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Fatal Turbine-helicopter Accidents Provide Clues to Safer Operations

The fatal-accident rate for U.S. turbine helicopters improved significantly over a previous five-year period and compared favorably with general aviation's fatal-accident rate. An analysis of the types of accidents suggests causal factors that still need attention.

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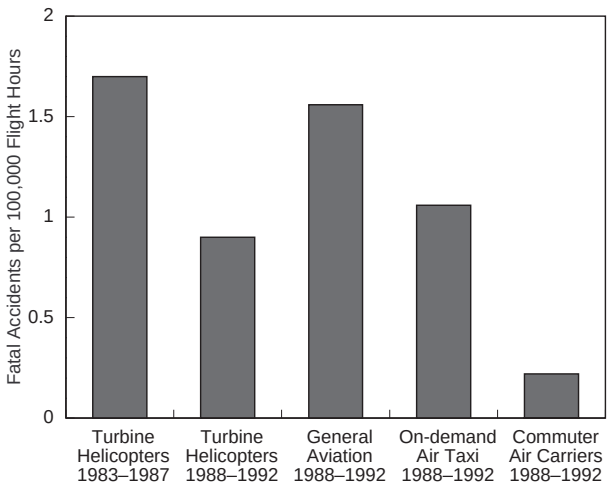
According to U.S. Federal Aviation Administration (FAA) and Helicopter Association International (HAI) data, the fatal-accident rate for U.S. turbine helicopters during the period from 1983 to 1987 was 1.70 per 100,000 flight hours. Data for the following five-year period, from 1988 to 1992, indicate that the fatal accident rate was reduced by 47 percent, to 0.90 per 100,000 flight hours.

One reason why U.S. aviation safety statistics continue to show improvement is the pursuit and study of accident data. These data often yield clues to safer operations, and can be applied at little relative cost and with no additional regulations. These data can assist helicopter operators and pilots to avoid the types of mistakes that have resulted in fatal accidents.

During the 1988–1992 period, U.S. turbine helicopters flew an estimated 9,423,000 flight hours. Although the vast majority of flights were conducted safely, 172 people were killed in 85 fatal accidents. The fatal-accident rate of 0.90 for U.S. turbine helicopters (Figure 1, page 2) during this period compares favorably with the fatal-accident rate of 1.56 for all U.S. general aviation (civil operations not under U.S. Federal Aviation Regulations [FARs] Part 121 or Part 135), and 1.06 for on-demand air taxi operations (both fixed- and rotary-wing flights conducted under Part 135). Commuter air carriers operating under Part 135, however, tallied a fatal-accident rate of only 0.22 for the same period.

Following is a review of the operational safety of U.S. civil turbine-powered helicopters. An accident was included in the statistics only if all the following criteria were satisfied: The accident involved a U.S. civil-registered turbine-powered helicopter; the accident occurred between 1988 and 1992; and the accident involved at least one fatality. The statistics do not include public-use helicopter operators (police departments and government agencies) because of insufficient operational and accident data. Public-use aircraft operators were not required to report accidents or incidents to the FAA or to the U.S. National Transportation Safety Board (NTSB) during this period. [Since April 23, 1995, FAA regulatory authority and NTSB investigative authority have been expanded by law to include all "public" aircraft other than those operated by U.S. armed forces or intelligence agencies.]

Helicopter accident information, obtained from the FAA Accident/Incident Database System (A/IDS), was provided by Air Data Research in San Antonio, Texas, U.S. Data base entries were verified, and in some accidents, they were supplemented by NTSB accident reports. If an accident reported in the A/IDS could not be verified by an NTSB report, it was not



Sources: All flight hours: U.S. Federal Aviation Administration (FAA) *Statistical Handbook of Aviation, Calendar Year 1992* (APO–94–5). Turbine helicopter fatal accidents 1983–1987: Helicopter Association International (HAI) "Bigstats" spreadsheet.[1] Turbine helicopter fatal accidents 1988–1992: FAA Accident/Incident Data Base System (A/IDS) and U.S. National Transportation Safety Board (NTSB) accident reports. Note: HAI "Bigstats" lists 76 fatal turbine accidents and 8,581,000 hours for the period 1988–1992, for a fatal accident rate of 0.89 per 100,000 flight hours. General aviation, on-demand air taxi and commuter air carriers 1988–1992 fatal accident data: FAA *Statistical Handbook of Aviation, Calendar Year 1992.*

Figure 1

included in the study. If a discrepancy existed between the A/IDS data and the NTSB accident report, the NTSB report was given precedence.

Pilot Error Most Frequently Cited Causal Factor

An array of environmental, mechanical and human-performance factors can cause or contribute to fatal helicopter accidents. Pilot error was cited as a causal or contributing factor in 62 of 85 fatal accidents. Nevertheless, accidents in which flight-crew performance is cited typically involve other human, mechanical and environment factors as well. The A/IDS assigns a general cause category to each accident. The seven general cause categories and number of accidents (in parentheses) attributed to each category are:

1. **Pilot Error** (55). The pilot was the principal causal factor. An example of a pilot-error accident occurred in 1990. According to the NTSB, a 10,769-hour commercial-rated pilot of a Bell 206B "... took off from a clear area in front of a private residence. The helicopter accelerated in ground effect for about 370 feet [113 meters], utilizing an airspeed-over-altitude departure profile. It then flew directly into … power lines which were located about four feet [1.22 meters] above the elevation of the takeoff area."

2. **Pilot and maintenance** (7). Both pilot and maintenance were causal factors. A commercial pilot in 1990 took off in a Bell 204B with a sling load. The aircraft was being operated at a weight in excess of the maximum gross weight for the aircraft (pilot error). This resulted in turbine disc-stress ruptures. When the aircraft lost power, the pilot was unable to jettison the load because of an intermittently inoperative jettison switch (maintenance error).

3. **Improper or inadequate maintenance** (9). A maintenance discrepancy was a causal factor. In a 1989 accident, four people were killed when an Aerospatiale AS 350D helicopter crashed. According to the NTSB, "the main-rotor swashplate bearing failed due to lack of lubrication. A service bulletin (SB) and an airworthiness directive (AD) had not been complied with."

4. **Operational deficiency** (4). An operational deficiency is typically a mechanical failure in which neither the pilot, maintenance, nor the manufacturer contributed to the accident. In 1991, an Aerospatiale SA 316B suffered a tail-rotor drive-shaft failure resulting in an in-flight breakup of the helicopter. Neither the pilot, maintenance, nor the manufacturer was found to be at fault.

5. **Manufacturer** (1). Only one accident was attributed to a manufacturing error. In 1989, a twin-turbine helicopter was cruising at 2,200 feet (671 meters) mean sea level (MSL) when a part of one of the main rotor blades separated from the helicopter. A metallurgical examination of the separated blade revealed that it had failed because of fatigue. The fracture had initiated at a manufacturer-induced scratch in the spar of the blade.

6. **Miscellaneous** (4). Miscellaneous accidents were those for which the cause was determined, but did not fit into other causal categories. According to the NTSB, in 1990 a Bell 206B pilot was conducting a "barehand live-line operation over a 345,000-volt energized power line and was lowering the electrical lineworker toward the work area. The worker raised his arm, which compromised the airgap, resulting in a flashover and electrocution."

7. **Undetermined** (5). For a few accidents, a cause could not be determined. In 1991, the pilot of a Bell 206L-1 departed an offshore platform in the Gulf of Mexico. After takeoff, the pilot received a weather briefing informing him of adverse conditions in the area. He did not make a mandatory 15-minute position report. A search was initiated, but was hampered by bad weather. Only the lower flooring of the cabin section, a skid and a main-rotor blade tip were found. An examination of the recovered items revealed signatures consistent with a high-speed impact with the water.

Figure 2 (page 3) shows these categories as percentages.

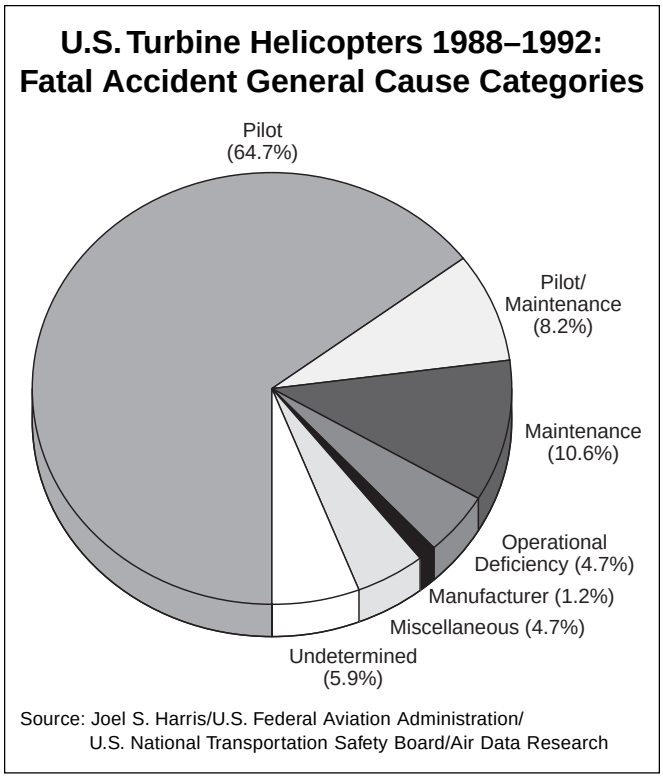


Figure 2

NTSB Categories Offer Another Classification

In addition to dividing accidents by general cause, they can be classified by what the NTSB calls "accident categories." Using the taxonomy that the NTSB used in its safety study on emergency medical service (EMS) helicopter accidents,[2] the 85 fatal accidents can be divided into six accident categories. The categories and number of fatal accidents in each category are as follows:

1. **Weather-related.** Twenty-four accidents involved adverse weather or reduced visibility, including rain, fog, snow or dark-night conditions. In nearly all of the weather-related accidents, one of two things occurred. Either the pilot was operating under visual flight rules (VFR) in instrument meteorological conditions (IMC) and lost control of the aircraft, or the pilot was operating the aircraft at a very low altitude in an effort to avoid or escape IMC, and struck an obstruction or flew into terrain.

    - Thirteen of 24 accidents probably involved spatial disorientation of the pilots;

    - Twelve of 24 accidents occurred during darkness, one occurred at dawn and one at dusk. Only 10 occurred during full daylight;

    - In five of 24 accidents, the helicopters struck an obstruction (power line, tower or trees) while flying at very low altitude. In one accident, a helicopter piloted by an 8,100-hour airline transport pilot (ATP)-rated pilot struck power lines, a cement wall and trees while "trying to negotiate a pass in 30- to 40-foot [9.15- to 12.2-meter] ceilings";

    - In five of 24 accidents, the helicopters impacted mountainous terrain while flying in IMC; and,

    - None of the weather-related accidents occurred during operation on an instrument flight rules (IFR) flight plan.

2. **Mechanical Failure**. Twenty-two accidents were attributed to a mechanical failure of some component of the helicopter (Figure 3).

    - Seven of 22 mechanical-failure accidents resulted from a complete or partial loss of engine power. In each accident, the helicopter was equipped with a single engine. In an accident in which pilot error was the general cause, the ATP-rated pilot of an Aerospatiale AS 350D reset the engine chip detector light "five to 10 times" in flight. During that time he passed an airport but did not land his helicopter. Eventually, the compressor bearing shaft seized. Three of the aircraft's occupants were killed in the resulting crash. The pilot had more than 7,000 hours of flight time, nearly 1,000 of which were in the exact type of helicopter in which he crashed;

    - Incorrect or inadequate maintenance contributed to 15 of the 22 accidents. In at least four accidents, ADs or SBs were not complied with;

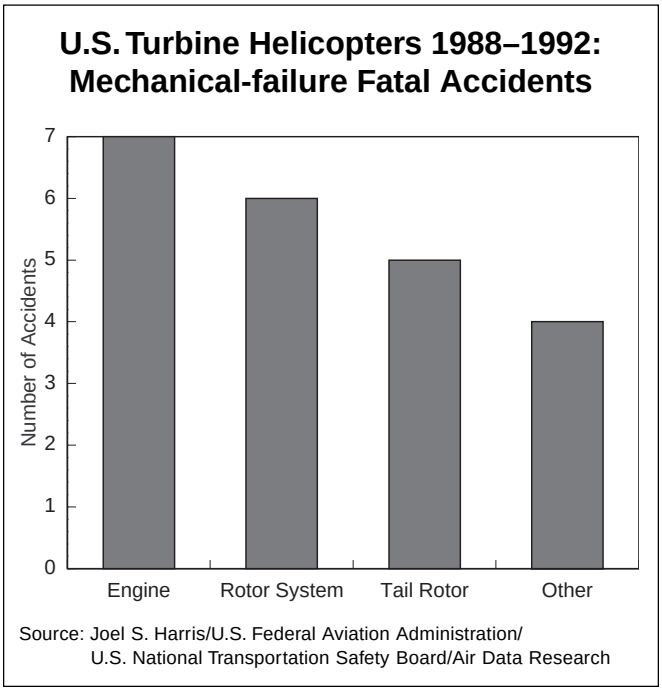


Figure 3

- In six of 22 accidents, a failure of the swashplate or other main-rotor component was a causal factor; and,

- Failure of a tail-rotor component was responsible for five of 22 accidents.

3. **Obstacle Strikes.** Eleven accidents were attributed to nonweather-related obstacle strikes. Obstacle strikes involved either the main rotor or tail rotor contacting obstacles such as wires or buildings.

   - In 10 of 11 accidents, the helicopters struck power lines. In a California accident, a Bell 206 was hired to fly four passengers to survey a strait for an oil spill. The pilot was familiar with the area, which was near his home base. On a clear day, while in slow flight at about 210 feet (64 meters) above ground level (AGL), the helicopter collided nearly perpendicularly with a power line. The helicopter crashed and all five people aboard were killed. The line was depicted on the appropiate aeronautical chart, but an FAA inspector, who flew the same route, reported that the power line was difficult to see until he was within 1,000 feet (305 meters) of it. The inspector said that the towers, from which the lines were suspended across the strait, were located 4,426 feet (1,350 meters) apart and contributed to the power line's inconspicuousness;

   - In three of 11 accidents, the helicopters were involved in activity involving the power lines that were struck. In one accident, the helicopter was placing ball markings on the wires. In two of these three accidents, a lack of proper training was cited;

   - Two of 11 obstacle strikes occurred during agricultural operations; and,

   - Only one accident involved an obstacle strike by the tail rotor. In that accident, a Bell 206 "struck a chain-link safety fence around a helipad deck on an oil rig" with its tail rotor, and the helicopter "tumbled into Gulf waters."

4. **Control Loss.** Ten accidents involved some element of control loss.

   - Three of 10 accidents involving control loss occurred during unauthorized aerobatic displays. In one of these accidents, a private pilot was giving rides at a company picnic in an Aerospatiale SA 341G. According to the NTSB, he was "demonstrating a helicopter maneuver from a television show" and the helicopter was seen diving steeply and performing turns in hilly terrain when it impacted trees. Two people were killed and three people suffered serious injuries;

   - Two control-loss accidents resulted from the loss of tail-rotor effectiveness; and,

   - Other control-loss accidents included a downwind takeoff, operation exceeding gross weight, operation at very-high-density altitude and a private helicopter pilot giving instruction to a nonhelicopter-rated airplane pilot.

5. **Midair Collisions.** Six accidents were midair collisions.

   - All six accidents occurred during daylight;

   - All six accidents occurred close to an airport, and only the accident of a Bell 412 colliding with a fixed-wing twin-engine Piper Aerostar, while checking the condition of the Aerostar's nose gear, occurred at an airport with an operating control tower;

   - In five of six accidents, one of the helicopters was in a climb after takeoff; and,

   - Four accidents involved fixed-wing aircraft.

6. **Miscellaneous**. The remaining 12 accidents involved a variety of factors not easily categorized.

   - Eight of the 12 miscellaneous accidents involved long-line operations. In four of these, the long-line was found to have fouled the tail-rotor or main-rotor systems. The commercial pilot of a Bell 214B "had the mechanic attach a 30-foot [9.2-meter] cable to the hook, so the cable would touch the ground prior to passenger pickup and dissipate static electricity. After picking up his passengers, he flew through turbulence and the tail-rotor gearbox separated from the aircraft." The unsecured 30-foot cable had fouled the tail rotor. The pilot autorotated into trees. There were six fatalities;

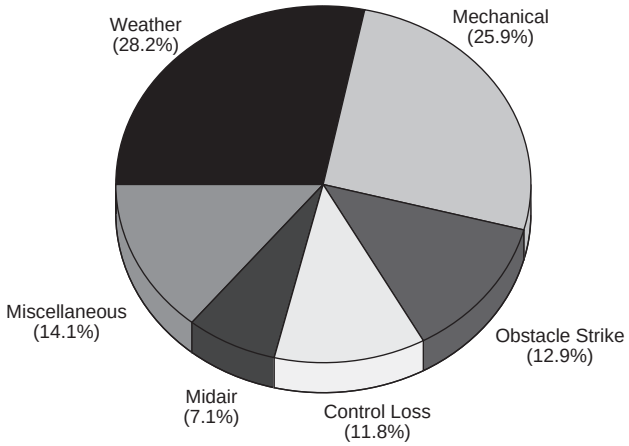
   - Two accidents involved fuel starvation. In one of these, the pilot of a single-engine helicopter was attempting to upright an animal cage using a long-line. The engine failed when the nose of the helicopter raised during the procedure, unporting the fuel pick-up. At the time, the aircraft was found to have had less than 115 pounds [52.2 kilograms] of fuel on board;

   - One accident involved a pilot who cooked and ate day-old fish. He became incapacitated from food poisoning and "tried to land in a marsh but lost consciousness and crashed." Only his passenger survived; and,

   - A passenger who had been cautioned previously about approaching the rear of the helicopter "exited the helicopter prior to the pilot's OK and walked into the rotating tail rotor."

Figure 4 (page 5) shows the 85 fatal accidents by accident category.

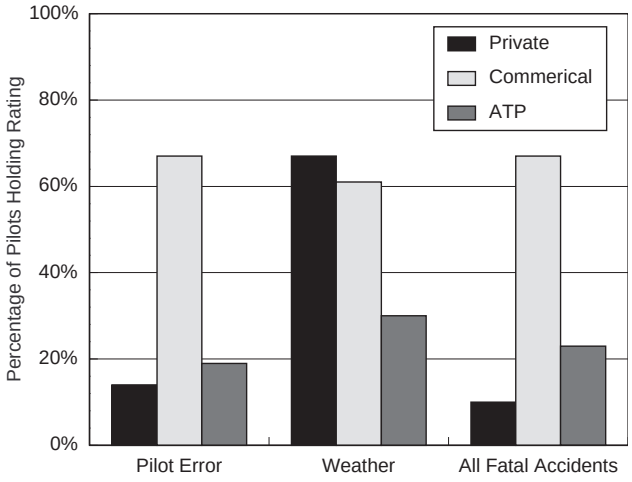
U.S. Turbine Helicopters 1988–1992: Fatal-accident Categories



Source: Joel S. Harris/U.S. Federal Aviation Administration/
U.S. National Transportation Safety Board/Air Data Research

Figure 4

U.S. Turbine Helicopters 1988–1992: Ratings Held by Pilots of Fatal-accident Aircraft



Source: Joel S. Harris/U.S. Federal Aviation Administration/
U.S. National Transportation Safety Board/Air Data Research

Figure 5

Accident Aircraft Pilots' Flight Hours Ranged from Less Than 1,000 To More Than 10,000

Table 1 and Figure 5 show data for accidents that fell under the category of "Pilot-error" (including "pilot/maintenance"), and those that fell under the category of "Weather." These are shown in relationship to pilot ratings and flight hours.

Table 1 shows the percentage of pilots holding private, commercial and ATP certificates at the time of the accident. Because not all data entries showed pilot ratings, eleven are "Not Listed." Table 1 also shows the number of pilots with less than 1,000 hours total flight time and the number of pilots with more than 10,000 hours total flight time.

Table 2 shows the 62 pilot-error accidents by accident category. Weather is the single greatest helicopter hazard and is nearly twice as prevalent as obstacle strikes, the next leading cause among pilot-error helicopter accidents.

Table 1
U.S. Turbine Helicopters 1988–1992: Pilot-error and Weather Accidents

Certificate/Hours	Pilot-error	Weather	All Fatal Accidents
Private	8 (14%)	2 (9%)	8 (10%)
Commercial	39 (67%)	14 (61%)	53 (67%)
ATP	11 (19%)	7 (30%)	18 (23%)
Not listed	4	1	6
Total	**62**	**24**	**85**
Less than 1,000 Flight Hours	7	3	7
More than 10,000 Flight Hours	10	4	15
Average Flight Hours	5,897	5,456	6,192

Source: Joel S. Harris/U.S. Federal Aviation Administration/
U.S. National Transportation Safety Board/Air Data Research

Table 2
U.S. Turbine Helicopters 1988–1992: Pilot-error Accidents by Accident Category

Category	Accidents
Weather	21
Obstacle Strike	11
Control Loss	10
Mechanical Failure	6
Midair	6
Other	8
Total	**62**

Source: Joel S. Harris/U.S. Federal Aviation Administration/
U.S. National Transportation Safety Board/Air Data Research

Most Accidents Involved Single-pilot Aircraft

Of the 85 fatal turbine-helicopter accidents, it was also found that:

- Sixteen (18.9 percent) of the accidents involved twin-engine helicopters. The remainder were single-engine helicopters;
- From 1990 to 1992, 18.6 percent of U.S. turbine-helicopter flight hours were by twin-engine aircraft;[1]
- Five accidents occurred while two qualified flight crew members were operating the helicopter. Eighty accident helicopters were operated by a single pilot;
- The highest flight time for any pilot involved in an accident was 17,000 hours. This was a pilot-error accident involving a long-line operation;
- The lowest flight time of any pilot involved in an accident was 77 hours. This was a pilot-error accident involving loss of tail-rotor effectiveness;
- Only two accidents were related to alcohol and none were related to illegal drugs. Both involved private pilots, not subject to the federally mandated random drug and alcohol testing program currently imposed on pilots employed by commercial operators; and,
- Twenty-four accidents involved VFR operations in IMC.

References

1. Data obtained from the Helicopter Association International (HAI) electronic bulletin board, 1994, with the assistance of David Carter, HAI director of safety.
2. U.S. National Transportation Safety Board (NTSB). *Commercial Emergency Medical Service Helicopter Operations — Safety Study.* Report No. NTSB/SS-88/01. January 1988.

About the Author

Joel S. Harris holds an airline transport pilot certificate and a flight instructor certificate with ratings in both helicopters and airplanes. He is an instructor, supervisor and courseware developer at FlightSafety International's West Palm Beach Learning Center in Florida, U.S. He has given more than 10,000 hours of flight, simulator and ground school training to professional helicopter pilots. Harris is the author of numerous articles about helicopter flight.

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