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Improper Response to Stall Warning Cited in A310 CFIT off Ivory Coast

The pilot flying applied forward pressure on the control column but did not increase power when the stall-warning system activated during takeoff. The airplane descended into water soon thereafter. The controlled-flight-into-terrain (CFIT) accident occurred on a dark night with limited external visual references available for the flight crew.

FSF Editorial Staff

At 2109 local time Jan. 30, 2000, an Airbus A310-300 operated by Kenya Airways struck the Atlantic Ocean soon after takeoff in nighttime visual meteorological conditions from Félix Houphouët-Boigny International Airport in Abidjan, Ivory Coast. The airplane was destroyed. The 10 crewmembers and 159 passengers were killed; 10 passengers were injured.

The Ivory Coast Commission of Inquiry said, in its final report, that the cause of the accident was "a collision with the sea that resulted from the pilot flying applying one part of the [stall-recovery] procedure, by pushing forward on the control column to stop the stick shaker, following the initiation of a stall warning on rotation while the airplane was not in a true stall condition."

The report said, "The FCOM [flight crew operating manual] used by the airline states that whenever a stall warning is encountered at low altitude (stick-shaker activation), it should be considered as an immediate threat to the maintenance of a safe flight path. It specifies that at the first sign of an imminent stall or at the time of a stick-shaker activation, the following actions must be undertaken simultaneously: thrust levers in TOGA [takeoff/go-around] position; reduction of pitch attitude; wings level; check that speed brakes are retracted.

"The investigation showed that the pilot flying reduced the pitch attitude but did not apply TOGA thrust on the engines. The investigation was unable to determine if the crew performed the other two actions: leveling the wings and checking that the speed brakes were retracted."

The report said that the following contributing factors were involved in the accident:

- "The pilot flying's actions on the control column put the airplane into a descent without the crew realizing it, despite radio altimeter callouts;
- "GPWS [ground-proximity warning system] warnings that could have alerted the crew to an imminent contact with the sea were masked by the priority stall [warnings] and overspeed warnings, in accordance with the prioritization of warnings; [and,]
- "The conditions for a takeoff performed toward the sea and at night provided no external visual references that would have allowed the crew to be aware of the direct proximity of the sea."

At the time of the accident, Kenya Airways had 2,100 employees and 10 airplanes, including four A310s, two Boeing 737-200s and four B-737-300s.

The accident airplane was scheduled for a flight from Abidjan to Nairobi, Kenya, with an en route stop in Lagos, Nigeria. Manufactured in 1986, the airplane had accumulated 58,115 flight hours and 15,026 cycles (takeoffs and landings).

The weight-and-balance form indicated that the takeoff weight was 127,855 kilograms (281,869 pounds) and the center of gravity (CG) was at 26.3 percent mean aerodynamic chord (MAC). Maximum takeoff weight was 153,000 kilograms

(337,304 pounds) and CG limits were from 20.7 percent MAC to 33.8 percent MAC.

The first officer, 43, was the pilot flying. He had 7,295 flight hours, including 5,599 flight hours as an A310 first officer. He was employed by Kenya Airways as a second officer in 1988. He served as a Douglas DC-9 first officer before completing training as an A310 first officer in 1991.

The captain, 44, had 11,636 flight hours, including 1,664 flight hours in type and 570 flight hours as an A310 captain. He was employed by Kenya Airways as a second officer in 1984. He served as a Fokker F27 and A310 first officer before completing training as a B-737 captain in 1992. He completed training as an A310 captain in July 1999.

Both pilots previously had conducted four landings and four takeoffs at the Abidjan airport. They had been off duty for 52 hours before the accident.

The airport is 13 kilometers (seven nautical miles) southeast of the city and is bounded by a lagoon to the north and the Atlantic Ocean to the south. Runway 03/21 is 2,700 meters (8,859 feet) long and 50 meters (164 feet) wide.

Surface winds were from 250 degrees at three knots. Visibility was greater than eight kilometers (five statute miles), and there were a few stratocumulus clouds about 1,200 feet above ground level. "At the time of the accident, the sky was black," the report said.

At 2101, the ground controller instructed the flight crew to taxi the airplane to Runway 21. At 2107:45, the tower controller cleared the crew for takeoff. The first officer's acknowledgement of the takeoff clearance was the last radio communication between air traffic controllers and the flight crew.

At 2108:06, the captain said, "Final checks complete?"

"Final checks complete," the first officer said. "Cleared for takeoff."

The cockpit voice recorder (CVR) recorded the sound of the engines spooling up at 2108:18. At 2108:29, the captain said, "Takeoff power is set."

The first officer said, "OK."

Power was set at 97 percent of N_1 (engine low pressure rotor [fan] speed), and the autothrottle system was engaged in thrust mode (i.e., to maintain the thrust setting). The report said that selecting the TOGA mode increases thrust to the maximum value: 117.5 percent N_1.

The captain said, "One hundred knots."

"Checks," the first officer said.

At 2108:50, the captain said, "V one and rotate." (Takeoff decision speed, V_1, was 149 knots, and rotation speed was 151 knots.)

At 2108:56, the captain said, "Positive."

The first officer said, "Positive rate of climb. Gear up."

Airbus A310-300

Introduced into service in 1983, the Airbus A310 has a shorter fuselage and smaller wings and horizontal tail surfaces than the A300. The A310-300 is an extended-range version that was first flown in 1985 and is the first Airbus airplane to have triangle-shaped wing tip fences, which were developed to reduce drag.

Extended range was achieved by increasing maximum takeoff weight to 150,000 kilograms (330,690 pounds) to accommodate greater fuel capacity. The extra fuel is carried in the tail. An increase in maximum takeoff weight to 153,000 kilograms (337,304 pounds) was available as an option. Maximum landing weight for both versions is 123,000 kilograms (271,166 pounds).

The A310-300 accommodates two flight crewmembers and up to 280 passengers. The airplane is powered by two General Electric CF6-80C2 turbofan engines, each producing 22.4 kilonewtons (50,000 pounds) static thrust.

Typical long-range cruising speed at 37,000 feet is Mach 0.80 (459 knots). Typical range with 218 passengers is 8,612 kilometers (4,650 nautical miles) with standard fuel or 9,334 kilometers (5,040 nautical miles) with optional fuel.♦

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

At 2108:59, the stick shaker activated and the stall-warning horn sounded. The report said that a stall warning can be activated by any of the following conditions:

- "If the slats are at a position lower than 15 degrees (retracted or moving from 15 degrees toward zero) and the angle-of-attack is greater than 10 degrees;
- "If the slats are extended to 15 degrees or more and the angle-of-attack is greater than 17.5 degrees;
- "If the V_{SS} (stick-shaker-activation speed) is less than 1.138 V_S (computed stall speed) in smooth [clean] configuration; [or,]
- "If the V_{SS} is less than 1.08 V_S in non-smooth configuration."

The report said that none of the conditions existed and that despite the stall warning, a stall was not imminent.

"The investigation was unable to determine precisely the cause of this false alarm," the report said. "It could [have been] generated by an anomaly in the airplane's speed-calculation system (for example, an ADC [air-data computer] anomaly), in the airplane's angle-of-attack calculation system (for example, an anomaly in one of the angle-of-attack sensors) or in the stall-warning-generation system (for example, an FWC [flight-warning computer] anomaly)."

In response to the stall warning, the captain voiced an exclamation and the first officer pushed forward on the control column. The captain did not retract the landing gear, as commanded by the first officer.

The airplane reached a maximum height between 300 feet and 400 feet. The report said that the first officer likely maintained forward pressure on the control column to stop the stall warning although there were indications on his primary flight display (PFD) — including airspeed, airspeed trend and thrust — that a stall was not imminent.

The airspeed scale on the PFD, however, did not show V_{SS}. The display of V_{SS} — with black-and-red strips on the airspeed scale — is inhibited until five seconds after takeoff.

At 2109:07, the GPWS generated a radio altitude callout of "three hundred."

The first officer said, "Ahhh? What's the problem?"

At 2109:15, a radio altitude callout of "two hundred" was generated.

At 2109:18, the first officer said, "Silence the horn." Soon thereafter, a radio altitude callout of "one hundred" was generated. The captain pressed the stall-warning-disconnect button, silencing the stall-warning horn.

At 2109:21, the CVR recorded the beginning of a GPWS "whoop, whoop, pull up" warning that was interrupted by rapid radio altitude callouts of "fifty," "forty," "thirty," "twenty" and "ten."

The CVR then recorded the beginning of a continuous repetitive chime associated with a master warning. The report said that the master warning likely was generated by an increase in airspeed to the maximum airspeed for flight with the flaps and slats extended 15 degrees.

"The airplane's speed was at least 210 knots, the maximum speed limit for a configuration with slats/flaps at 15 degrees," the report said.

At 2109:22, the captain said, "Go up."

The CVR recorded the first sound of impact at 2109:24. The CVR recording ended three seconds later.

The airplane struck the ocean 2.8 kilometers (1.5 nautical miles) from the departure end of the runway. The report said that there was no fire before impact or after impact. Twelve passengers survived the accident and were rescued that night; two survivors subsequently died.

"Of the 10 survivors, nine were seriously injured and one [was] slightly injured," the report said. "Four of the survivors had first-degree burns resulting from contact with the jet fuel spread over the water on impact."

Several survivors told investigators that the airplane began to descend rapidly soon after takeoff.

"The airplane seemed to them to have swung suddenly to the left, then to the right, then to crash into the ocean with a deafening noise," the report said. "They stated that there was no announcement from the crew before the accident."

The report said that the airplane's emergency locator transmitter likely was destroyed on impact and did not activate.

"The accident site could, thus, not be located using the COSPAS SARSAT [search-and-rescue satellite] system," the report said.

Most survivors clung to objects floating in the water until they were rescued by the crews of pleasure boats and commercial vessels. One survivor was found on a beach.

The report said that the airport had ground equipment for search-and-rescue operations but no maritime rescue equipment; authorities had difficulty organizing sea-rescue operations. Several light airplanes and helicopters were involved in an airborne search, which was discontinued at 0215 because of fog. The last survivors were rescued by a tugboat crew about 0348. Rescue operations were terminated at 1000.

The wreckage was found on the seabed, about 50 meters (164 feet) below the surface. The flight data recorder was recovered

but was found to have malfunctioned; the recorded data were unintelligible.

The report said that in December 2000, Airbus revised the "Recovery From Approach to Stall" procedure in the A310 flight crew training manual. The revised procedure includes the following information:

- "At stick shaker activation, even with reduced lift margins, an aircraft still has positive performance capability. So, instead of trying to recover in minimum time by power application and pitch-down, the technique recommended is a minimum loss of altitude by power application and flying optimum pitch;

- "The FPV [flight path vector displayed by the PFD] can be a great help in controlling flight path so as to minimize the height loss during recovery. Pitch attitude should then be adjusted to hold FPV on [the horizon] or close to the horizon; [and,]

- "Use the maximum thrust allowable. Pitch-up is noticeable with thrust application; move the control column to smoothly adjust the pitch attitude as necessary during the recovery. Avoid abrupt control inputs; they may induce a secondary stall."

Based on the findings of the accident investigation, the Commission of Inquiry made the following recommendations:

- "Civil aviation authorities [should] ask training organizations and operators under their authority to integrate into type-rating [training programs] and recurrent training programs, for crews of all aircraft likely to be subject to false stall warnings, the elements necessary to recognize and manage such a false alarm during phases of flight close to the ground;

- "The French DGAC [Direction Générale de l'Aviation Civile should] ensure that Airbus harmonizes the procedures in the FCOM with those taught during type-rating training; [and,]

- "Civil aviation authorities responsible for coastal airports or [airports] near water [should] ensure that appropriate equipment (aerial, maritime, etc.) be put in place so as to ensure immediate intervention at an accident site located in an area near a coastal airport."♦

[FSF editorial note: This article, except where specifically noted, is based on the English translation and publication by the French Bureau d'Enquêtes et d'Analyses pour la Sécurité de l'Aviation Civile (BEA) of the Ivory Coast Commission of Inquiry report 5y-n00130, *Accident which occurred on 30 January 2000 in the sea near Abidjan Airport to the Airbus 310-304 registered 5Y-BEN operated by Kenya Airways*. The 168-page report contains illustrations and appendixes.]

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