AUTOMATION at Odds

The pilots of a Boeing 737-800 did not heed indications of a significant decrease in airspeed until the stick shaker activated on final approach to Runway 18R at Amsterdam (Netherlands) Schiphol Airport. Their reactions to the stall warning were uncoordinated and incorrect, and maximum thrust was applied too late to prevent the aircraft from stalling at an altitude from which recovery was not possible.

Five passengers, a flight attendant and the three pilots were killed, and 117 passengers and three flight attendants were injured when the aircraft struck terrain 0.8 nm (1.5 km) from the runway. Six passengers escaped injury.

The final report by the Dutch Safety Board (DSB) concluded that the Feb. 25, 2009, accident "was the result of a convergence of circumstances," including air traffic control (ATC) handling that brought the aircraft in high and close to the runway for an instrument landing system (ILS) approach, a radio altimeter malfunction that caused the autothrottle system to prematurely reduce power to approach idle while the autopilot compensated by increasing the pitch attitude to maintain the glideslope, and the flight crew's nonadherence to standard operating procedures — chiefly, their neglect or dismissal of indications that a go-around was required.

A 737 stalled when a radio altimeter malfunction caused the autothrottle and autopilot to diverge during an approach to Schiphol.

BY MARK LACAGNINA

The aircraft broke into three pieces when it struck the ground short of the runway.

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The aircraft, operated by Turkish Airlines as Flight TK1951, was en route to Amsterdam from Istanbul. "As this was a 'line flight under supervision,' there were three crewmembers in the cockpit, namely the captain, who was acting as instructor; the first officer, who had to gain experience on the route of flight and who was accordingly flying under supervision; and a safety pilot who was observing the flight," the report said.

All three flight crewmembers held 737-800 type ratings. The captain, 54, had about 17,000 flight hours, including 10,885 hours in 737s with 3,058 hours as pilot-in-command. The first officer, 42, who was flying the aircraft from the right seat, was making his 17th line flight under supervision and his first flight to Schiphol. He had 4,146 flight hours, including 44 hours in type. The safety pilot, 28, had 2,126 flight hours, including 720 hours in type. Turkish Airlines requires a safety pilot on the flight deck during a trainee pilot's first 20 line flights under supervision because of the extra instructional workload imposed on the captain.

The aircraft was over Germany at Flight Level 360 (approximately 36,000 ft) at 0953 Amsterdam time when the crew listened to the automatic terminal information service (ATIS) broadcast for Schiphol. Surface winds were from 200 degrees at 7 kt, and visibility was 3,500 m (about 2 1/4 mi) in mist. There were a few clouds at 600 ft, a broken ceiling at 1,100 ft and an overcast at 1,300 ft. The ATIS advised that the ceiling was becoming broken at 600 ft and that visibility was expected to decrease temporarily to 2,500 m (about 1 1/2 mi).

The first officer was not authorized to conduct Category II or Category III landings, so the crew briefed for the Category I ILS approach to Runway 18R before beginning the descent to Schiphol.

'Short Lineup'

The aircraft was descending through 7,000 ft with the autothrottle and right autopilot engaged when the captain established radio communication with Schiphol Approach at 1015. The approach controller told the crew to descend to 2,000 ft and to maintain a heading of 265 degrees. The controller then amended the heading to 210 degrees and cleared the crew to conduct the ILS approach to Runway 18R (Figure 1, p. 34).

The report said that the controller did not ask the crew if they could accept a "short lineup" before issuing these instructions, which did not allow the crew to intercept the glideslope from below in level flight, as required by International Civil Aviation Organization (ICAO) standards and by Netherlands ATC standards.

"This heading ultimately resulted in interception of the localizer signal 5.5 nm [10.2 km] from the runway threshold," the report said. It noted that the aircraft would have had to intercept the localizer course no less than 6.2 nm (11.5 km) from the runway threshold to intercept the glideslope from below while flying level at 2,000 ft. As a result of the short lineup, "the aircraft had to lose speed and descend in order to intercept the glide path," the report said.


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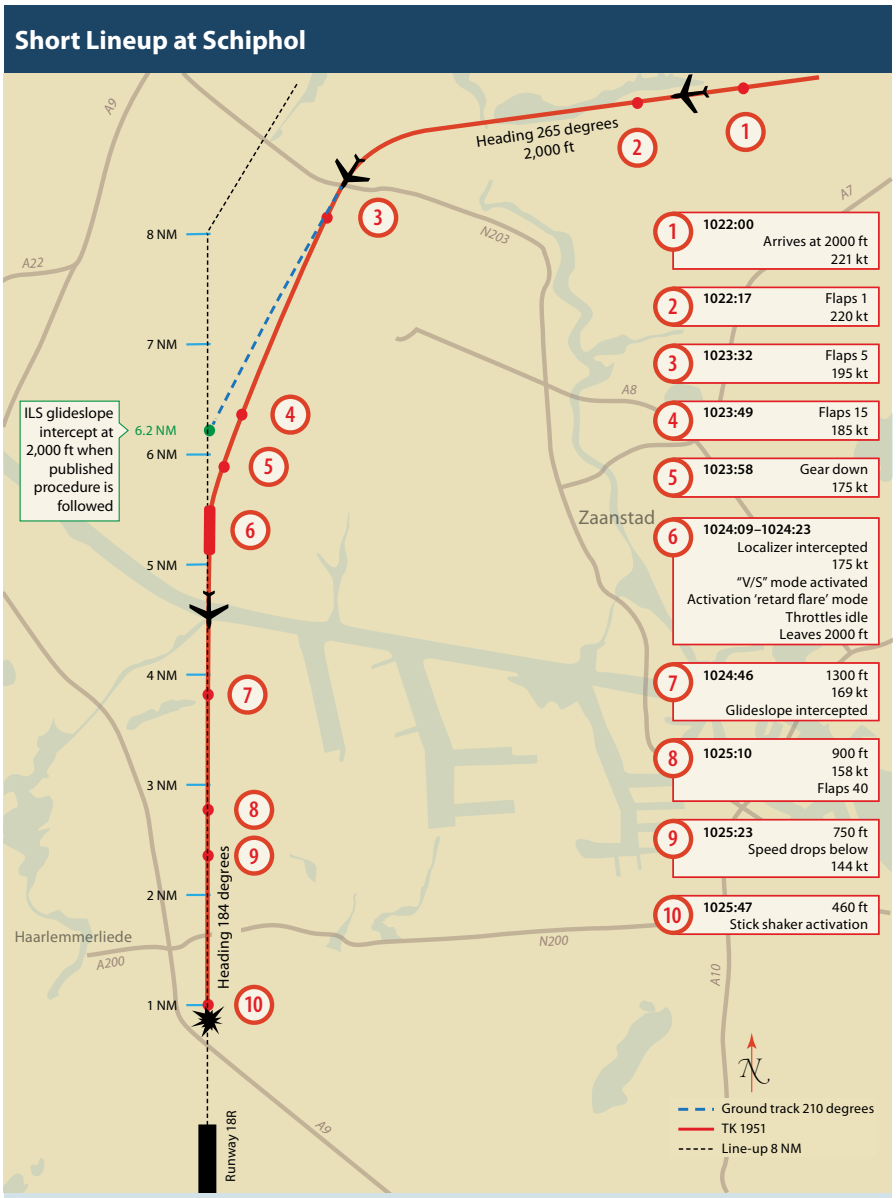


ILS = instrument landing system ; V/S = vertical speed

Source: Dutch Safety Board

Figure 1

Turkish Airlines trains its pilots to conduct ILS approaches with both autopilots engaged. However, when the crew attempted to engage the left autopilot, it would not engage; moreover, the right autopilot disengaged. Several factors were involved in this. The autopilots cannot be engaged simultaneously unless the ILS frequency is tuned and the approach mode is selected. The crew had not selected the approach mode. Consequently, they unintentionally switched from using the right autopilot to using the left autopilot. The left autopilot would not engage, however, because it was receiving an erroneous height measurement from the left radio altimeter system.

The crew subsequently re-engaged the right autopilot and selected the approach mode but did not make another attempt to engage the left autopilot. Although a "single-channel" message on the primary flight displays (PFDs) showed that only one autopilot was engaged for the ILS approach, the first officer announced "second autopilot engaged." The report said, "The approach was executed without further discussion."

The crew selected flaps 15 and extended the landing gear before the autopilot intercepted the localizer course at 1024. The aircraft was above the glideslope, and the crew initially used the altitude selector to manage the descent, selecting 1,200 ft initially and 700 ft shortly thereafter. However, the resulting descent rate was not sufficient to capture the glideslope, so the crew changed to the vertical speed mode and selected a descent rate of 1,400 fpm. The aircraft was descending through 1,300 ft when the autopilot captured the glideslope.

The report said that the captain, as pilot monitoring, did not make several required callouts during the approach, including changes in flight mode annunciations. "The times when these callouts should have been made coincided with the times that the captain was communicating with ATC," the report said.

Unstabilized Approach

Turkish Airlines' criteria for a stabilized approach in instrument meteorological conditions include completion of the landing checklist before the aircraft reaches 1,000 ft above runway touchdown zone elevation; a go-around is required if this is not accomplished. "This provision is not confined to Turkish Airlines, in fact, but is a general rule," the report said. "Being stabilized is important not only to ensure that the aircraft is in the correct configuration and power selection for the landing but also to provide the pilots with a chance to monitor every aspect of the final approach."

The landing checklist typically is conducted after flap 15 is selected and the landing gear is extended. However, the pilots did not begin the landing checklist until after they selected flaps 40 as the 737 descended through 900 ft. The report said that the delay likely was caused by the extra workload involved in capturing the glideslope from above.

The airline requires the captain, even if he or she is not the pilot flying, to make the decision about a go-around. Although the 737 captain had made a callout when the aircraft descended through 1,000 ft, he did not command a go-around.

Recorded flight data showed that the left radio altimeter system — the primary source of height measurements for the autothrottle — had begun to provide erroneous data shortly after takeoff from Istanbul. As the aircraft descended from 2,000 ft, the height measured by the left radio altimeter and displayed on the left, or captain's, PFD changed to minus 8 ft.

Investigators were unable to determine why this error occurred or why the radio altimeter computer did not recognize and flag the error, which would have caused the autothrottle to resort to using heights measured by the right radio altimeter system, which was functioning normally (Figure 2). "The only indication of the defect in the left radio altimeter system was the minus 8 ft indication on the left PFD," the report said. The right PFD, which is channeled to the right radio altimeter system, provided accurate height indications to the first officer.

'Retard Flare'

The autothrottle had been set to adjust engine thrust to hold an airspeed of 160 kt. However, the erroneous height measurement provided by the left radio altimeter prompted the autothrottle to change from the airspeed-hold mode to the "retard flare" mode and reduce thrust to the approach idle setting at about the same time the crew had begun the descent from 2,000 ft.

The retard flare mode "is normally only activated in the final phase of the landing, below 27 ft," the report said. In addition to the indication that the aircraft was below 27 ft, another precondition had been satisfied: The crew had selected flaps 15, the minimum flap position required for activation of the retard flare mode.

Shortly before the captain established radio communication with the airport traffic controller and received clearance to land, the safety pilot apparently saw the erroneous height indication on the captain's PFD and remarked that a radio altimeter failure had occurred. The captain confirmed the failure, but there was no further discussion or action taken about it. "The cockpit crew did not have information regarding the interrelationship between the failure of the left radio altimeter system and the operation of the autothrottle," the report said.

The crew completed the landing checklist as the aircraft descended below a height of 500 ft. The last item on the checklist was to instruct the flight attendants to take their seats; the captain asked the safety pilot to do this.

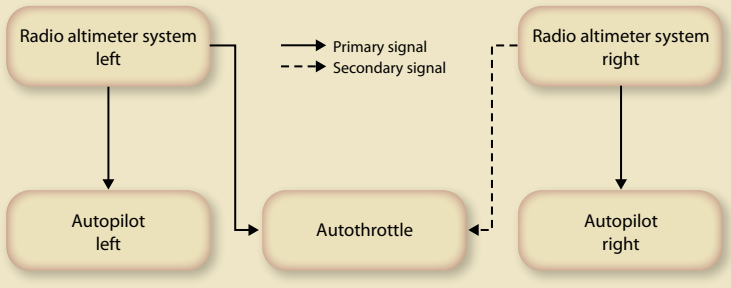
As airspeed decreased, the right autopilot, which was receiving correct height information from the right radio altimeter system, continued to trim the aircraft nose-up, increasing the angle-of-attack to maintain the lift required to keep the aircraft on the glideslope.

As the aircraft descended from 2,000 ft, the height measured by the left radio altimeter changed to minus 8 ft.

Unheeded Warnings

An indication of the autothrottle mode change, "RETARD," was displayed on both PFDs. "When subsequently the airspeed reached 126 kt, the

Systems Channeling



Source: Dutch Safety Board

Figure 2

frame of the airspeed indicator also changed color and started to flash," the report said. "The artificial horizon also showed that the nose attitude of the aircraft was becoming far too high."

The report said that cockpit voice recorder data provided no indication that the crew observed any of these warnings or that they noticed that the autothrottle did not command an increase of thrust after flaps 40 was selected. The latter would have been indicated in part by forward movement of the thrust levers.

"Because the cockpit crew, including the safety pilot, were busy completing the landing checklist, no one was engaged in the primary task of monitoring the flight path and the airspeed of the airplane," the report said. "The reduction in speed and the excessively high pitch attitude of the aircraft were not recognized until the approach-to-stall warning (stick shaker) went off at an altitude of 460 ft."

The first officer responded immediately to the stick shaker by moving the thrust levers forward and pushing his control column forward. However, he stopped when the captain announced that he was assuming control of the aircraft. The first officer had moved the thrust levers only slightly more than halfway forward. "The result of this was that the autothrottle, which was not yet switched off, immediately pulled the thrust levers back again to the position where the engines were not providing any significant thrust," the report said. During this time, airspeed decreased to 107 kt.

The aircraft was descending through 420 ft at 1025 when the captain disengaged the autopilot and pushed his control column full forward. About six seconds later — or about nine seconds after the stick shaker activated — he moved the thrust levers full forward. "At that point, the aircraft had already stalled, and the height remaining, about 350 ft, was insufficient for a recovery," the report said.

At 1026, the aircraft struck terrain in a 22-degree nose-up pitch attitude and banked 10 degrees left. "The aircraft came to a standstill in a field relatively quickly due to the low forward speed [on] impact," the report said. There was no fire.

"A few passengers exited the aircraft through the tear on the right-hand side of the fuselage in front of the wing," the report said. "The other passengers used the two emergency exits above the right wing, the front emergency exit above the left wing and the opening at the rear of the main section of the fuselage."

Similar Incidents

Investigators found that inadvertent activations of the retard flare mode had occurred during flights by the accident aircraft on both days preceding the accident. "After the accident, four similar incidents were brought to the attention of the DSB," the report said, noting that in each case the aircraft was landed without further incident after the crew disengaged the autothrottle.

Moreover, the report said, "Radio altimeter system problems within the Boeing 737-800 fleet had existed for many years." For example, Turkish Airlines had complained to Boeing about fluctuating and negative height measurements that caused landing gear warnings, autopilot disconnects and ground-proximity warning system warnings. "Turkish Airlines and other operators dealt with the problems as a technical problem and not as a safety problem," the report said. "As a result, the pilots were not informed of this issue."

Suspecting that corrosion was causing the problems, Turkish Airlines installed gaskets between the radio altimeter antennas and the fuselage skin, and wrapped the connectors to block moisture. But this did not eliminate the problems. The greatest success was achieved by replacing the antennas, but tests of some of the removed antennas did not reveal why the problems had occurred. "It is almost impossible to take the correct measures if the cause of the fault cannot be identified," the report said.

Boeing in 2004 added a warning in the 737-800 dispatch deviation guide that an autopilot or autothrottle must not be used during approach and landing if its associated radio altimeter is found to be inoperative *before* the flight begins. However, the report noted that the aircraft's quick reference handbook and flight crew operating manual do not contain similar guidance for a radio altimeter malfunction that occurs *during* flight.

Investigators also found that the ATC handling that resulted in the accident aircraft's interception of the localizer course high and close to the runway, without prior consultation with and approval by the crew, was not an isolated event but was characteristic of more than 50 percent of the approaches to Runway 18R at Schiphol.

Based on the findings of the investigation, the DSB recommended improvement of the reliability of the 737-800 radio altimeter system, evaluation of the benefits of installing an aural low-speed warning in the aircraft, and monitoring to ensure that air traffic controllers in the Netherlands adhere to ICAO and national standards for lining up aircraft for approach.

This article is based on the DSB accident report "Crashed During Approach, Boeing 737-800, Near Amsterdam Schiphol Airport, 25 February 2009," May 2010. The full report is available at <safetyboard.nl>.