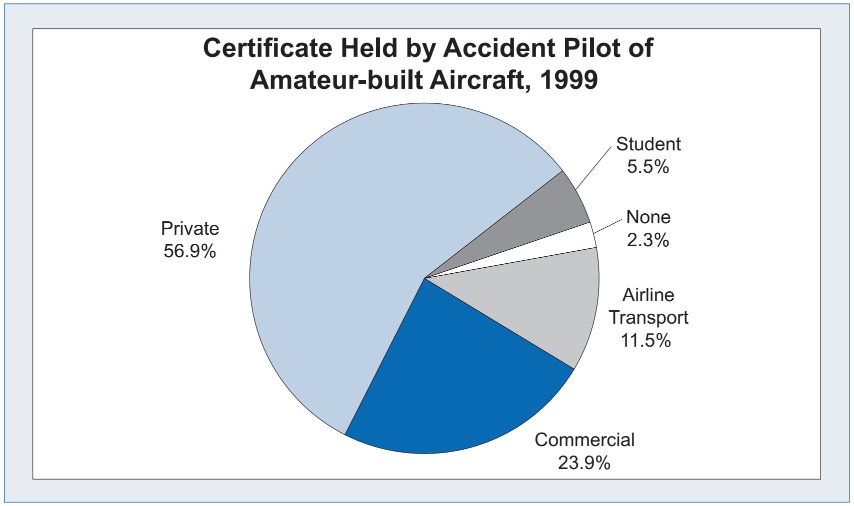
Of the 218 amateur-built and 869 manufactured aircraft accidents during 1999 with findings available, amateur-built aircraft were nearly twice as likely to have cited a cause/factor related to the

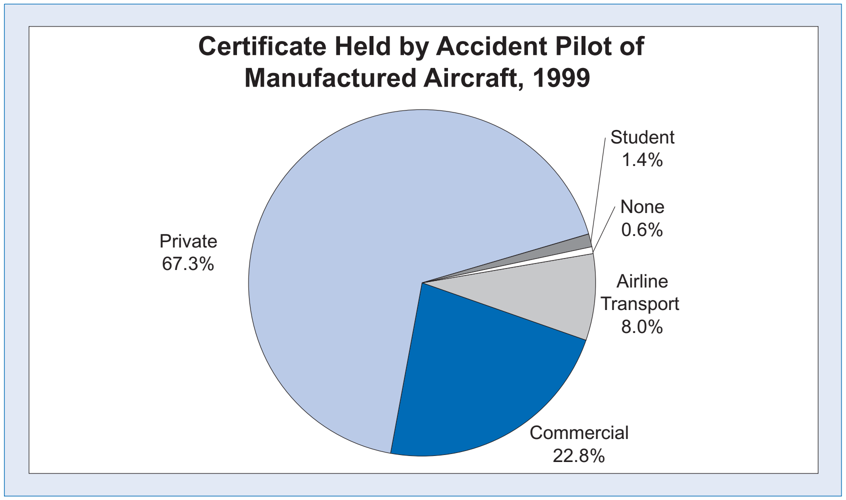
[47] Because of the possibility of multiple findings for a single accident, the sum of the subcategory values may be greater than the category total.

aircraft power plant. Although a smaller percentage of accidents for both groups cited aircraft structure and flight control malfunction/failure, the disparity between groups was even greater, with amateur-built aircraft being more than 2.5 times more likely to cite such problems. Manufactured aircraft only exceeded amateur-built aircraft in the percentage of causes/factors related to aircraft fluids and landing gear.

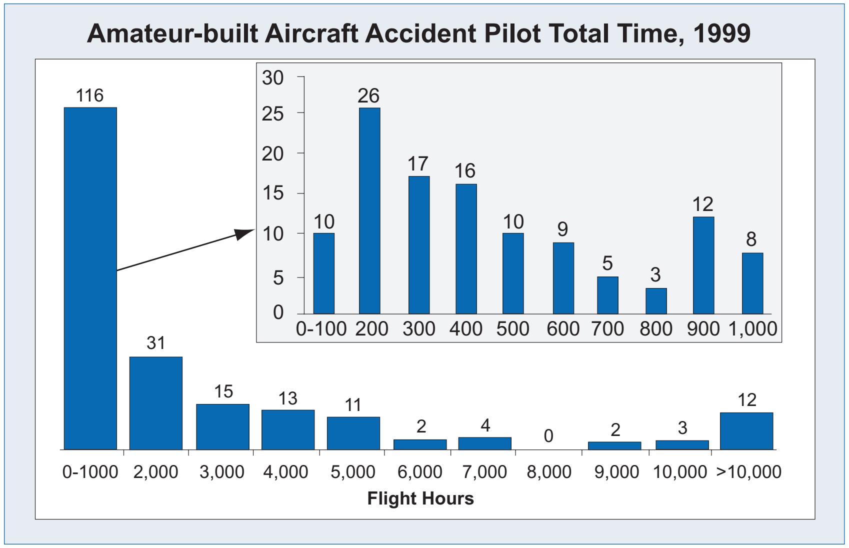
Accident Pilots

Another potential difference between amateur-built and manufactured aircraft accidents is pilot flight experience. However, accident pilots flying amateur-built aircraft appear to have, on average, more experience than accident pilots flying manufactured aircraft. The average age of accident pilots in 1999 was 52.8 years for amateur-built aircraft and 49.7 years for comparable manufactured aircraft. As the following charts illustrate, similar percentages of accident pilots held commercial pilot certificates, and larger percentages of amateur-built aircraft pilots held ATP certificates.

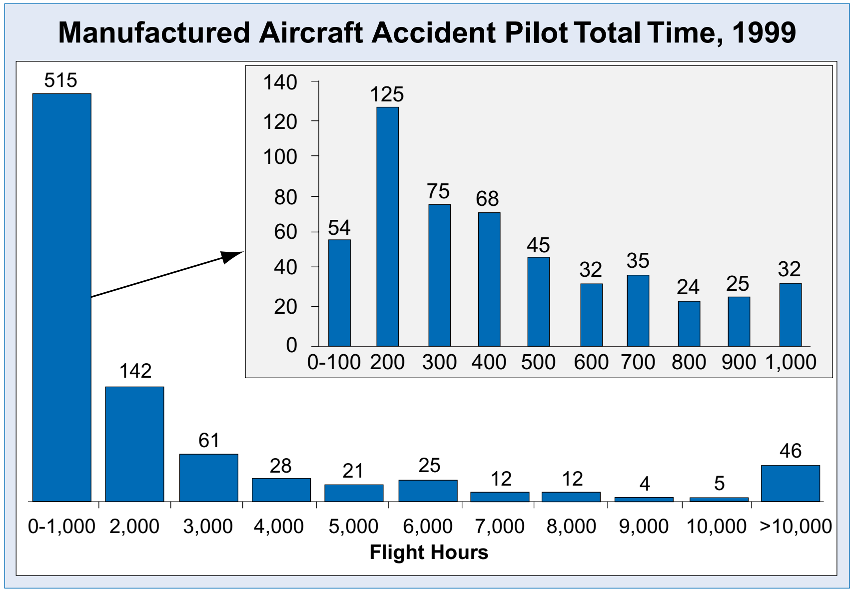




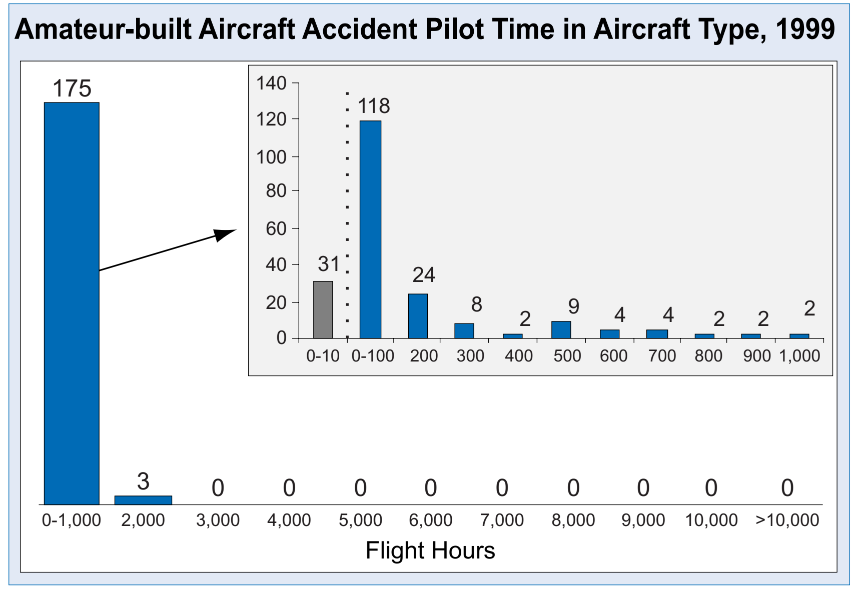
The average flight experience of accident pilots flying amateur-built aircraft also appears to be similar to that of accident pilots in 1999 flying similar manufactured aircraft. Of the 209 amateur-built aircraft pilots with total flight time data available, 55.5% had 1,000 or fewer hours of total time, and 25.4% had 300 or fewer hours.



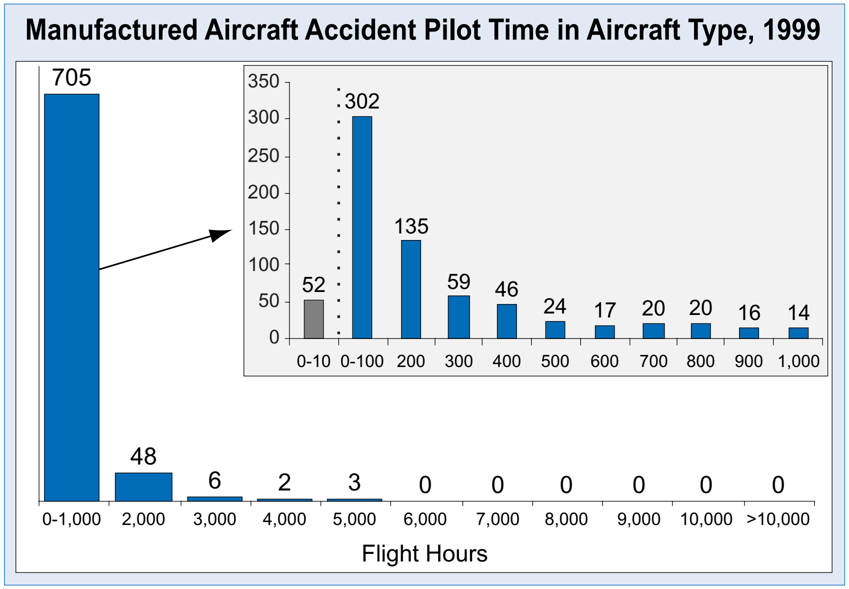
In comparison, 59.1% of accident pilots flying similar manufactured aircraft had 1,000 or fewer hours of total flight time, and 29.2% had 300 hours or fewer.



Accident pilots of amateur-built and manufactured aircraft appear to differ slightly with regard to the number of hours of flight experience in aircraft type. Among pilots of amateur-built aircraft with data available, 98.3% had 1,000 or fewer hours in make and model, and 17.4% had 10 hours or fewer.



In comparison, for the pilots for whom data are available, 92.3% of those flying manufactured aircraft had 1,000 or fewer hours in make and model of accident aircraft, and only 6.8% had 10 hours or fewer. One reason for this difference may simply be that amateur-built aircraft are not as common. Pilots of amateur-built aircraft may have fewer hours in make and model because they do most of their flying in manufactured aircraft and at some point have transitioned to amateur-built aircraft, while pilots of manufactured aircraft continue to fly the same make and model. An additional fact worth noting is that 9 of the 31 accident pilots with fewer than 10 hours in aircraft make and model accumulated those hours in newly completed aircraft.



In summary, the accident data suggest that although the disparity between manufactured and amateur-built aircraft is decreasing, amateur-built aircraft are still more likely to be involved in an accident. Furthermore, the data also suggest that accidents involving amateur-built aircraft are likely to result in higher levels of injury and/or aircraft damage than are accidents involving similar manufactured aircraft conducting similar operations. Finally, comparisons of accident occurrences, cause/factor findings, and pilot-specific data suggest that these results are primarily due to aircraft-specific differences.

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Appendix A

Definitions

Definitions of Safety Board Severity Classifications

The severity of a general aviation accident is classified by the highest level of injury (that is, fatal, serious, minor, or none) and level of aircraft damage (that is, destroyed, substantial, minor, or none).

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.[60]

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."[61]

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

None – No damage.

[50] 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.

[51] See 49 CFR 830.2.

Appendix B

The National Transportation Safety Board Investigative Process

The National Transportation Safety Board investigates every civil aviation accident that occurs in the United States. 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.[62] 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 an accident, investigators consider facts, conditions, and circumstances. 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.

[52] For more detailed information about the criteria for Safety Board investigation of an aviation accident or incident, see 49 CFR 831.2.

Appendix C

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 approximately 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 after the investigation has been completed.

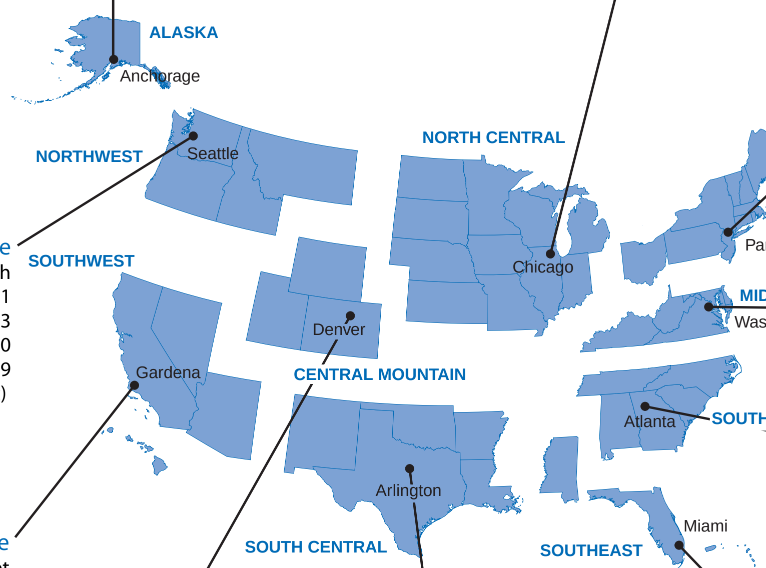
An accident-based relational database is currently available to the public at http://www.ntsb.gov/ntsb/query.asp#query_start. It contains records of approximately 40,000 accidents and incidents that occurred between 1982 and the present. Each record may contain more than 650 fields of data concerning 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 D

National Transportation Safety Board Regional Offices[1]

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)

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)

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)

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 a.m.-4:30 p.m. (Eastern)

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)

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)

[53] As of FY 2003