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Analysis of Sikorsky S-76 Helicopter Data Shows Comparatively Low Accident Rate

A survey of several independent accident data bases suggests that the aircraft's twin-turbine design, rigorous training requirements and frequent two-pilot crewing have contributed to its overall safety record.

by
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An analysis of accident and incident data between 1980 and 1993 involving the Sikorsky S-76 helicopter indicated that the twin-turbine S-76's design and training requirements likely have contributed significantly to its overall safety record.

During the period studied, the average U.S. accident rate for all helicopters was 10.95 per 100,000 flight hours. Turbine helicopters experienced an accident rate per 100,000 flight hours of 6.69, while the S-76 worldwide accident rate per 100,000 flight hours was 3.59.

The general aviation accident rate (including both fixed- and rotary-wing aircraft) was 9.11 per 100,000 flight hours. U.S. Federal Aviation Regulation (FAR) Part 135 air taxis (fixed- and rotary-wing aircraft) had an accident rate of 4.52 per 100,000 hours.

The fatal accident rates shown in Figure 1 are relative to the number of accidents that involved at least one fatality per 100,000 flight hours. With the exception of the S-76, all data in Figure 1 are for operations conducted in the United States; the S-76 data are for the worldwide fleet.

There may be several reasons why the S-76 accident rate appears low. The S-76 is an expensive aircraft and is one of the "top-of-the-line" helicopter models in the civilian fleet. Pilots who are hired to fly S-76s are typically very experienced with good safety records. Other factors might be that the S-76:

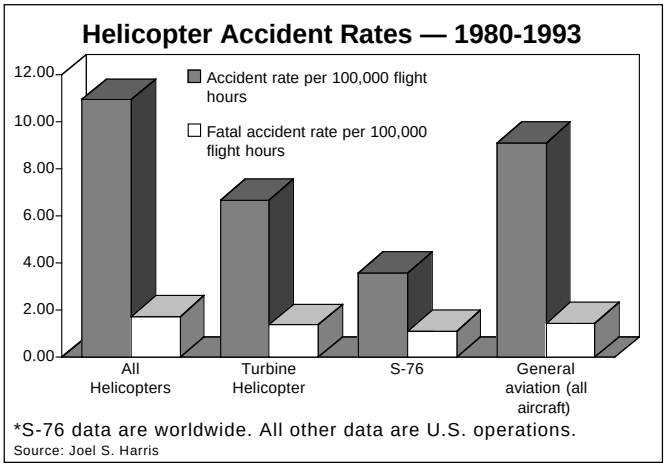

Figure 1

- Is equipped with twin-turbine engines (the accident rate for single-engine piston helicopters was 20.66 per 100,000 hours for the same period);
- Usually has a two-pilot crew;

- Requires significant training. In the United States, only the S-76, Bell 212/412 and the Bell 222 helicopters have full motion/visual simulators;

- Is less involved in some high-risk helicopter operations, such as primary training and agricultural work; and,

- Is less likely to be flown by inexperienced private pilots operating their own aircraft.

The four-bladed single-main-rotor S-76 was first manufactured in 1979. The helicopter is equipped with retractable landing gear and is designed to carry up to 13 passengers and a pilot. It is certified for day and night visual flight rules (VFR) operations and day and night instrument flight rules (IFR) operations. However, unless the S-76 is specially equipped, IFR operation requires two pilots.

There are four S-76 models. The "A" model is equipped with Allison C30 engines, the "B" model with Pratt & Whitney PT6B-36A engines and the "A+" and "C" models with Turbomecca Arriel engines. According to Sikorsky's worldwide fleet statistics, a total of 395 S-76s have been placed in service (Table 1).

Table 1
Number of Aircraft and Mission

Mission	S-76A/A+	S-76B	S-76C	Total
Corporate/ VIP	88	60	4	152
Offshore	139	6	6	151
EMS*	19	2	0	21
Other	55	5	11	71
Total	301	73	21	395

*Emergency medical services

Source: Sikorsky Aircraft

The number of aircraft is nearly evenly divided between corporate and offshore operations. As of November 1993, by far the largest number of flight hours (63 percent) was by offshore operators (Table 2).

Three data sources were used in the following study of S-76 accidents and incidents:

- Air Data Research's FAA (U.S. Federal Aviation Administration) Accident/Incident Database System. This is a data base of all U.S. aircraft accidents and incidents during the period 1972 to 1993. The data base also used information supplied by the U.S. National Transportation Safety Board (NTSB) and other sources.

- Sikorsky Aircraft "Class A" accident records. Sikorsky has records of S-76 Class A accidents from 1980 to the present. An S-76 Class A accident is any accident resulting in a fatality or damage greater than US$1 million. The Sikorsky records provided the source for non-U.S. accidents.

- Helicopter Association International (HAI) information based on NTSB data. The HAI 1972 to 1993 information is categorized into flight hours per year, accidents per year, fatalities per year, accidents per 100,000 hours and fatal accidents per 100,000 hours.

According to the NTSB, an aircraft accident is defined 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."[1] The operator of an aircraft is required to immediately notify the NTSB within 10 days after an aircraft accident occurs.

An incident is defined by the NTSB as an "occurrence other than an accident, associated with the operation of an aircraft, which affects or could affect the safety of operations." Many aircraft mishaps are classified as incidents when the extent of aircraft damage or personal injury does not meet the NTSB definition of an accident. Only certain types of incidents must be reported to the NTSB. These include:

- Flight control malfunctions;

- Inability of a required crew member to perform normal duties as a result of injury or illness;

- Certain failures of structural components of turbine engines;

- in-flight fires;

Table 2
Aircraft Fleet Hours 1980-November 1993

Model	Corporate/VIP	Offshore	EMS	Other	Total
S-76A/A+	236,450	987,833	126,602	138,591	1,489,476
S-76B	77,444	25,179	3,210	4,299	110,132
S-76C	1,150	10,272	0	5,481	16,903
Total	315,044	1,023,284	129,812	148,371	1,616,511

Source: Sikorsky Aircraft

- Midairs; and,

- Damage to property other than the aircraft estimated to exceed $25,000 for repair.

Those accidents and incidents reported to the NTSB and subsequently investigated by the FAA are included in Air Data Research's FAA Accident/Incident Database.

For the purpose of this study, accidents from Air Data Research's data have been combined with Sikorsky's Class A noncombat, non-U.S. accidents to arrive at a worldwide S-76 accident total. Since Sikorsky Class A records began in 1980, the study is limited to the period from 1980 through November 1993.

The 22 non-U.S. accidents defined by Sikorsky as Class A may represent a somewhat smaller number of accidents than would have been recorded under the NTSB's definition (Table 3). The difference in definitions may affect some of the data by a small percentage.

Table 3
S-76 Events — 1980-1993

	U.S.	Non-U.S.	Total
Accidents	30	22	52
Incidents	64	Unknown	64
[Fatal]	[4]	[12]	[16]
[Injury]	[15]	[Unknown]	[15]
All Events	94	22	116

Source: Joel S. Harris

The incidents included in the study are only those reported to the NTSB or the FAA. Additional incidents likely occurred and were not reported. Therefore, the number of incidents cannot be compared with the number of flight hours to reach an accurate "incidents per 100,000 hours."

The S-76 accident and incident data is compared with NTSB accident data supplied by HAI (Figure 1). These data represent the period 1980 through 1993, except for general aviation data, which were only available through 1992. HAI arrived at accident rates per 100,000 flight hours by determining a mean average for the years studied. The same method is used to calculate S-76 accident rates.

Table 3 shows that from 1980 through November 1993, there was a total of 116 S-76 events recorded. Of these, 30 were U.S. accidents and 22 were non-U.S. Class A accidents, for a total of 52 accidents during 1.6 million flight hours.

During the same period, there were 64 S-76 incidents recorded in the Air Data Research Accident/Incident Database System.

Four of the U.S. accidents and 12 of the non-U.S. accidents each resulted in at least one fatality. Fifteen injury accidents were recorded in the United States.

The 52 S-76 accidents are categorized by general cause in Figure 2.

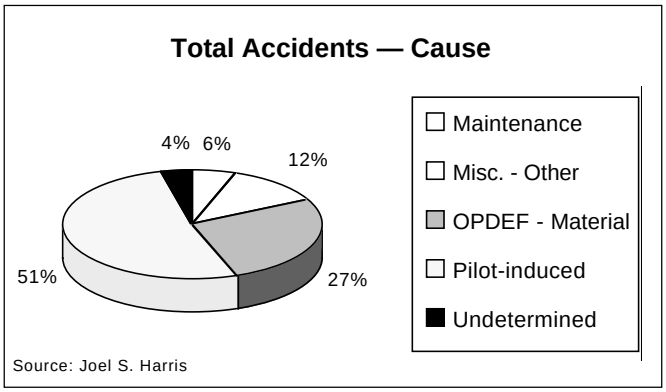

Figure 2

The Air Data Research FAA data base classifies aircraft accidents and incidents by general cause category. The 10 categories are:

- Design of aircraft;

- Manufacturer/builder;

- Improper maintenance;

- Inadequate maintenance;

- Pilot-induced;

- Pilot and ground crew;

- Pilot and maintenance;

- Operational deficiency other than pilot (OPDEF);

- Miscellaneous other than pilot; and,

- Undetermined.

There were no S-76 events in the data base attributed to "design of aircraft," "manufacture/builder," or "pilot and ground crew." For simplification, the one "pilot and maintenance" event has been classified as "pilot-induced." "Improper maintenance" and "inadequate maintenance" were combined into a single category of "maintenance."

Sikorsky assigns Class A accident causes to either material, pilot, maintenance, other, unknown or combat. Two combat losses were deleted as not relevant. The other categories were combined with the appropriate FAA categories.

Figure 2 shows that 51 percent (27 of 52) of S-76 accidents were attributed to pilot error, making it the largest single accident cause factor. When all events are considered, pilot error is a cause in 42 percent (49 of 116).

OPDEF accounts for an additional 45 percent (52 of 116). Worldwide statistics indicate that 70 percent to 80 percent of aircraft accidents involve human performance failure (pilot error) as a significant cause factor.

The S-76's lower accident rate may be attributable in part to its lower-than-average pilot error accident rate. Based on flight training experiences and other factors, other reasons might include:

- Nearly all S-76 crews are IFR current and rated;
- Many S-76 operators have well-developed in-house training programs;
- Standard operating procedures and checklist use are strongly encouraged in this complex aircraft; and,
- Many S-76 crews are simulator trained.

Pilot-induced accidents are followed by 14 accidents attributed to operational deficiency/material failure. The OPDEF-material category in Figure 2 is described in the FAA Database System literature as "an operational deficiency, other than the pilot."

Table 4 shows operational deficiencies by component and includes both accidents and incidents. Thirty of the 52 operational deficiencies involved one or more aircraft engines. Of these, 24 resulted in landings with one engine inoperative (OEI). Only one of the OEI events is classified as an accident. All engine-out events, except for one, involved the S-76 A model. One OEI event, classified as an incident and resulting in no damage, involved an S-76 B model. In that case, a single-engine landing was made after a faulty oil transmitter signaled a drop in oil pressure and the pilot elected to secure the engine.

Table 4
Operational Deficiencies by Components

OPDEF-Material	Accidents U.S./Non-U.S.		U.S. Incidents	Total Events
Engine	3	4	23	30
Main Rotor	1	2	3	6
Electrical	0	0	3	3
Control Problem	0	0	3	3
Tail Rotor	2	0	0	2
Rotor Brake	1	0	1	2
Door/Cowl Off	0	0	2	2
False Fire	0	0	2	2
Landing Gear	0	1	0	1
Transmission	0	0	1	1
Total	7	7	38	52
OEI (One Engine Inoperative)	1	0	23	24
Autorotation	2	1	1	4

Source: Joel S. Harris

Engine fires in conjunction with other engine malfunctions occurred a total of four times, while two false fire indications resulted in reported incidents.

A total of three accidents and three incidents involved operational deficiencies or material failure of the main rotor. Two non-U.S. accidents involving main-rotor spindle failure occurred in 1980 and 1981. These were the only main-rotor-related fatalities during the study period.

Autorotations were performed four times (Table 4). Fatalities resulted in two cases; one occurred in the United States and one outside the United States. In the other two nonfatal events, one resulted in minor damage and one in substantial damage. In the more serious event, which occurred in 1984, an exploding turbine disabled both engines and the float system. After a successful autorotation to the water, the aircraft rolled over and received substantial water damage. There were no fatalities and no injuries among the 12 passengers and crew.

Table 5 shows pilot-induced events listed in the order of frequency. Combining blade strikes with other ground events and rollovers produces a total of 23 of the 49 pilot-induced events occurring on or near the ground while taxiing on the wheels, hovering or static with blades turning.

Table 5
Pilot-induced Events

Pilot Error	Accidents U.S./Non-U.S.		U.S. Incidents	Total Events
Blade-strike	1	0	10	11
Weather-related	4	3	1	8
Other Ground Events	2	1	5	8
Landing Event	1	2	2	5
Rollover	4	0	0	4
Flew Into Water	1	3	0	4
Hit Wires, Trees on Takeoff	1	2	0	3
Mismanaged Controls	2	0	0	2
Window Came Off	0	0	1	1
Gear-up Landing	0	0	1	1
Fuel Starvation	0	0	1	1
Control Problem	0	0	1	1
Total	16	11	22	49

Source: Joel S. Harris

Seven weather-related accidents and one incident appeared in the data. Of the eight weather-related pilot-induced events, six involved attempting VFR flight in IFR conditions. Two

of these resulted in fatal accidents and four resulted in injury accidents.

Figure 3 shows the phase-of-flight category for all 116 events. While the largest percentage (46 events) occurred in cruise flight, a significant number (31) occurred on the ground. Ground events are defined as occurring prior to the beginning of a takeoff or after completing an approach. They may occur during hover, while taxiing or while static.

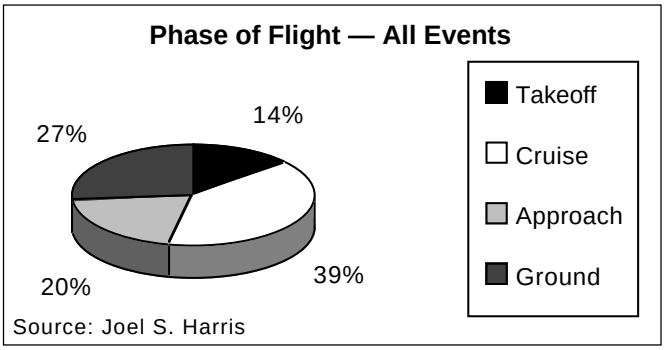

Figure 3

Ground events occurring from all causes are shown in Table 6. A total of 16 of the 31 ground events involved the main rotor striking an object. In two of these cases, the object was the tail section of the helicopter. In four other cases, the object was human. In one of the four rotor strikes on a human, three people were killed and three people were injured after the helicopter landed on a barge in strong winds and rough seas. The wind blew the helicopter on its side, causing the spinning rotor to strike de-planing passengers.

Table 6
Ground Events — All Causes

Ground Events — All Causes	Accidents U.S./Non-U.S.		U.S. Incidents	Total Events
Rotor-blade Strikes	4	3	9	16
Gear Damage	0	2	3	5
Rollovers	4	0	0	4
Other	1	0	2	3
Tail-rotor Malfunctions	0	0	2	2
Tail-rotor Strikes	1	0	0	1
Total	10	5	16	31
Rotor Hit Human	2	2	0	4

Source: Joel S. Harris

Dynamic rollover was a factor in four of the ground events. In all four of these events the helicopter was destroyed or substantially damaged, but without loss of life.

Table 7 shows the disposition of 16 fatal S-76 accidents. Eight of the accidents were the result of pilot error, five from operational deficiencies (material failure) and the remaining three were either "other" or "undetermined." Of the four U.S. fatal accidents, one was the result of a 1984 turbine burst. The other three included inadvertent flight into instrument meteorological conditions (IMC), uncontrolled altitude deviation while operating under IFR, and the barge landing in strong winds (described above).

Table 7
Fatal Accidents — All Causes

	U.S.	Non-U.S.	Total
Blade-strike	1	3	4
Weather-related	1	2	3
Flew into Water	0	3	3
Engine	1	1	2
Main Rotor	0	2	2
Hit Object on Takeoff	0	1	1
Undetermined	1	0	1
Total	4	12	16

Source: Joel S. Harris

The data suggest that the S-76 is a safe helicopter when operated by well-trained pilots. The low percentage of pilot-error accidents is an indication of pilot training and experience levels.

Nevertheless, there were 116 accidents and incidents. At 42 percent, pilot error remains the largest, and perhaps most preventable, cause of S-76 accidents and incidents.♦

References

1. U.S. National Transportation Safety Board. "Notification and Reporting of Aircraft Accidents or Incidents and Overdue Aircraft, and Preservation of Aircraft Wreckage, Mail, Cargo, and Records." Part 830.2 — Definitions.

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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