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Engine-power Loss Was Most Frequent Category of U.S. Agricultural-helicopter Accidents, 1989–1995

Fuel exhaustion and mechanical malfunction together accounted for the majority of agricultural-helicopter engine power–loss accidents. Other significant accident categories included obstacle strikes, malfunction other than loss of power and loss of control.

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According to the U.S. Federal Aviation Administration (FAA) Statistical Branch, 516 helicopters were serving primarily in aerial application of agricultural chemicals in 1994 (the latest statistics available). The FAA estimated that those aircraft flew a total of 150,362 hours during that year. Table 1 (page 2) shows the 1993 and 1994 accident rates for agricultural helicopters, all agricultural aircraft, and general aviation, including fixed- and rotary-wing aircraft.[1,2]

In April 1997, the FAA issued a report, *Analysis of Agricultural Aircraft Safety*.[3] The study examined accidents for the seven-year period from 1989 through 1995 that involved aircraft operating under U.S. Federal Aviation Regulations (FARs) Part 137, *Agricultural Aircraft Operations*. Although the report was comprehensive, it did not categorize agricultural helicopter accidents by their causes, circumstances or the resulting injuries or fatalities.

To analyze helicopter agricultural accidents in greater detail for the study described in this article, the author obtained an appropriate section of the FAA Accident/Incident Database System (A/IDS),[2] which stores general aviation accident reports. Accidents in the study database were reported by the U.S. National Transportation Safety Board (NTSB) field offices. Accident reports were reviewed by FAA technical specialists to assign a general cause, a field that can contain any one of 10 possible entries, such as "PILOT" (that is, pilot-induced), "PILTM" (pilot and maintenance) or "IMPRM" (improper maintenance). The FAA-assigned general cause is not necessarily the same as the NTSB's determination of the "probable cause." There are more than 200 other fields in the A/IDS, including time of day, weather and pilot age.

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The A/IDS is an easily searchable tool for compiling statistics, but lacks the lengthy narratives found in the NTSB reports. Therefore, for additional details about specific accidents, the NTSB factual reports were also reviewed.

According to the FAA database, helicopters operating under Part 137 experienced 178 accidents during the seven years from 1989 through 1995. (This number was roughly consistent with NTSB records, which indicated 184 accidents.) Of the accident helicopters, 157 (88 percent) were single-engine, piston-powered aircraft. The remaining 21 were turboshaft-powered, and three of those were twin-engine.

The 178 agricultural accidents resulted in 15 fatalities and 74 injuries. Fifty-five of the accident helicopters (31 percent) were demolished, and 123 (69 percent) received substantial damage.

Table 1
Selected Agricultural-helicopter Accident Categories Compared With General Aviation

	Year 1993	Year 1994
Agricultural-helicopter Flight Hours (x 1,000)	111	150
Agricultural-helicopter Accidents (number)	25	24
Agricultural-helicopter Accident Rate (per 100,000 flight hours)	22.5	16.0
Overall Agricultural-aircraft Accident Rate (per 100,000 flight hours)	12.4	12.6
General Aviation Accident Rate (per 100,000 flight hours)	9	9.1

Source: U.S. Federal Aviation Administration

Time of day. One hundred sixty-eight of the accidents (94 percent) occurred during daylight, and seven occurred at dusk or dawn. Three of the accidents occurred at night.

Weather. Weather was considered a factor in only seven accidents (4 percent). Among those, wind was cited as a factor in four accidents, turbulence in one, fog in one and light rain in one.

Pilot age. The age distribution of pilots involved in the accidents was not considered to be a significant factor.

General cause. Figure 1 shows the distribution of "general cause" categories in agricultural-helicopter accidents according to the A/IDS. Of 178 accidents, 114 (64 percent) cited the pilot or the pilot and maintenance in the general cause category of the accident. This is consistent with NTSB accident reports for other categories of aviation, wherein the pilot is typically cited as contributing to 70 percent to 80 percent of accidents.

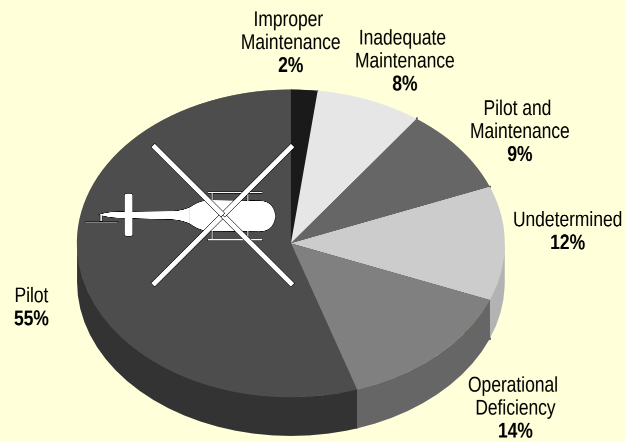
An example of an accident in which the pilot was cited as the general cause of the accident occurred in November 1992, in Palm Beach County, Florida, U.S. The NTSB reported that the pilot of the Bell 47G "stated that he had completed his spraying and had landed, when a grove worker requested a ride over the grove. While [the pilot was] maneuvering [the helicopter] at [46 meters (150 feet)], the engine lost power. During the autorotation, the rotor RPM [revolutions per minute] decayed and the helicopter landed hard." The helicopter was substantially damaged and there were two minor injuries.[4] The A/IDS listed the pilot as the general cause. The NTSB report more specifically said that the probable cause of the accident was "the pilot's inadequate preflight planning," and added that a contributing factor was "the pilot's failure to maintain rotor RPM during the autorotation."

In some instances, the FAA and the NTSB differed on the cause of an accident. For example, in August 1990, the pilot landed a Bell OH13M7 to reload the helicopter with chemicals for another agricultural spraying flight. According to the pilot, shortly after the helicopter's departure from the loading site, a loud sound from the engine was followed by vibration and a sudden loss of power. The pilot then, the NTSB report said, "immediately executed an autorotation to an open area but misjudged the flare altitude and experienced a hard landing," which caused substantial damage to the helicopter but resulted in no injuries.

The postaccident investigation revealed the failure of the right magneto contact points. The NTSB said that the probable cause of the accident was that "the pilot misjudged the altitude during the flare/touchdown phase of the autorotation," and said that "factors relating to this accident [include the] failure of the right magneto."[5] The A/IDS, however, listed as the general cause of the accident an "operational deficiency other than the pilot."

Apparently, the NTSB does not always consider failure to execute a successful autorotation after an engine failure a reason to classify the pilot as the probable cause of an accident. For example, in May 1992, the pilot's Hiller UH-12E near Milford, Iowa, U.S., experienced a complete loss of engine power while spraying agricultural chemicals. According to the NTSB factual report, "The failure occurred as [the pilot] was turning to reverse direction between swath runs. The pilot stated [that] he returned to level flight and entered autorotation. He stated [that] his main-rotor RPM was low when he applied collective pitch to cushion the landing and the helicopter landed hard."

FAA A/IDS General Cause Category Distribution, Agricultural-helicopter Accidents, 1989–1995



FAA A/IDS = U.S. Federal Aviation Administration Accident/Incident Database System

Source: U.S. Federal Aviation Administration

Figure 1

The report said that the skids collapsed, the helicopter rolled onto its right side and suffered substantial damage, and that the pilot was uninjured. Investigators could find no mechanical defects after the accident when the engine was examined. The NTSB assigned the probable cause of that accident to "a total loss of engine power for an undetermined reason as the helicopter was performing aerial application maneuvers."[6]

The A/IDS listed "operational deficiency" as the second most prevalent general cause of agricultural helicopter accidents during the period of the study. Twenty-five accidents (14 percent) included operational deficiency in the general cause category. Operational-deficiency accidents usually involved mechanical failure that was not the result of improper or inadequate maintenance, aircraft design, manufacture or pilot error.

An example of an operational-deficiency accident occurred in July 1995, near Hammonton, New Jersey, U.S. The A/IDS said that the Bell 47G3B1 "crashed into trees on forced landing. Collective pitch-control bearing failed [because of] being worn out. No required inspection." In that accident, the pilot was killed and the aircraft was demolished.

The NTSB report described the accident: "At the end of an aerial application mission, the helicopter was refueled, and the pilot departed for home base. A few minutes after takeoff, the helicopter collided with trees. Examination of the engine and drive train revealed no preimpact failure; however, the collective pitch-control yoke bearing had failed. The ball bearings and race in the yoke bearing were observed to be pitted, and the ball bearings were worn [so that they were] undersized.

"The last inspection of the yoke bearing occurred about nine years and 839 flight hours before the accident, during the 1,200-hour inspection. The yoke bearing was not required to be inspected during the recent 600-hour inspection. The bearing was an on-condition item, and did not have a scheduled time change. The bearing could not be inspected while installed on the helicopter." The NTSB found the probable cause of the accident to be "failure of the collective yoke bearing, which resulted in an uncontrolled descent and collision with trees."[7]

Maintenance. Maintenance played a part in nearly one out of five accidents studied. In the A/IDS, 34 (19 percent) of the accidents had "inadequate" or "improper" maintenance, or "pilot and maintenance," listed as the general cause.

An example of an accident in which the A/IDS cites improper maintenance as a cause occurred in April 1994, near Yuma, Arizona, U.S. The pilot in that accident said that after he completed a swath run and was pulling up to clear a line of trees, the engine decelerated to idle.

The pilot entered an autorotation and landed hard, substantially damaging the aircraft. According to the NTSB accident report, postaccident inspection of the engine revealed that "the throttle arm had come off the carburetor-throttle body shaft." The operator said that the arm and shaft were new components, installed in February 1994 by a contract mechanic. The operator also stated that an "excessive amount (about [five centimeters (two inches)]) of safety wire was on the arm, which allowed the arm to slip off the shaft," the accident report said.[8]

Inadequate maintenance was listed in the A/IDS general cause category for an accident that occurred in June 1995, near Zillah, Washington, U.S. The NTSB narrative described the accident: "The pilot was maneuvering the helicopter about [15 meters (50 feet)] AGL [above ground level] when he suddenly lost lateral cyclic control. The helicopter began to roll to the left despite the pilot's efforts at correction. The main rotor blades contacted trees and the helicopter cartwheeled into the ground. Examination revealed that a portion of the left cyclic control rod had failed. Further metallurgical examination showed that the failure was caused by severe corrosion. An examination of the maintenance records revealed that the helicopter had not received an annual inspection in [more than] two years."[9]

Pilot and maintenance. In 16 accidents (9 percent), the A/IDS listed the general cause as both the pilot and maintenance. An example occurred in June 1993, near Phlox, Wisconsin, U.S. The NTSB narrative described what happened: "The pilot departed from the road adjacent to the potato field he had been spraying and [he] was going to reposition for another spraying run. While the helicopter was making a right turn, it rolled to the right and crashed into the brush and trees south of the river.

"The pilot's son stated there was no indication of a mechanical problem prior to the accident. No anomalies were discovered during engine teardown. However, the cyclic stick controls for the right seat, the seat the pilot was flying from, were different than those for the left seat. The right stick was significantly [farther] back and to the left than the left controls. In fact, the son said to a witness that 'to fly the helicopter level, he (the pilot) had to have the cyclic almost full left.'"[10]

For this study, the 178 accidents were classified by the author into six more-specific categories (Figure 2, page 4): loss of engine power; malfunction other than loss of engine power; loss of control; obstacle strike; accident on the ground; and unknown.

Engine-power loss. The largest accident category involved engine-power loss, which resulted in 58 accidents (33 percent). Accidents in this category resulted in no fatalities, 27 injuries, 10 demolished aircraft and 48 substantially damaged aircraft. These accidents were further subdivided according to the cause of the power loss (Figure 3, page 4).

Fuel exhaustion. Fuel exhaustion resulted in 18 engine power–loss accidents (31 percent of the subcategory of engine power–loss accidents). The average flight time of a pilot involved in an accident resulting from fuel exhaustion was 9,663 hours. The

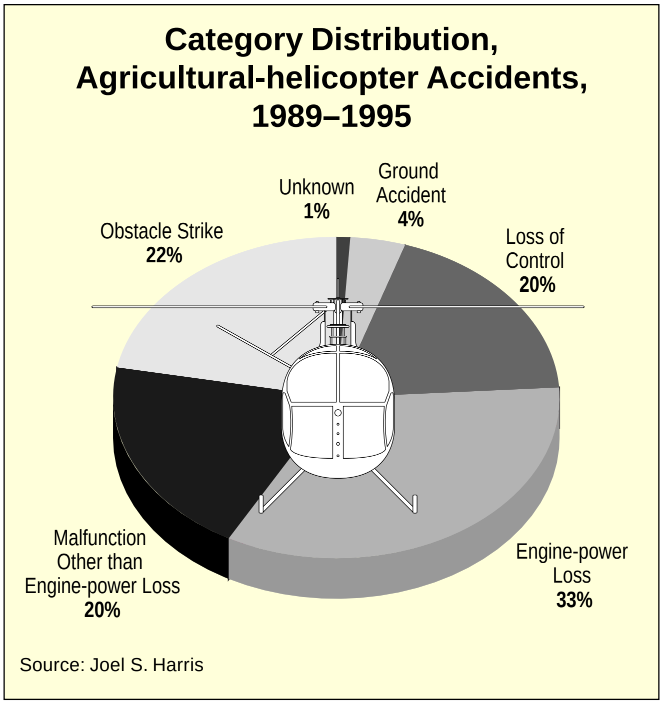


Figure 2

high and low flight times were 21,083 hours and 2,100 hours respectively. Two of the pilots had airline transport pilot (ATP) ratings, with the remainder holding commercial certificates.

Fuel-exhaustion accidents resulted in eight injuries, one aircraft demolished and 17 aircraft substantially damaged. In eight of the accidents, the pilot was returning to base when the helicopter exhausted its fuel supply. In one accident, an 11,000-hour ATP was injured and his aircraft received substantial damage when the helicopter's fuel was exhausted while surveying a "dusting site." According to the database, he was "too low and too slow" for a successful autorotation.[11]

Engine mechanical failure. Failure of some component of the engine resulted in 18 accidents (31 percent of the subcategory). In some accidents, those failures were the result of inadequate or improper maintenance, and in some accidents they resulted from an operational deficiency.

Fuel contamination. Fuel contamination resulted in six accidents (10 percent of the subcategory), demolishing one aircraft and substantially damaging five. Among these, water, dirt or other debris was found in the fuel. In one accident, gasoline was found to be contaminated with diesel fuel.

Miscellaneous. Four accidents (7 percent of the subcategory) resulted from miscellaneous causes. These included carburetor ice, intake fouling and compressor stall.

Undetermined cause. The causes of 12 engine power–loss accidents (21 percent of the subcategory) could not be determined. In several of these accidents, the pilot's report of a loss of power could not be substantiated after the accident.

For example, the pilot of a Hughes 269A1 was injured when his helicopter impacted terrain while spraying Christmas trees with herbicide. The pilot reported a partial power loss and resulting rotor-speed decay. Postaccident investigation revealed no mechanical or other irregularities with the aircraft, which was substantially damaged.[12]

Malfunction other than engine-power loss. Thirty-six of the 178 accidents (20 percent) involved the failure of components including the main rotor, transmission, tail rotor and flight controls. Some were the result of inadequate or improper maintenance, and others were categorized as resulting from operational deficiencies.

An example occurred in May 1989, near Keystone Heights, Florida, U.S. A helicopter pilot with a commercial rating and 11,800 hours of flight time lost tail-rotor control after departing on a spraying operation. According to the NTSB, "the aircraft yawed to the right and when left-pedal application would not correct the yaw, he performed an autorotative landing, subsequently pulling the collective to cushion [the helicopter's] impact with trees." The A/IDS said that the pilot "autorotated safely" after the "tail-rotor shaft became uncoupled." The pilot was only slightly injured and the Bell 47G3B1 received substantial damage.[13]

Obstacle strike. The accident category resulting in the most casualties was obstacle strike. There were 39 obstacle strikes (22 percent), including in-flight collisions with wires (27 strikes), trees (5), poles (3), a levee, a wind machine, an irrigation-field stand pipe and an unknown object. Twenty helicopters were demolished and 19 were substantially damaged, resulting in eight fatalities and 15 injuries.

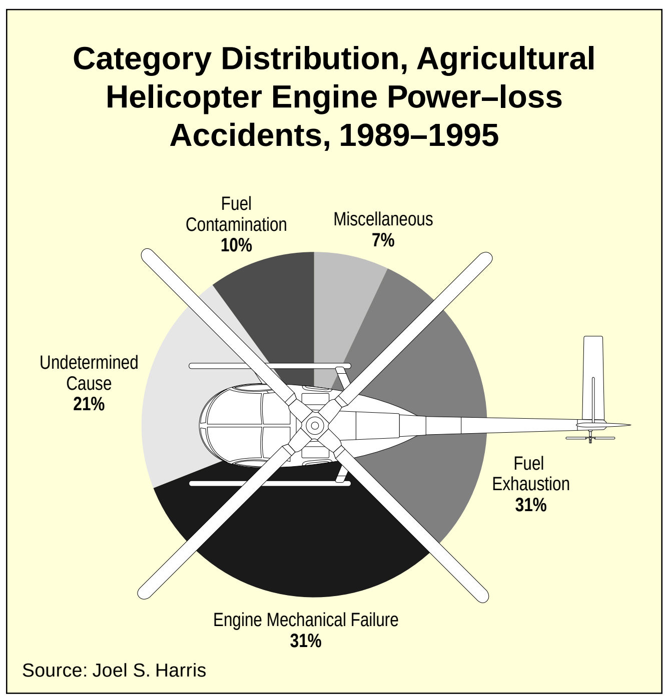


Figure 3

Obstacle strikes often occur when pilots are flying in unfamiliar areas, but not always. A 54-year-old commercial pilot was killed when the Bell 47 he was flying struck a powerline and impacted terrain while entering a field to be sprayed. The owner of the field said that the pilot "should have known where the wires were [because] he had been spraying that same field for 20 years."[14]

Loss of control. Loss of control resulted in 36 accidents (20 percent), all of which occurred during daylight hours. In 29 of these (81 percent of the category), the pilot was cited as the cause. Weather (wind) was a factor in three loss-of-control accidents. Loss of control resulted in five fatalities, 13 injuries and 11 demolished and 25 substantially damaged helicopters.

These accidents occurred during landing, takeoff and aerial application. Some events were aerodynamic — for example, settling with power, loss of lift turning downwind and operating beyond gross-weight limits. But most involved either losing rotor RPM and then losing control, or striking the ground during a low-level application run.

At least one accident was the result of the pilot's accidental exposure to chemicals. In August 1989, near Norman Park, Georgia, U.S., a 30-year-old commercial pilot with 1,607 hours of flight time had been making flights all day, applying the agricultural chemicals Lannate, an insecticide, and Bravo, a fungicide. When the helicopter did not return from a spray run, a search was initiated. According to the NTSB, "No preimpact mechanical malfunction or failure was found … . A toxicology check of the pilot's blood revealed the presence of Lannate … ." The probable cause of that accident, the report said, was "improper planning/decision by the pilot, which resulted in his physical impairment from exposure to Lannate, and his failure to maintain altitude/clearance above the ground. A factor related to the accident was failure of the pilot to use a respirator while handling or being exposed to Lannate." The pilot was killed and the aircraft was demolished.[15]

Accidents on the ground. Seven accidents occurred while the helicopter was on the ground. They resulted in no fatalities, two injuries, two demolished helicopters and five substantially damaged helicopters. All occurred during daylight hours and all were caused by pilot error. A few quotations from the "remarks" field of the A/IDS indicate the nature of accidents in this category:

- "On ground with rotors idling while chemical was loading. Leaned forward. Hit cyclic. Main rotors hit chemical truck."
- "Failed to unfasten a strap holding a skid on trailer. Helicopter fell over on its side during attempted liftoff."
- "Took off with chemical filler hose attached. Jerked helicopter out of control. Collapsed skid. Chopped tailboom."
- "During fueling helicopter. Walked away. Failed to remove hose. Then tried take off, hose attached. Hit parked pickup."♦

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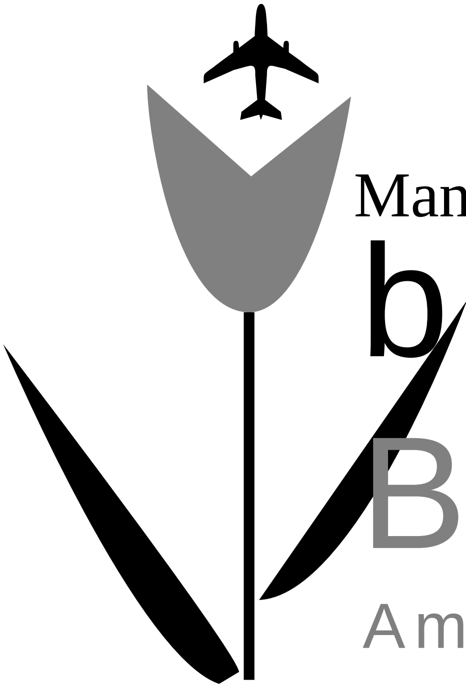

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