

BY MARK LACAGNINA

Check Flight



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Goes Bad

The crew was unaware that the A320's angle-of-attack sensors were frozen.



The no. 2 angle-of-attack sensor vane is circled. The sensor body, shown in the diagram, is not heated — a factor involved in the accident.

An Airbus A320-232 was undergoing a series of functional checks required by a lease agreement when it stalled and descended into the Mediterranean Sea near Perpignan, France, the afternoon of Nov. 27, 2008. The airplane was destroyed, and all seven occupants were killed. In a final report published in September 2010, the French Bureau d'Enquêtes et d'Analyses (BEA) said that the flight crew was not aware that the angle-of-attack sensors had been blocked by ice. They lost control of the airplane while performing low-speed checks at a relatively low altitude.

Among the factors that contributed to the accident was the flight crew's lack of training and experience in performing functional check flights, the report said.¹ Investigators also found that the angle-of-attack sensors had not been shielded properly when the airplane was rinsed to remove accumulated dust, which resulted in water entering at least two of the three sensors and later freezing during the accident flight.

The A320 had been leased in 2006 from Air New Zealand (ANZ) by XL Airways Germany (GXL). The lease was expiring, and the German charter airline had ferried the airplane to EAS Industries at Perpignan's Rivesaltes Airport on Nov. 3, 2008, for a 30-month maintenance check and for repainting, which — along with the functional check flight — were required by the lease agreement before the airplane was returned to ANZ.

'Atypical Team'

The report said that there was an "atypical team" of three airline pilots in the cockpit

for the check flight. The captain and copilot were from GXL. The captain, 51, had 12,709 flight hours, including 7,038 hours in type. He was hired by the airline in February 2006 as a captain and as head of air and ground operations. He was qualified as an A318/A319/A320/A321 instructor and type-rating examiner. The copilot, 58, had 11,660 flight hours, including 5,529 hours in type. He was hired by GXL as a copilot in April 2006.

The other pilot was an ANZ captain with 15,211 flight hours, including 2,078 hours in type. Hired in 1986, he had served as an A320 captain since September 2004. During the check flight, he occupied the cockpit center seat to observe and record the results of the checks. He also had been designated to command the subsequent ferry flight to Auckland, New Zealand.

Also aboard the airplane were three ANZ engineers, who had supervised the maintenance performed in Perpignan, and a representative of the New Zealand Civil Aviation Authority, whose responsibilities included issuing a new airworthiness certificate before the airplane was returned to its owner. These passengers were aboard for transport to Frankfurt, Germany, at the end of the check flight.

The captain and the copilot had not flown together in 2008, and neither pilot had flown with the ANZ pilot. The report said that inadequate coordination among the three pilots during the check flight was a factor that contributed to the accident. The cockpit voice recorder (CVR) transcript indicates that some of the communication between the captain and copilot was in German. The ANZ pilot did not speak German.

The report also said that the performance of the GXL pilots during the check flight might have been affected by fatigue. The captain and the copilot had begun the commute to Perpignan from Frankfurt International Airport, their home base, at 0530 local time (also Perpignan time) with a taxi ride to Frankfurt–Hahn Airport, about 130 km (81 mi) west of Frankfurt International, to board a flight to Montpellier, France. There, they rented a vehicle for the drive to Perpignan, about 160 km (99 mi) southwest. They arrived in Perpignan at 1200.

‘Disguised Test Flight’

The flight was scheduled to begin at 1330 but was delayed until 1544. The pilots met for an hour before takeoff to review the flight plan. Airbus did not publish guidance for operators on conducting functional check flights. Therefore, ANZ had developed a list of items selected from the Airbus *Customer Acceptance Manual*, which prescribes checks that typically are performed by Airbus pilots, with a customer’s pilot aboard, before delivery of an airplane to the customer. At least one of the flight crewmembers must be a qualified test pilot, and an Airbus test engineer must be aboard to rebrief the pilots on the check procedures and expected parameters, and to record the results of the checks.

The report noted that although the GXL captain had participated in an A320 customer acceptance flight in 2004, neither he nor the copilot had received specific training to conduct functional check flights. Furthermore, although the ANZ pilot was included on the list of company pilots who could perform check flights, he had not actually performed such a flight.

When the A320 departed from Perpignan, visual meteorological conditions (VMC) prevailed, with light and variable surface winds, 10 mi (16 km) visibility in light rain, a few clouds at 3,300 ft and a broken ceiling at 5,100 ft.

The airplane was flown northwest, into airspace controlled by a regional air traffic control center (Figure 1). When the center controller received the A320’s flight plan, he called the Perpignan approach controller. “He wanted to ensure that the crew had the necessary authorizations to undertake what he described as a ‘disguised test flight,’” the report said. “He thought this flight had not been the subject of an appropriate request by the operator.”

An almost identical flight plan had been filed earlier that day for a Boeing 737-800 operated by GXL. The flight plan specified an unscheduled air transport flight; however, “test flight” had been inserted in the flight plan box for miscellaneous information. “The crew of this flight ... had asked on several occasions to perform maneuvers that had required coordination between the different control sectors,” the report said. Although the center had accommodated the 737 crew’s requests, the controller involved told investigators that the flight should have been conducted in airspace reserved for test flights.

Soon after the A320 copilot established radio communication with the center controller, he asked for clearance to perform a 360-degree turn. This time, the controller refused to accommodate the crew. “The controller explained to the crew that this type of flight could not be undertaken in general air traffic and that the flight plan was not compatible with the maneuvers requested,” the report said.

The crew did not contest the controller’s decision, but “the controller’s refusal of the request to perform maneuvers nevertheless disturbed the course of the rest of the flight,” and the crew had to “adapt and improvise in order to be able to complete their task,” the report said.

Immobile Vanes

The captain requested and received clearance to climb to Flight Level (FL) 320 (approximately 32,000 ft) and to maintain a 320-degree heading for about 20 minutes before turning back toward Perpignan. Recorded flight data indicated that shortly after the airplane reached that flight level, the vanes on the no. 1 and no. 2 angle-of-attack sensors stopped moving. The water that had entered the sensor bodies during the rinsing three days earlier had frozen on internal bearings, immobilizing the vanes for the remainder of the flight in positions corresponding with cruise angles-of-attack — 4.2 and 3.7 degrees, respectively.

The no. 1 and no. 2 angle-of-attack sensors are part of the air data system for the captain’s and copilot’s instruments, respectively. The no. 3 sensor is part of the standby air data system. The external vanes, which align in flight with the relative wind, are heated automatically with alternating electrical current when the engines are running; the interiors of the sensor bodies are not heated.

The A320 maintenance manual requires the application of adhesive tape to mask the gaps between the bases of the sensors and the fuselage plates to which they are attached before the airplane is washed or rinsed. This helps prevent water from entering the sensor bodies and causing corrosion, faulty electrical connections or icing in flight. Airbus warns that the sensors must not be exposed

directly to high-pressure water, even when the sensors are properly masked. The report said that the sensors on the accident airplane likely were not masked properly before the airplane was rinsed with water delivered under high pressure.

Control Laws

The CVR transcript indicates that the crew performed several checks “in a relaxed and professional manner” before turning back toward Perpignan at 1612, the report said. The crew requested and received clearance to climb to FL 390, where they performed an auxiliary power unit starting check. During the subsequent descent to FL 130, the crew performed checks of the wing anti-icing system and the overspeed-protection system.

The ANZ pilot then told the captain that the next item was a check of the flight controls in *alternate law*, which is among the flight control laws that govern the A320’s fly-by-wire system. “The airplane is [hand] flown using two sidesticks whose movements are transmitted in the form of electrical signals to computers that transform them into orders to the actuators of the various [control] surfaces,” the report said. Ordinarily, the system is governed by *normal law*, which provides a number of automatic “protections” against exceeding flight envelope parameters. Under certain conditions, including subsystem failures, the fly-by-wire system will revert to *alternate law* or to *direct law*, both of which provide fewer protections. For example, a dual air data computer failure will cause the system to revert from normal law to alternate law; a triple air data computer failure will cause a reversion from normal to direct law.²

At 1633, the crew established radio communication with a Perpignan approach controller and requested radar vectors for the instrument landing system (ILS) approach to Runway 33. The copilot told the controller that the approach would terminate with a go-around and that the flight would then proceed to Frankfurt. The controller told the crew to fly a heading of 090 degrees and to descend to FL 80. This heading took the A320 out over the sea. “The crew

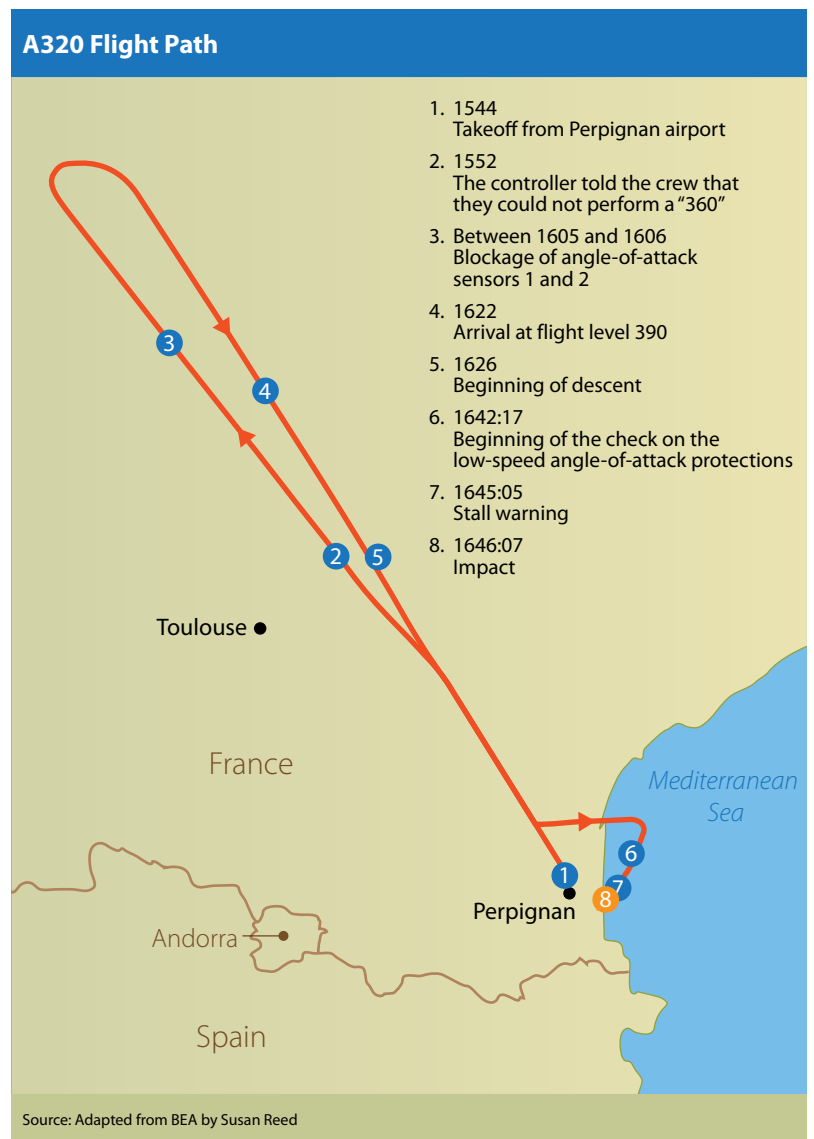


Figure 1

performed the check on the flight controls in alternate law before beginning the descent,” the report said.

By the Book

The captain and the ANZ pilot then briefly discussed the procedures for the next item: the low-speed checks. However, they did not review the altitude or airspeed limits appropriate for the checks, as prescribed by the Airbus *Customer Acceptance Manual*.

The manual also says that the low-speed checks must be performed in VMC and no lower than FL 100, and that icing conditions

should be avoided beforehand. The airplane must be in normal control law and in landing configuration. Prior to deceleration, the test engineer must brief the pilots on the minimum airspeeds that correspond to the airplane’s weight and configuration. “The crew must anticipate the incorrect functioning of the system under test and must define the manner in which the test or the check is to be stopped,” the report said.

The purpose of the low-speed checks is to determine if the *angle-of-attack protections*

— or *alpha protections* — activate at the corresponding airspeeds calculated by the flight augmentation computers and shown on the primary flight display (PFD) speed tapes. The automatic “protections” — which include retraction of the speed brakes, inhibition of the autotrim system and selection of takeoff/go-around thrust — are designed to prevent angle-of-attack from reaching the value at which the airplane will stall.

According to the Airbus manual, the pilot flying first stabilizes airspeed at V_{LS} (the lowest selectable airspeed), then reduces thrust to idle and adjusts pitch to achieve a deceleration rate of one kt per second. As the airplane decelerates, angle-of-attack increases to a value

called *alpha prot*, which corresponds to the indicated airspeed $V_{\alpha_{PROT}}$ near the bottom of the PFD speed strip (Figure 2). At this point, the crew should notice that the autotrim system has been inhibited and/or that the speed brakes, if deployed, have been retracted — both protections again exceeding *alpha prot*. “With no input on the sidestick, the angle-of-attack remains at this value,” the report said.

However, to continue the check, the pilot flying moves the sidestick aft to achieve further deceleration and an increase in angle-of-attack to the *alpha floor*. This is not shown on the PFD speed strip, but the automatic application of maximum thrust indicates that the protection against exceeding the *alpha floor* is functioning.

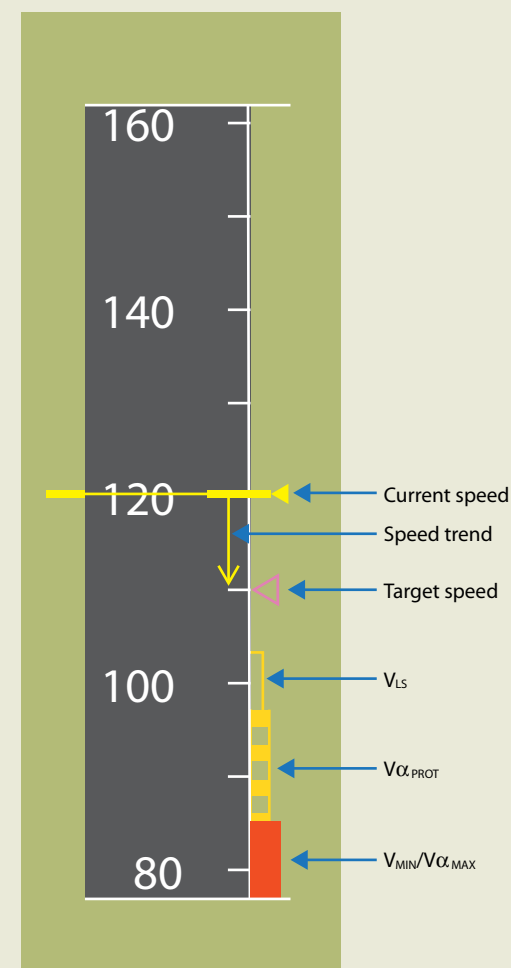
To complete the check, the crew disengages the autothrottle, and the pilot flying moves the sidestick to the aft stop. “The airplane can only decelerate to a limit angle-of-attack called *alpha max*,” the report said. “Its [corresponding] speed (V_{MIN} or $V_{\alpha_{MAX}}$) is maintained with an adapted flight path. The value of this angle-of-attack is lower than that of the stall angle-of-attack.”

No Protections

At 1640, the approach controller told the crew to turn right to a heading of 190 degrees, a vector toward an initial approach fix, and to maintain 180 kt. She then cleared the crew to conduct the ILS approach and told them to descend to 5,000 ft.

Likely concerned that the airplane was in instrument meteorological conditions and that they had been cleared for the approach, the captain told the ANZ pilot that they would postpone the low-speed checks until the flight to Frankfurt or not perform them at all. However, after receiving a further descent clearance to 2,000 ft and encountering VMC, the captain discontinued his approach briefing, and the flight crew began configuring the airplane for the low-speed checks. “The captain asked for speed values from the Air New Zealand pilot, who answered, ‘Just ... come right back to alpha floor activation,’” the report said.

Primary Flight Display Speed Strip



V_{LS} = lowest selectable airspeed; V_{α} = airspeed corresponding to α_{PROT} angle-of-attack; $V_{MIN}/V_{\alpha_{MAX}}$ = airspeed corresponding to α_{MAX} , or limit angle-of-attack

Source: Adapted from BEA by Susan Reed

Figure 2

The airplane was descending through 4,080 ft over the sea when the crew began the low-speed checks. Airspeed decreased rapidly from 167 kt, and the captain pulled his sidestick all the way back, anticipating the activation of the angle-of-attack protections. However, the angle-of-attack protections never activated. “The blockage of the angle-of-attack sensors made it impossible for these protections to trigger,” the report said.

As the airplane decelerated, the autotrim system gradually moved the horizontal stabilizer to the full nose-up position. Pitch angle was 18.6 degrees and airspeed was 99 kt when the no. 3 angle-of-attack sensor generated a stall warning at 1645. The captain moved the thrust levers to the takeoff/go-around detent and attempted to pitch the airplane nose-down. A series of roll and pitch oscillations occurred, with bank angles reaching maximums of 59 degrees left and 97 degrees right, and pitch attitudes varying from 52 degrees nose-up to 45 degrees nose-down.

According to the report, the asymmetric roll and pitch movements resulted in airspeed data divergences, which were interpreted by the flight control system as a failure of all three air data computers. Consequently, the flight control law reverted automatically from normal to direct. The most critical result was the disengagement of the autotrim system, which was indicated by a message displayed on the PFDs: “USE MAN PITCH TRIM.” Nevertheless, the captain did not reduce thrust or use the manual pitch-trim system to move the horizontal stabilizer from its full nose-up position.

“Under the combined effects of the thrust increase, the increasing speed and the horizontal stabilizer still at the pitch-up stop, the airplane was subject to a pitch-up moment that the captain could not manage to counter, even with the sidestick at the nose-down stop,” the report said. “The exchanges between the pilots at this time show that they did not understand the behavior of the airplane.”

Airspeed dropped to 40 kt before increasing rapidly as the airplane descended into the Mediterranean near Canet-Plage. “The last recorded

values were a pitch of 14 degrees nose-down, a bank angle of 15 degrees to the right, a speed of 263 kt and an altitude of 340 ft,” the report said.

The loud acceleration of the engines had drawn the attention of many witnesses. “A few seconds after the increase in the engine rpm, all the witnesses saw the airplane suddenly adopt a pitch-up attitude that they estimated as being between 60 and 90 degrees,” the report said. “The majority of the witnesses saw the airplane disappear behind a cloud layer. The noise generated by the engines was still constant and regular. The airplane reappeared after a few seconds with a very steep nose-down angle. ... Some witnesses remember a very loud ‘throbbing’ that they heard until the impact.”

The upset had occurred rapidly. “Between the time the stall warning sounded for the first time and the moment the recordings stopped, 62 seconds had passed,” the report said.

Among the recommendations generated by the BEA’s investigation of the accident was that the European Aviation Safety Agency (EASA) “undertake a safety study with a view to improving the certification standards of warning systems for crews during reconfigurations of flight control systems or the training of crews in identifying these reconfigurations and determining the immediate operational consequences.”

BEA also recommended that EASA work with manufacturers to “improve training exercises and techniques related to approach-to-stall to ensure control of the airplane in the pitch axis.”

This article is based on the English translation of the BEA report titled “Accident on 27 November 2008 off the Coast of Canet-Plage (66) to the Airbus A320-232 Registered D-AXLA Operated by XL Airways Germany.” The full report is available at <bea.aero/en/enquetes/perpignan/perpignan.php>.

Notes

1. Flight Safety Foundation will host a symposium on the challenges and best practices related to functional check flights Feb. 8–9, 2011, in Vancouver, Canada (see p. 28).
2. Airbus. *A319/A320A321 Flight Deck and Systems Briefing for Pilots*. September 1998.

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