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Maneuver Cited in AS 350's Uncontrolled Descent

The U.S. National Transportation Safety Board said that the pilot on the Grand Canyon air tour apparently flew the helicopter over a cliff and then initiated a descent that he was unable to stop.

FSF Editorial Staff

About 1428 local time Aug. 10, 2001, a Eurocopter AS 350B2 helicopter being flown on an air tour of the Grand Canyon struck terrain near Meadview, Arizona, U.S., during an uncontrolled descent. The helicopter was destroyed. The pilot and five passengers were killed, and another passenger received serious injuries.

The U.S. National Transportation Safety Board (NTSB), in its final report, said that the probable cause of the accident was "the pilot's in-flight decision to maneuver the helicopter in a flight regime and in a high-density-altitude environment, in which the aircraft's performance capability was marginal, resulting in a high rate of descent from which recovery was not possible."

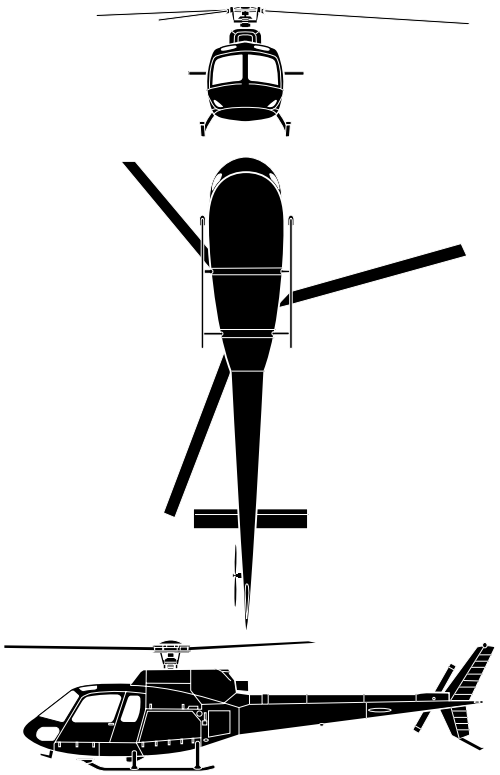
NTSB said that factors contributing to the accident were "high density altitude and the pilot's decision to maneuver the helicopter in proximity to precipitous terrain, which effectively limited any remedial options available."

The accident pilot held a commercial pilot certificate with ratings for helicopters and instrument-helicopter; he received a private pilot certificate with a rotorcraft-helicopter rating June 25, 1993, the commercial pilot certificate March 25, 1996, a flight instructor certificate June 11, 1997, and an instrument rating for helicopters July 29, 1999. He also held a second-class medical certificate, which had been issued July 3, 2001, with no limitations.

The pilot was hired by Papillon Airways on Sept. 14, 2000, and entered the Papillon training program for U.S. Federal Aviation Regulations (FARs) Part 135 operations. He completed initial ground training Sept. 16, 2000; ground training for the special federal aviation regulation (SFAR) Green Route 4[1] on Sept. 22, 2001, and flight training for the SFAR Green Route 4 on Sept. 26, 2000; recurrent ground training Feb. 20, 2001; and line checks and competency checks Feb. 21, 2001.

Company records showed that the pilot had 2,794 flight hours, all in helicopters, including 699 flight hours in AS 350s. He had flown 224 flight hours during the 90 days before the accident and 86 flight hours during the 30 days before the accident. The pilot's colleagues and supervisors said that they considered him one of their "very best" pilots.

The investigation found nothing unusual about the accident pilot's appearance, conduct or performance during the 72 hours before the accident.



Eurocopter AS 350B2

The Eurocopter (formerly Aerospatiale) AS 350B2 is a light utility helicopter with a Turbomeca Arriel 1D1 turboshaft engine and a main rotor of three fiberglass blades that rotate clockwise as viewed from above. A two-blade tail rotor is located on the right side of the tail boom.

The accident helicopter was configured for air tour operations, with a two-place bench seat in place of the copilot's seat and two two-place bench seats aft. In addition, the left cyclic, collective and anti-torque pedals had been removed.

Deliveries of the AS 350B began in March 1978, soon after certification in the United States of the AS 350C, which was powered by a Textron Lycoming (now Honeywell) LTS-101 turboshaft engine and marketed only in North America.

The AS 350B2 has a more powerful 732-shaft-horsepower (546-kilowatt) engine, uprated transmission and wide-chord main-rotor blades and tail-rotor blades that originally were designed for the twin-engine AS 355.

The helicopter's maximum normal takeoff weight is 4,960 pounds (2,250 kilograms), or 5,511 pounds (2,500 kilograms) with a maximum sling load. Maximum rate of climb at sea level is 1,990 feet per minute. The AS 350B2 has a maximum cruise speed at sea level of 133 knots and a service ceiling of 18,375 feet. Hovering ceiling in ground effect is 13,300 feet; hovering ceiling out of ground effect is 11,200 feet. With maximum fuel (143 U.S. gallons [540 liters]) at sea level, the helicopter has a range of 370 nautical miles (686 kilometers).♦

Source: *Jane's All the World's Aircraft*

Hard Landing Damaged Helicopter in 2000

The accident helicopter, which had 1,356 flight hours and 1,679 flight cycles, was manufactured in 1991 and delivered to a private owner in Japan, where the airframe and the Turbomeca Arriel 1D1 engine accumulated 1,307 flight hours before the helicopter received structural damage during a hard landing and ground-resonance event[2] Sept. 16, 2000. Afterward, the helicopter "was deemed to be not economically repairable," the report said. The helicopter was sold, in a non-airworthy status, to Heliquip International of New Zealand; accident investigators found no export airworthiness certificate, and authorities later determined that the Japan Civil Aviation Authority had not issued one.

The helicopter was registered in New Zealand on March 4, 2001, and the New Zealand Civil Aviation Authority issued a certificate of airworthiness and an export airworthiness certificate on April 17, 2001. Papillon Airways purchased the helicopter from Heliquip on April 4, 2001; the helicopter was delivered in a crate to Papillon's facilities in Arizona on June 20, 2001.

The helicopter's New Zealand maintenance records contained an entry that said that a maintenance C check had been performed "following Japanese report of a ground-resonance problem" and had been completed April 4, 2001. Related entries said that the work was performed in accordance with New Zealand Civil Aviation Regulations; the final two entries, both dated April 17, 2001, noted the issuance of a New Zealand standard airworthiness certificate and a New Zealand export airworthiness certificate.

American Eurocopter and Turbomeca include information about hard-landing inspection items in maintenance manuals for the AS 350B2 helicopter and the Arriel 1D1 engine; Japanese maintenance records did not indicate that the hard-landing inspections were performed after the hard landing. The New Zealand maintenance records showed that all but three items — a tail-rotor drive-shaft alignment, a landing-gear inspection and a dye-penetrant inspection of the starter generator and fuel-control mounting flanges — were included among the tasks performed before issuance of the two airworthiness certificates.

After the helicopter was delivered to Papillon, the company's maintenance personnel performed "numerous maintenance inspections and modifications" in accordance with either a supplemental type certificate or other U.S. Federal Aviation Administration (FAA) provisions. An FAA airworthiness certificate was issued Aug. 2, 2001, and the helicopter was placed in service Aug. 3, 2001, at an aircraft time and engine time of 1,319 flight hours. The repairs performed before the helicopter was placed in service were not related to the accident, the report said. Six routine scheduled maintenance inspections were performed between Aug. 3 and Aug. 10; maintenance records showed no unresolved discrepancies. Maintenance

records showed compliance with all FAA airworthiness directives and all service bulletins.

Papillon Airways was founded in 1965 as Grand Canyon Helicopters and originally operated from the South Rim of the Grand Canyon. The company's name was changed to Papillon Grand Canyon Helicopters after the owner's purchase of Papillon Helicopters, based in Hawaii, U.S. In 1993, the owner founded the Tour Operators Program for Safety, an organization intended to promote safety among operators of air tour flights and to improve the public image of Grand Canyon helicopter tour operators. In 1995, the company's name was changed to Papillon Airways.

At the time of the accident, the company had bases at McCarran International Airport (LAS) in Las Vegas, Nevada, and Grand Canyon West Airport (GCW) in Peach Springs, Arizona, with 36 helicopters and 55 line pilots. Papillon Airways helicopters flew more than 250,000 passengers per year and, during the tourist season, as many as 250 departures per day. In addition to air tours, the company also held contracts with two government agencies and several utility companies.

Pilots Served as Tour Guides

Papillon did not employ tour guides for its flights, and the pilot's responsibilities included providing tour narration and comments. (Passengers who did not speak English were given recorded audiotapes for the tour.)

The company prohibited its pilots from soliciting gratuities from passengers, but passengers voluntarily paid gratuities in sums that were "usually proportional to the quality of the entertainment," the report said. "Gratuities provided significant additional income for the pilots."

Several passengers who had flown with the pilot on tour flights about one month before the accident said that after the tour began, "the pilot was talking all the time, and they felt he knew his history and geography very well," the report said.

One passenger told investigators, "About 20 minutes into the flight, the pilot turned his head toward the back and was talking to the passengers as the helicopter flew toward a cliff. The people in the back [of the helicopter] were trying to get the pilot's attention and point out that he was flying toward a cliff, but he pretended he did not understand what they were saying, as if this was all being done on purpose. All this time, the pilot was turned around and talking to the passengers in the back seat, while the passengers were all pointing up trying to get him to climb. One witness said she finally picked up the microphone and said, 'They are really scared. … Turn around and pull up the helicopter,' and he did."

The passenger could not estimate how far the helicopter was from the cliff when the pilot pulled up.

The passenger told investigators that some "particularly exciting episodes" during the tour frightened some of the other passengers. For example, the pilot flew the helicopter over a site that had been used in filming a scene of the motion picture "Thelma and Louise" in which a car was driven off a cliff.

The passenger said that later, the pilot asked if the passengers "wanted to know what it was like to drive a car off of a cliff." The passenger said that "they all said 'no' to this question; however, [the pilot] proceeded to fly very fast toward the edge of the cliff and then dove the helicopter as it passed the edge."

A videotape supplied by the passenger showed the two episodes she had described; voices could not be heard because of noise from the engine and rotors. The report said that the videotape showed the helicopter approaching a "cliff-like terrain feature" from "about 50 [feet] to 100 feet below the top" and then clearing the top by 50 feet to 100 feet. Later, the videotape showed the helicopter being flown about 100 feet over the Grand Wash Cliffs plateau and entering a diving descent just after passing the edge of the cliff; the report said that the amount of nose-down pitch was 10 degrees or less and that the changes in engine noise and rotor noise "were consistent with a lowering of the collective and unloading of the rotor system during this maneuver."

Temperature at Accident Site Was Near 100 Degrees F

Weather at the airport in Kingman, Arizona — the closest official weather-observation station to the accident site, about 44 nautical miles (81 kilometers) south and at an elevation about 700 feet lower — 32 minutes before the accident included winds from 190 degrees at 10 knots, with gusts to 15 knots, visibility of 10 statute miles (16 kilometers), scattered clouds at 7,500 feet, a temperature of 36 degrees Celsius (C; 97 degrees Fahrenheit [F]) and an altimeter setting of 30.07 inches of mercury.

Eight minutes after the accident, Kingman weather included winds from 320 degrees at 12 knots, visibility of 10 statute miles, clear skies, a temperature of 34 degrees C (93 degrees F) and an altimeter setting of 30.05 inches of mercury. The peak wind — from 320 degrees at 28 knots — and a wind shift occurred at 1416.

Other Papillon pilots who landed their helicopters at the accident site minutes after the accident said that the temperature was about 41 degrees C (106 degrees F) and skies were clear; two pilots said that there was no turbulence, and a third pilot said that there was very light to moderate turbulence that "jostled" his helicopter but was "nothing to cause a problem," the report said.

The accident helicopter was not equipped with a cockpit voice recorder (CVR) or a flight data recorder (FDR); neither was required. Company maintenance personnel had planned

to install a maintenance-trend-monitoring system to sample engine parameters and store the information for retrieval by maintenance personnel, but the installation had not yet been performed.

Papillon helicopter tours that departed from LAS were flown in accordance with the following procedures: After departure, each helicopter toured Lake Mead and the Hoover Dam, about 30 nautical miles (56 kilometers) east of Las Vegas on the border between Nevada and Arizona, before proceeding over rugged, mountainous terrain toward Grand Canyon National Park. About 45 minutes after takeoff, each helicopter was landed at one of Papillon's two designated landing sites for a 30-minute picnic lunch; during this time, passengers had an opportunity to take photographs. If additional fuel was required for the return flight to LAS, the helicopters were flown — either before or after the 30-minute lunch stop — to GCW, where Papillon operated a fueling facility, and then back to LAS.

The accident helicopter was being flown along a route from east to west over a plateau formed by the Grand Wash Cliffs. The SFAR requires that, after passing the western face of the cliffs, where "the terrain drops off dramatically to barren desert floor 3,000 feet below," the aircraft must be flown from 5,500 feet above mean sea level (MSL) to 4,500 feet MSL to avoid opposite-direction traffic and to comply with hemispheric flight-altitude rules.

In interviews with accident investigators, Papillon pilots said that if they encountered an emergency during this portion of the tour flight, they would conduct an emergency autorotative landing on flat land west of the cliffs rather than at the accident site, which the report described as "the least advantageous location available."

Pilot Refused Request to 'Perform Stunts'

At 0843 the morning of the accident, the pilot reported for duty at LAS. He was scheduled to fly the accident helicopter on four tour flights — at 0945, 1230, 1515 and 1800. The 0945 flight was completed without incident.

Company procedures required that passengers be weighed and be given cards that indicated their seat assignments; Papillon used a computer program to assign passenger seats for optimum weight-and-balance control. Pilots were permitted to alter seat assignments only after re-computing the helicopter weight and balance; nevertheless, company pilots said that they rarely allowed passengers to change seats. Before boarding a bus for the ride to their helicopter, passengers also observed a safety video. After arriving at the helicopter, the pilot conducted a safety briefing and ensured that passengers were in their assigned seats. The report said that the surviving passenger, in an interview with accident investigators, "gave seating positions for the passengers that differed significantly from the manifest provided by Papillon."

The flight departed at 1245 as the third of six Papillon helicopters on the scheduled 1230 flight; five minutes elapsed between each departure. The accident helicopter was landed at Quartermaster Canyon for lunch, and at 1400, the pilot conducted a takeoff and flew the helicopter to the fueling facility at GCW. At 1420, the helicopter departed from the fueling facility for the return flight to LAS; visual meteorological conditions prevailed, and a visual flight rules flight plan had been filed.

The surviving passenger said that all six passengers wore headsets to listen to the pilot's commentary and his announcements. She said that during the flight, the pilot refused another passenger's request that he "perform stunts that he had seen another helicopter do"; she said that the pilot "said no, because he had seen too many accidents and he wasn't ready to die."

She said that she did not hear bells, horns or any verbal warning from the pilot before the accident and that she did not overhear any radio transmission in which the word "mayday" was spoken.

"The passenger stated that she remembered being 'up in the air' and that she had 'traveled quite some time' when everything 'went quiet, the blades stopped turning, and we fell,'" the report said. "She did not remember seeing the pilot move any switches or buttons before the accident."

Pilots of other Papillon helicopters in the area said that they did not recall hearing any radio transmissions from the accident pilot after his departure from GCW. The report said that, during the return to LAS, one Papillon pilot observed the accident helicopter "about two [minutes] to three minutes in front" of him at about 5,500 feet MSL near the Grand Wash Cliffs, which were used by the pilots as a navigational landmark. The pilot did not recall hearing the accident pilot make the radio-frequency change required by company procedures before crossing the Grand Wash Cliffs.

One pilot said that as he flew his helicopter past the Grand Wash Cliffs, he saw black smoke to his left and confirmed that the smoke was rising from the wreckage of a Papillon helicopter. He notified the company, requested emergency medical services and landed nearby to aid the surviving passenger.

Radar Coverage in Accident Area Was Limited

The remote area in which the accident site is located had limited radar coverage. A review of radar data showed two secondary radar targets (in which the aircraft's position, altitude and transponder beacon code appear on an air traffic controller's radar screen) that could be associated with the

accident helicopter and no primary radar targets (in which only a radar return from the aircraft is visible on a radar screen). The first secondary target, at 1428:05, showed an aircraft at 5,400 feet MSL above or just west of the edge of a cliff; the next secondary target, at 1428:17, showed an aircraft at a reported altitude of 4,500 feet MSL and at a horizontal distance of about 1,100 feet from the accident site. Other pilots in the area said that immediately after the accident, other helicopters were flown to the site; the report said that the radar data review showed that between 1429 and 1432, "numerous other secondary targets appear over and around the accident location."

The accident site was at 4,041 feet MSL on a hillside about five nautical miles (nine kilometers) east of Meadview, with the main wreckage about 0.25 nautical mile (0.46 kilometer) west of and 1,800 feet (549 meters) below the rim of the Grand Wash Cliffs. The terrain sloped upward at about 40 degrees. The hazardous nature of the topography "makes it improbable that the pilot intentionally selected the accident site as a landing spot in response to any emergency," the report said.

At impact, both the engine and the rotor system were developing "a significant amount of power," the collective pitch control was in the maximum pitch position and the anti-torque pedals were full right — "consistent with a high-power demand from the pilot and a high-power output from the engine to the rotor system."

Scars on the ground at the initial impact point showed that the helicopter was not rotating or spinning — another indication that the pilot had positive directional control. The tail rotor and yaw-control system also was fully functional, the report said. The investigation revealed that the engine was operating normally at the time of impact, that there was no condition that would have prevented normal operation of the fuel control and that there was no hydraulic system anomaly. The helicopter's weight (estimated at the time of the accident at 4,515 pounds [2,048 kilograms]) and balance were both within acceptable limits.

An evaluation of the helicopter's performance capabilities — considering its weight and the high density altitude conditions that prevailed along the flight route — showed that the helicopter would have been "marginally capable" of hovering out of ground effect at the top of the cliff and at the altitude of the accident site.

"The available power margin at the accident site altitude translates into a helicopter vertical-climb capability from a hover of only 421 feet per minute at best," the report said. "If the helicopter were descending vertically (or nearly so) at a greater rate, the pilot could not arrest the descent."

In addition, the report said, "Use of the right anti-torque pedal utilizes drive-train power that would otherwise be available for hover or vertical-climb capability. Full-right pedal input consumes almost 20 percent of the available drive-train power and would significantly affect the power-available margin to the main-rotor system."

One scenario that would be consistent with the investigation's findings is that of "settling with power" (vortex ring state) — a condition characterized by "unstable, chaotic and disorganized rotational airflow around and through the main rotor, which results in a net decrease in the thrust produced by the main rotor." In this condition, if the pilot uses collective pitch in an attempt to slow the rate of descent, the result is the opposite — an increase in the rotational airflow around the rotor disc and a consequent increase in the descent rate.

This scenario, however, "assumes that the pilot elected to execute a descending 180-degree turn with an abrupt slowing of forward speed back toward the cliff after crossing the face of the Grand Wash Cliffs," the report said. "In the absence of a survivor providing an explanation or any flight recorder data, the investigation could not determine why the pilot would have initiated such a maneuver; therefore, a determination of a settling-with-power event cannot be made."

NTSB Recommends Requiring Image-recording Systems

The report said that the accident investigation was hindered by the "almost complete destruction of the helicopter" and that investigators would have benefited if the helicopter had been equipped with an FDR and/or a CVR. FARs require FDRs and CVRs on larger passenger aircraft but not on smaller aircraft — specifically single-pilot certificated turbine-powered aircraft and dual-certificated cargo/passenger aircraft.

The report said that NTSB "recognizes the economic impact of requiring both a CVR and an FDR on smaller aircraft and consequently proposes that all smaller turbine-powered aircraft be equipped with a single crash-protected recorder: the video image recorder. Such recorders obtain not only audio information like that from CVRs and event data like that from FDRs but also information about the environment outside the cockpit window."

As a result of the accident investigation, NTSB sent a safety recommendation letter to FAA on Dec. 22, 2003, containing the following recommendations:

- "Require the installation of a crash-protected image-recording system on all turbine-powered, nonexperimental, nonrestricted-category aircraft manufactured after January 1, 2007, operating under [FARs] Parts 91, 135 and 121;
- "Amend the current regulations for [FARs] Parts 91, 135 and 121 operations to require all turbine-powered,

nonexperimental, nonrestricted-category aircraft that have the capability of seating six or more passengers to be equipped with an approved two-hour [CVR] that is operated continuously from the start of the use of the checklist (before starting engines for the purpose of flight) to completion of the final checklist at the termination of the flight;

- "Require all turbine-powered, nonexperimental, nonrestricted-category aircraft that are manufactured prior to January 1, 2007, that are not equipped with a [CVR], and that are operating under [FARs] Parts 91, 135 and 121 to be retrofitted with a crash-protected image-recording system by January 1, 2007; [and,]

- "Require all turbine-powered, nonexperimental, nonrestricted-category aircraft that are equipped with a [CVR] that are manufactured prior to January 1, 2007, and that are operating under [FARs] Parts 91, 135 and 121 to be retrofitted with a crash-protected image recording system by January 1, 2010."

[In a March 29, 2004, interim response, FAA Administrator Marion C. Blakey said that representatives of FAA and NTSB would meet to develop a consensus on the handling of these and 21 similar NTSB safety recommendations involving CVRs, FDRs and video recorders.[3]

"Recorder recommendations present unique challenges, including difficulties in cost/benefit analysis, technical hurdles, retrofit problems, issues about the use of data and privacy concerns," Blakey said.]♦

[FSF editorial note: This article, except where specifically noted, is based on U.S. National Transportation Safety Board (NTSB) Aircraft Accident Brief LAX01MA272 (47 pages with illustrations) and NTSB Factual Report LAX01MA272 (1,151 pages with illustrations and appendixes).]

Notes

1. Green Route 4 is one of several predetermined, charted routes described in Special Federal Aviation Regulation (SFAR) 50-2, which specifies operating procedures for pilots of aircraft in the airspace above and near Grand Canyon, Arizona, U.S.

2. The U.S. Federal Aviation Administration, in its *Rotorcraft Flying Handbook*, FAA-H-8083-21, defines ground resonance as "an aerodynamic phenomenon associated with fully articulated rotor systems. It develops when the rotor blades move out of phase with each other and cause the rotor disc to become unbalanced. This condition can cause a helicopter to self-destruct in a matter of seconds. However, for this condition to occur, the helicopter must be in contact with the ground."

3. Blakey, Marion C. Letter to Ellen Engleman Conners, chairman, U.S. National Transportation Safety Board. March 29, 2004.

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