



## Captain Stops First Officer's Go-around, DC-9 Becomes Controlled-flight-into-terrain (CFIT) Accident

*Poor crew cooperation, altimeter misreading and a navigation radio malfunction were cited in the fatal CFIT accident.*

by  
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The crash of an Alitalia McDonnell Douglas DC-9-32 on approach to Zürich, Switzerland, airport stressed the need for recognizing navigation equipment failures and proper cockpit crew coordination, the official Swiss accident report said. Forty passengers and six crew members were killed in the crash.

During an instrument landing system (ILS) approach to Runway 14 at Zürich on Nov. 14, 1990, Alitalia Flight AZ 404 followed the localizer precisely, but descended below the glideslope until it crashed 5.2 nautical miles (9.6 kilometers) short of the runway. The Swiss Aircraft Accidents Inquiry Board (AAIB) concluded that the aircraft's No. 1 very high frequency (VHF) navigation receiver apparently malfunctioned and caused all four cockpit glideslope indicators to give "on glide" indications without a warning flag appearing.

The AAIB stated that "the possibility of such a failure on the navigation equipment in use has been known since 1984. Alitalia was informed by the aircraft manufacturer about the possibility of these failure possibilities in 1984 and 1985. They [the failure possibilities] were unknown to the crew of AZ 404."

The AAIB said that other causes of the accident included a probable altimeter misreading by the captain, no ground proximity warning system (GPWS) warning in the cockpit

and unsuitable cooperation between the pilots during the approach. The report added that the first officer's initiated go-around was aborted by the captain and that the approach controller did not observe the aircraft descending through its cleared altitude of 4,000 feet (1,220 meters) mean sea level (MSL) before the final approach point (FAP).

Alitalia Flight AZ 404 departed Milan-Linate (LIN) Airport at 1836 hours local time. The first officer was flying while the captain assumed the duties of assisting pilot. At 1851, the aircraft was at its assigned cruising altitude of Flight Level 200 (20,000 feet [6,100 meters]), and the crew was in contact with Zürich radar. Two minutes later, AZ 404 was cleared to descend to Flight Level 140 (14,000 feet [4,270 meters]). The pilots listened to the Zürich automatic terminal information service (ATIS) as they descended, the report said.

The ATIS broadcast included the following weather, observed at 1850: 2/8 clouds at 1,500 feet (457.5 meters), 5/8 clouds at 3,000 feet (915 meters), 7/8 clouds at 4,000 feet, visibility 6.2 miles (10 kilometers), mist, wind 240 degrees at four knots.

At this point, said the report, the cockpit voice recorder (CVR) indicated that the captain entered an unusually long discussion about the possibility of circling to land on Runway 28.

At 1857, AZ 404 was in contact with Zürich arrival and was descending to a newly assigned altitude of 9,000 feet (2,745 meters). The crew was told to fly a heading of 325 degrees for radar vectors to the ILS Runway 14. The first officer said, “We perform a CAT II [approach].” The captain agreed. While verifying the decision height, the first officer was still consulting the approach chart for Runway 16, according to the report.

The captain then said, “We are by Kloten, FL 90. He is bringing us in high.” At 1902, AZ 404 was told to reduce speed to 210 knots, then cleared to descend to 6,000 feet (1,830 meters). Shortly thereafter, AZ 404 was told to turn left to a heading of 325 degrees, the report said.

At this point according to the report, the No. 1 VHF navigation receiver was tuned to Trasadingen (TRA) VHF omnidirectional radio range (VOR), the No. 2 VHF navigation receiver was tuned to Kloten (KLO) VOR and a course of 068 was set to define the fix at Ekron.

The captain said: “The outer marker is at 1,200 feet (366 meters) [above runway threshold — QFE] (atmospheric pressure of runway elevation or runway threshold), it can be verified by 3.8 [nautical miles (7 kilometers)] from Kloten. Rhine [RHI NDB] 5.6 [nautical miles (10.4 kilometers)].” At 1905, AZ 404 was told to turn right to a heading of 070, which the captain acknowledged. The identification for the Runway 14 localizer was heard on the CVR, the report said.

At 1906:20, Zürich arrival told AZ 404 to “descend to 4,000 feet [1,220 meters], turn right heading 110, cleared ILS approach Runway 14,” the report said (Figure 1, page 3). When the captain acknowledged the clearance, he read back a heading of 120. The controller did not correct the captain’s read-back of the wrong heading. The report said that the incorrect read-back of the clearance caused the first officer some uncertainty about the heading to be flown. The captain confirmed the approach clearance and the cleared altitude of 4,000 feet.

The first officer then ordered, “radio approach,” the report said. At this point, the aircraft was descending through 5,000 feet (1,525 meters) MSL. At 1907, Zürich arrival told AZ 404 to reduce speed to 180 knots, which the captain acknowledged. One of the pilots then asked the other whether he had a glideslope indication. The aircraft was about to intercept the localizer, and descending through 4,700 feet (1,433.5 meters) MSL (1,300 feet [396.5 meters] below the glideslope).

Answering the question about the glideslope, the other pilot replied (hardly understandable), “On 1 ... I don’t

have ... ,” the report said. The captain then said, “Good, so let’s do it on 1,” the report said. The first officer ordered, “Radio 1,” the report said. The aircraft passed through the localizer and was slightly east of it.

At 1908, Zürich arrival told AZ 404 to reduce to 160 knots, the report said. The captain acknowledged the speed reduction and said to the first officer, “Capture localizer capture glideslope capture, so we are on the localizer, a little off track but ... .” The aircraft was descending through 4,000 feet MSL (about 1,200 feet below the glideslope) and was about 11.5 nautical miles (21.3 kilometers) from the runway threshold, the report said.

As the aircraft descended through 3,700 feet (1,128.5 meters) MSL, the altitude exit alert was heard on the CVR. The captain cancelled the warning by setting 5,000 feet (the go-around altitude) on the Altitude Preselect, the report said.

The captain then said to the first officer: “There is another one in front quite close. You can reduce even further to 150, otherwise we’ll end up with a go-around.” A discussion followed about possible icing, after which the flaps were set to 25 degrees. The aircraft was established on the localizer and at 3,000 feet MSL (1,200 feet below the glideslope), the report said.

The captain said, “Outer marker check is at 1,250 feet ([381.2 meters] [QFE]).” The flaps were then set to 50 degrees. The report said that the aircraft was descending through the outer marker height of 1,250 feet QFE. When the aircraft was eight nautical miles (14.8 kilometers) from the runway, the captain said, “3.8 almost 4 miles.”

At about seven nautical miles (13 kilometers) from the runway, the first officer asked the captain, “Haven’t we passed it?” Twelve seconds later, the first officer again asked the captain, “Haven’t we passed the outer marker?” The report said their altitude was then 670 feet (204.3 meters) QFE.

The report said that the captain answered, “No, no it hasn’t changed yet.” At 6.6 nautical miles [12.2 kilometers] from the runway, the captain said, “Oh, it shows seven.”

Zürich arrival called, “AZ 404, speed now as convenient, four miles behind a DC-9, contact tower eighteen-one, good night.” The captain acknowledged the frequency change and said to the first officer, “That doesn’t make sense to me.” The report said the first officer responded, “Nor to me.”

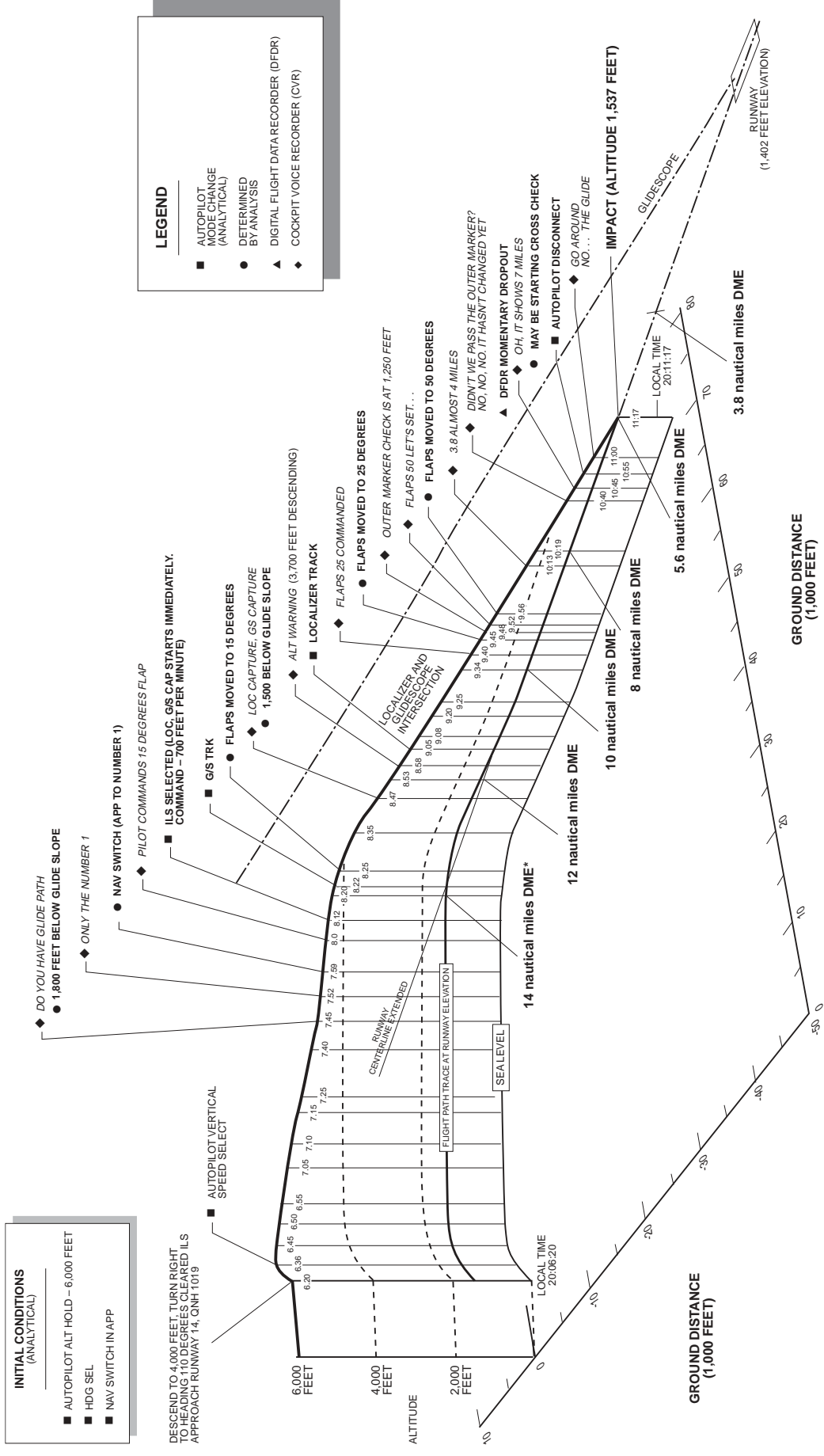
The report said that two seconds after this conversation, the captain called out, “Pull, pull, pull, pull!” A

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*... the incorrect read-back of the clearance caused the first officer some uncertainty about the heading to be flown.*

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# Final Approach Track of Alitalia Flight AZ404



\*DME: Distance measuring equipment  
Source: Swiss Aircraft Accidents Inquiry Board

Figure 1

simultaneous disconnect of the autopilot could be heard. The aircraft was now 500 feet (152.5 meters) above ground level (AGL). Two seconds later, the first officer called out, "Go around," the report said. The captain responded, "No, no, no, no ... catch the glide," the report said.

The aircraft pitch changed from -2 degrees nose-down attitude to +5.4 degree nose-up attitude, said the report. At the same time, the thrust increased from 1.3 to 1.7 engine pressure ratio (EPR). The sink rate decreased from 1,100 feet (335.5 meters) per minute to 190 feet (58 meters) per minute, said the report.

After 11 seconds, the pitch oscillated at +1 degree nose-up and the captain asked, "Can you hold it?" The first officer replied, "Yes." One second after the first officer's answer, the report said that the radio altimeter warning could be heard, indicating they were 200 feet (61 meters) AGL. The captain said, "Hold on let's try to ... ." At 1911:18, the aircraft struck the northern slope of the Stadlerberg, a wooded hill 2,090 feet (637.4 meters) high, located 5.2 nautical miles (9.6 kilometers) from the runway.

"The aircraft contacted the first trees in an essentially level flight path and with no roll angle, mainly with the right wing and forward fuselage," the report said. "As a result of the destruction, particularly in the right wing area, the aircraft received an asymmetric lift force which led to the next impact point with the trees having a considerable right wing low attitude. The aircraft turned itself further about its longitudinal axis to the right until it struck the ground, where the right engine was torn off before the tail unit finally separated, and the fuselage (together with the occupants) impacted the steep hillside."

The report said that the aircraft caught fire immediately after impact, and that the fire spread rapidly, although not over the immediate surroundings. Fire brigades were on the scene quickly and immediately began fighting the fire, the report said. The fire was not completely extinguished until the evening of the following day, because water spray was used to prevent unnecessary damage to the debris for the investigation, the report said.

The report noted that, "Among other reasons, the cause and the duration of the fire can be traced back to the 5,160 kilograms [11,376 pounds] of kerosene in the wing tanks."

During the next two days, a full in-flight calibration of ILS Runway 14 was conducted, and all parameters were found in order, the report said. It said all the other navigational aids were checked and found to be serviceable.

The report said that from the CVR recordings it was evident that as AZ 404 intercepted the localizer, the crew at first had trouble receiving the glideslope and selected No. 1 VHF navigation radio for the final approach. At about 12 to 13 nautical miles (22.2 to 24 kilometers) from the runway, they received a glideslope signal. The captain reported, "capture LOC, capture glide path capture, so we are on the beam a little off track, but ... ," the report said.

The report stated, "That the crew were of the opinion that the aircraft was on the ILS, a little offset to the east (this small initial offset caused by a slight overshoot of the localizer, is confirmed by the radar recording)." The aircraft was on the localizer, but about 1,300 feet (396.5 meters) beneath the glideslope, the report said.

On March 9, 1991, a reconstruction of the approach was flown using an Alitalia aircraft of the same type and equipment as AZ 404. The flight path was followed exactly down to an altitude of 4,000 feet MSL, the report said. It

was determined that until glideslope interception, the glideslope needles on all four instruments were in the fully UP position (out of sight), the report said.

On March 20, 1991, following data from the accident flight, an IFR-equipped helicopter made approaches down to the accident site. The glideslope indications remained in the full UP position, although in one instrument no warning flag appeared and in the other a flag appeared at a distance of 6.8 nautical miles (12.6 kilometers) on the ILS/DME (distance measuring equipment), the report said.

During AZ 404's approach, the captain reported the presence of a glideslope signal to the first officer, although this was at a distance and altitude where no glideslope indication should have occurred, the report said. The report said that since "the test of the ILS installation undertaken immediately after the accident confirmed its correct operation, particular attention was focused on the aircraft's navigation equipment."

The accident aircraft was one of a number of DC-9-32 aircraft that Alitalia had acquired from Aero Transporti Italiani (ATI), the report said. The ATI aircraft were equipped with King navigation receivers. The Alitalia aircraft of the same type were equipped with Collins navigation receivers. According to the report, the Collins and King receivers are completely interchangeable. In time, these units became fully intermixed, the report said.

On the day of the accident, the aircraft operated as AZ 404 arrived at Milan-Linate from Düsseldorf, Germany, at 0927

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hours. The report said that the inbound crew who flew the aircraft made the following entries in the Technical Logbook:

“1. VHF NAV 2: In Radio Selector position Radio 2 VHF-NAV 2 does not give a TO-FROM indication on (horizontal situation indicator) HSI 2. In position Approach no TO-FROM indication on HSI 2.

“2. CAT II Simul. Appr. At 200 feet [61 meters] the autopilot had a tendency to fly under the glide path then to return to it followed by an accentuated dive. The autopilot was switched off and we continued manually.”

The aircraft was then flown by the crew of AZ 404 from LIN to Frankfurt and return. The report said that upon return to LIN, the captain did not make an entry in the technical logbook. The captain explained the problem to the mechanic verbally: The failure had now been observed in position “Radio 1,” the report said. As a result of these observations, both VHF navigation receivers were replaced. The crew was asked to make a simulated CAT II approach at Zürich so the aircraft could gain its full CAT II status for the return flight to LIN; the weather indicated the possibility of CAT II conditions for the landing at LIN, the report said.

Alitalia employees changed both VHF navigation receivers for a King receiver KNR 6030 in the No. 1 navigation system, and a Collins 51RV-2B in the No. 2 navigation system, the report said. A self-test was conducted on both systems. Both technicians then checked the functioning of the equipment in the navigation mode, in that they switched off the signals of the LIN VOR and that of the LIN localizer. However, it was not possible to test the reception of the ILS glideslope signals because of the parking position of the aircraft, the report said.

Both the VHF navigation receivers installed in the accident aircraft were unmonitored units. According to the report, a major disadvantage of their analog ILS systems is that when no output signal is produced by the navigation receiver, the same indication is given as “on course” or “on glideslope.” This situation could occur with a short circuit or signal break between the receiver output and the indicator, e.g., HSI, the report said.

The report stated, “Based on the cockpit conversations, it can be assumed that the crew believed that there was a problem with glideslope signal No. 2, and therefore switched from approach to Radio 1.” The report added, “Based on the flight progress, it must be assumed that glideslope

indication No. 1 was unreliable.” The investigation concentrated on navigation receiver No. 1 (King KNR 6030).

The report said that examination of the navigation receiver gave no firm indications of a precrash deficiency. The report added that, “It can not, however, be excluded that this unit could have accounted for a ‘frozen’ centered glideslope indication.”

In June 1991, Alitalia informed the accident investigator-in-charge, “During an approach a centered localizer indication without a warning flag had been reported. The defective King KNR 6030 receiver had been removed. The defect could be verified in the workshop. A cold solder in the deviation driver circuit could be identified as the cause of the ‘frozen’ indication.”

The report stated that, “It cannot be excluded that a similar fault in the glideslope deviation driver unit could lead to a ‘frozen’ glideslope indication.”

In 1984, the Douglas Aircraft Company issued an “All Operator Letter” about the possibility of a frozen glideslope or localizer indication without a warning flag, the report said. The letter specified two navigation receiver groups: receivers that did not have a localizer and glideslope output signal monitor, and receivers with the respective monitoring.

The report said that in the group of monitored units Douglas Aircraft assumed that all Collins 51RV-2B units had been modified to monitoring status, as Collins had recommended in 1975. This assumption about the Collins units may have led to certain customers (such as Alitalia) not being alerted, and continuing to operate with unmonitored units, the report said. At the time of the accident, the Collins receivers were not modified at Alitalia, the report said.

In 1985, Douglas Aircraft conducted a seminar in the United States on the subject of “HSI/Glideslope Unflagged Failures,” the report said. Captains from Alitalia and ATI attended this seminar. The report said that during this seminar, attention was again drawn to the dangers of “unflagged glideslope failure” in connection with navigation receiver switching.

But the report said information from the All Operator Letter and the seminar was disseminated to Alitalia operating crews. The report said, “They, including the affected crew, were unaware of the possible false indications in question.” After the accident, Alitalia informed all pilots about the problem and such failures have been included in the training and refresher programs in the simulator, the report said.

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AZ 404 was equipped with two navigation receivers. The pilots had a choice of selecting as a source for their indicating instruments (HSI 1 + 2, ADI [attitude director indicator] 1 + 2) navigation receiver 1, 2 or separated, as desired. The switching was effected by a navigational switching unit (NSU) between the navigation receivers and the indicating instruments.

The NSU consists of a number of rotary switches that are positioned by a motor. The motor receives its control signals from a Radio switch located on the flight director control panel.

The radio switch has three positions:

- Radio 1: All indicators (HSI 1 + 2, ADI 1 + 2) receive signals from the output of navigation receiver 1;
- Radio 2: All indicators (HSI 1 + 2, ADI 1 + 2) receive signals from the output of navigation receiver 2; and,
- APP: HSI 1 and ADI 2 are fed from navigation receiver 1. HSI 2 and ADI 1 are fed from navigation receiver 2.

The NSU from AZ 404 was recovered from the accident site. Examination of the NSU showed that the switch position was undoubtedly Radio 1. Finding the NSU in position Radio 1 confirmed the position that the pilots selected for the approach according to the cockpit conversations. The report noted that during a routine approach with Alitalia, the position APP would be used.

AZ 404 was equipped with a navigation instrument comparator, which compares, among other things, the deviation signals of the glideslope and localizer. It produces an optical warning for the pilot on a “bow tie” indicator if a discrepancy is detected above a predetermined threshold. This comparator is only active when the Radio selector is in the APP position, e.g., when both navigation receivers deliver valid glideslope and localizer signals. In addition, the signal must be valid. In position Radio 1 or Radio 2 (e.g., navigation 1 or navigation 2), the comparator is not active.

The report said that as AZ 404 was being vectored for the approach, the crew had selected Radio APP on the Radio selector. Conflicting glideslope indications were observed on the captain’s HSI and the first officer’s HSI. Because of the disparity of the glideslope indications, the glideslope comparator warning light came on, the report said. The first officer asked the captain, “Do you have the glide?” The captain replied, “On 1...”

Five seconds later, the first officer said, “I don’t have it.” According to the report, the captain’s comment “on 1” referred to the indication on HSI 1, which was centered. When the first officer said, “I don’t have it,” he was referring to the indication on HSI 2, the report said.

The captain then said, “Good, let’s do it on 1,” whereby the first officer ordered “Radio 1,” the report said. On switching to Radio 1, all four instruments switched to the signal on navigation Receiver 1, the report said. The crew had a centered indication on all four instruments. This presentation corresponded with the pilots’ idea of their position and altitude, the report said.

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According to the report, the comparator of AZ 404 was recovered in a considerably damaged state. A closer examination of this unit was impossible. There was a slight possibility that a short circuit in the glideslope signal input of the comparator could have caused a centered glideslope No. 1 indication (without a warning flag), the report said.

According to Alitalia documentation, a Sundstrand Mark II ground proximity warning system (GPWS) was installed

in the aircraft. The GPWS belonging to the accident aircraft was not found, the report said.

The report said the sound of the GPWS was never heard on the CVR. The report said this “played a significant role in the accident sequence.”

The report said that in the final phase of the accident flight, the following GPWS warning modes might have applied because of the aircraft’s configuration (gear down, flaps down):

- Mode 1: Excessive sink rate;
- Mode 2b: Excessive terrain closure rate; and,
- Mode 5: Excessively below glideslope.

Referring to Mode 1, the report stated that “as the sink rate was within the specified limits at all times, this warning can be ruled out.” Referring to Mode 2a, the report stated that “a closure rate of about 4,000 feet [1,220 meters] per minute would have been necessary for a warning to be triggered.” With regard to Mode 2b, the fact that the “terrain” warning did not occur could be traced back to a combination of flight profile and terrain profile, the report said.

At one point, all conditions required for a Mode 5 warning were definitely fulfilled, the report said. The

possible reasons the report listed for the failure to occur were a GPWS computer defect and a false (centered) glideslope indication.

AZ 404 was equipped with a Sperry SP-50A autopilot. The report said that this autopilot enabled the pilots to lead the aircraft automatically to the glideslope and the localizer beams, and to remain on these beams.

The report said, "It appears from the digital flight data recorder (DFDR) trace that, in all probability, the aircraft captured and tracked the localizer beam with the autopilot." It is assumed that the navigation selector on the autopilot control panel was placed in the position ILS shortly before reaching the localizer beam, the report said.

In this position, the aircraft will continue in the same pitch mode ("altitude hold," "vertical speed," "indicated airspeed hold"). Shortly before reaching the glideslope, the autopilot will command the aircraft to descend with a descent rate of 700 feet (213.5 meters) per minute for 10 seconds and thereafter to follow the glideslope.

The report said that on the accident flight, on switching the navigation selector on the autopilot control panel, the aircraft was immediately commanded into a descent rate of 700 feet per minute. It can be assumed that the autopilot received an almost centered signal from navigation receiver No. 1, the report said.

The report said, "An analysis of the autopilot function and the flight profile shows that the autopilot was most probably following a centered 'frozen' glideslope signal." A reconstruction of the flight conducted by Alitalia showed that with the same fault, the profile was identical to that of the accident flight, the report said.

The report said that the following evidence supported a fault in the glideslope deviation circuit of navigation receiver No. 1:

- It is inferred from the cockpit conversation that the crew had set the Radio switch to the Radio 1 position (NAV 1). Alitalia requires the APP position;
- The examination of the navigation switching unit clearly shows that this was in position Radio 1; and,
- The impressions on the side of the glideslope scale on HSI 1 just above the center mark originate

from the glideslope needle and were caused by the acceleration forces during the collision process.

The report said that the following clues supported a malfunction in the glideslope deviation circuit of navigation receiver No. 1:

- The behavior of the autopilot during the approach;
- The behavior of the GPWS;
- The normal functioning of the ILS transmitter for Runway 14; and,
- The fact that even before this accident, similar problems had existed on other aircraft (centered "frozen" indications, according to the aircraft manufacturer).

The AAIB reviewed the possibility that a portable telephone or other portable electronic device might have been used by one of the passengers during the approach. No portable telephones were found in the wreckage, the report said. The report concluded: "There were no clues which could be traced back to the presence of other portable electronic devices except for an electronic calculator."

The AAIB also reviewed the possibility that the captain misread his altimeter by 1,000 feet (305 meters) during the approach. Because the captain was convinced that the outer marker height of 1,250 feet QFE had only been undershot by a small amount, he intervened during the first officer's go-around order, the report said. It said, "He [the captain] prevented the missed approach in the belief that with a reduced rate of descent or even a short level flight segment, the nominal glidepath could be attained within a short time."

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***"An analysis of the autopilot function and the flight profile shows that the autopilot was most probably following a centered 'frozen' glideslope signal."***

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AZ 404 was equipped with "drum-pointer" altimeters, according to the report. On this type of altimeter, the altitude is presented in 1,000-foot steps on a drum. For the details of the altitude above or below the particular 1,000-foot point, a needle points on a round scale. The 100-foot (30.5-meter) steps are numbered one through nine, and each step is marked by a small line.

The report noted that "these older models have the disadvantage that the altitude can only be read in two steps, because the main information is shown on the drum, and the refinements by a pointer on the round scale." A further complication is that in certain pointer positions, it is

not possible to read the drum adequately as the numbers on the drum are partially obscured by the pointer, the report said. Despite the white band that appears on the left side of the “thousands” figures, this can lead to an incorrect interpretation of the “thousands” value, the report said.

The report cited five studies by the U.S. National Aeronautics and Space Administration (NASA) on the problem of altimeter misreading. The following summary about these studies was made in the report:

- Misreading of drum-pointer altimeters occurs often;
- Several glances at the altimeter scale are necessary to assimilate all the information that is available;
- The pilot can recognize the relative needle position (left/right) with a short glance (0.1 seconds);
- Reading the drum (thousand indication) requires 0.6 seconds and is more difficult than reading a needle. As a result, the drum is consulted less frequently; and,
- During an approach, the altimeter is consulted about 3 to 6 percent of the time. The NASA studies showed that the pilots surveyed believed that they had monitored the altimeter during 20 percent to 25 percent of the approach.

The report cited a NASA study that contained the following results of a survey of 169 Boeing 727 pilots. The study concluded that 137 pilots said that they had already misread an altimeter; that 137 pilots had observed another pilot misreading an altimeter; that 85 percent of both groups explained that they had made these observations more than once; and that a surprisingly high number of misreadings (50) occurred during the approach phase.

Seven other reports and articles on the problem of drum-pointer altimeters were listed in the report, including a Flight Safety Foundation *Pilots Safety Exchange Bulletin*, 69-103/105, “Misreading of Altimeters.”

The report said that only small parts of one of the drum-pointer altimeters on AZ 404 were found in the wreckage. The report noted that the “degree of destruction was so great that no readings and no further examination was possible.”

The AAIB reviewed the qualifications, personal conduct and professionalism of the captain and first officer of AZ 404. The captain, 47, held an airline transport pilot license

(ATPL) issued by the Italian government and was fully qualified to act as captain on the DC-9-32. His flight experience totaled 10,193 hours, with 3,194 hours in the DC-9.

The captain entered service with Alitalia in 1970. His military flying experience was about 1,200 hours. He had flown about 8,000 hours as first officer on DC-8, DC-9 and B-727 aircraft and had been operating as captain on the DC-9 since 1988, the report said. His last license medical check, in June 1990, found him fit without restrictions, the report said.

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***The captain and first officer flew together the day before the accident.***

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The first officer, 28, held an ATPL issued by the Italian government, and was fully qualified to act as first officer on the DC-9-32. His flight experience totaled 831 hours, with 621 hours (all as first officer) in the DC-9-32. The first officer received his pilot training from Alitalia, after which he was employed as a first officer on the DC-9-32 in 1989, the report said. His last license medical check, in June 1990, found him fit without restrictions, the report said.

The captain and first officer flew together the day before the accident. Before these two working days, both pilots had more than 48 hours off-duty.

The AAIB attempted to judge the human relationship in the cockpit by reviewing the CVR. The report said that the quality of the CVR was poor, thereby requiring a great deal of effort to understand the cockpit conversations. The report added: “The reasons for this bad comprehension are due on the one hand to the inferior technical quality of the recording equipment, but in particular it is due to the fact that the pilots, even during the approach, did not make use of the headsets (with attached microphones) for communications with the approach controller as is usual.” Thus the conversations between the pilots were partly obscured by external radio communications.

The report said that the psychological interpretation of the sound levels with respect to the feeling and atmosphere in the cockpit was particularly difficult. “It can certainly be stated that during the entire flight, the conversation restricted itself to operational matters,” the report said. It said the captain showed his experienced-based superiority.

During the cruise portion of the flight, the crew received the ATIS, which indicated weak surface winds and that Runway 14 was the landing runway. The report said it was noteworthy that the captain then entered an unusually long discussion about the possibility of circling to land on Runway 28. During their descent, the captain questioned the first officer about radio failure procedures, which was unusual, the report said. According to the report, errors developed during the confirmation of the CAT II minimum



and the go-around procedures, and the first officer had the wrong landing chart in front of him. The instructional tone used by the captain to the first officer on many occasions was noteworthy, the report said.

The report said evidence suggested that the crew did not strictly adhere to Alitalia operating procedures. Had the crew followed the procedures, the void (coordination and cooperation) between the captain and the first officer would probably have been covered during the critical phases, the report said. Extracts from the Alitalia company manual were cited, which required:

- Approach briefing;
- Initial approach altitude;
- Minimum safe altitude (MSA) briefing;
- Standard operative call-outs, e.g., “localizer alive,” “glideslope alive”; and,
- Conditions requiring a missed approach.

The report cited Alitalia flight operating rules, which contained the instruction that “during an IMC [instrument meteorological conditions] instrument approach, a go-around shall be flown if there is any doubt about the functioning of available navigation aids.”

About 40 seconds before impact, the first officer asked whether the outer marker had been overflowed; the captain said it had not. Immediately afterward, the first officer noted that the distance was seven nautical miles on the ILS/DME. The report noted that the “resultant uncertainty is audible on the CVR.” Even if the altimeter had been misread by 1,000 feet, this still would have suggested a go-around, the report said. But the go-around executed by the first officer was not accepted by the captain. The report stated that, “Even the radio altimeter warning which sounded 10 seconds later caused no reaction.”

The report concluded: “Two independent studies have shown that had a go-around been continued, the Stadlerberg would have been cleared, albeit very close.”

A go-around is seen as a failure, a lack of professional competence and even loss of prestige, the report said. Before the critical situation, the captain had already mentioned a possible go-around because of the proximity of the preceding aircraft, suggesting that the captain wanted to avoid a go-around. His pointed self-confident manner

toward the first officer, in addition to internal resistance, did not make it easier for him to accept a go-around, the report said.

The AAIB reviewed the actions of the air traffic controllers and the procedures and equipment at the time of the accident. As AZ 404 received the final radar vector for the ILS, the approach controller instructed the crew to descend to 4,000 feet, turn right to 110 degrees and cleared the flight for the approach. This clearance guaranteed terrain clearance until the FAP.

As the aircraft’s heading changed to 150 degrees, the controller assumed that the crew of AZ 404 was navigating on its own and was establishing the aircraft on the localizer, the report said. According to procedures, the radar vectoring is completed after the “established” on the ILS call. This call should be requested by the controller and in this case was omitted, the report said. The crew of AZ 404 did not call on their own initiative, the report said.

According to the published procedure, AZ 404 should not have descended below 4,000 feet until established on the ILS and at a distance of eight nautical miles (14.8 kilometers) on the ILS/DME. In fact, the aircraft descended below 4,000 feet when intercepting the localizer at a distance of about 11.5 nautical miles, flying parallel and beneath the glideslope with a constant descent rate until impact, the report said.

Although the altitude transmitted by the aircraft transponder was clearly visible on the approach controller’s radar screen, he did not recognize it, and he did not notice that the aircraft had already left its cleared altitude before the FAP (eight nautical miles), the report said. According to standing instructions, until this point the approach controller must check the adherence to cleared altitudes and must intervene in an undershoot, the report said. The report said that the controller omitted this check because he believed that his monitoring function was finished. The aircraft was on the localizer at the instructed speed, and he assumed that the aircraft was also established on the ILS.

The report said that this assumption could be explained because during the duty time of an approach controller, a large number of aircraft are observed on the localizer on the radar screen compared with very rare cases of aircraft being below the cleared altitudes and the glideslope. The failure to call “established” by the pilots happens from time to time and was generally tolerated by air traffic control, the report said. The constant flow of traffic at Zürich can be dense and did not seem to allow time-consuming questioning. In this situation, it is expected

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that an aircraft observed on the localizer will also follow the prescribed approach profile, the report said.

The report said, "It must be noted that the approach controller never gave Flight AZ 404 position or distance information relative to Runway 14." He merely gave a distance to the preceding aircraft, the report said. The instruction to change frequency with an indication of the relative position to the preceding airplane and the clearance that there were no more speed restrictions did not give the crew any reason to analyze their position, the report said.

The AAIB said that the clearances and instructions of air traffic control contained no incorrect statements. But the report concluded: "As a result of omissions by not following the standing instructions, the disastrous sequence was not interrupted by ATC."

The report noted that the radar equipment at Zürich did not have minimum safe altitude warning (MSAW), which is standard in the United States.

In reviewing airport equipment, the AAIB reported that Runway 14 was not equipped with a visual approach slope indicator (VASI) or a precision approach path indicator (PAPI). The accident site lies on the extended centerline of Runway 14 and has no obstruction lighting, the report said.

Other aircraft on the approach during the same period as AZ 404 had the approach and runway lighting almost continuously in sight according to the report. The report noted: "In the final phase, it could be that the approach and runway lighting of Zürich Airport may have been obscured for an aircraft flying too low by a cloud cap on the Stadlerberg."

The AAIB report listed the following causes for the accident:

- A false indication of VHF navigation unit No. 1 in the aircraft;
- A probable altimeter misreading by the captain;
- No GPWS warning in the cockpit;
- Pilots not aware of the possibility of incorrect indications in the navigation equipment in use (without flag alarm);
- Inadequate failure analysis by the pilots;
- Noncompliance by the pilots with basic procedural instructions during the approach;

- Unsuitable cooperation between the pilots during the approach;
- Go-around initiated by the first officer aborted by the captain; and,
- Failure of approach controller to observe the aircraft descending below the cleared altitude of 4,000 feet MSL before the final approach point.

The AAIB issued 15 recommendations as a result of its investigation that included:

- Navigation equipment that does not have monitoring of the output signal should no longer be used;
- The use of the drum-pointer altimeter of the type used in AZ 404 should be discontinued immediately;
- The GPWS should operate in the event of a navigation receiver failure;
- It should be evaluated whether all navigation instruments should be allowed to be switched onto one receiver as a normal procedure;
- The flight procedures of an air transport company should ensure that a go-around once started cannot be stopped;
- The duties of the approach controller should include warning pilots in the event of an altitude undershoot of the minimum safe altitudes. A warning system similar to that used in the United States (MSAW), which gives an optical and acoustic warning when an aircraft undershoots an altitude, should be added to ATC equipment;
- Obstacle lighting should be installed on the Stadlerberg; and,
- ILS runways should be fitted with optical approach aids.

A representative of the U.S. National Transportation Safety Board (NTSB) participated in this accident investigation. In a letter to the AAIB, the NTSB made the following comments on four areas of the final report:

1. "Although the final report concludes that if the go-around initiated by the first officer had been completed, the accident would not have occurred, this is not listed as a cause. The NTSB believes the captain's

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***The report noted that the radar equipment at Zürich did not have minimum safe altitude warning (MSAW), which is standard in the United States.***

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actions to stop the go-around should be considered a cause of the accident.” [This was later added to the list of causal factors.]

2. The NTSB noted that there are newer, more advanced navigation receivers that are not able to detect a signal break or open circuit between the receiver output and the cockpit instruments. “We would like readers of the report to also realize that the basic avionics design concerning navigation receiver failure monitoring depends on the flight crew properly performing the checklist, when differences are noted between receivers, regardless of the type of receiver installed in the aircraft. Had the flight crew properly ascertained which receiver was malfunctioning, they should have been able to successfully complete the approach.

3. “We do not fully understand the fourth cause of the accident, ‘Pilots not aware of the possibility of incorrect indications in the navigation equipment in use.’ It appears to us that the crew of I-ATJA was aware of the possibility of incorrect indications in front of them on the accident flight. What we believe is that Alitalia pilots in general were not aware of the fact that the instrument indications could be incorrect with no ‘off’ flags showing.

4. “The NTSB believes that the final report overemphasizes the disadvantages of the drum-pointer altimeters in this particular accident sequence of events. The second cause states, ‘Probable altimeter misreading occurred by the captain.’ It is possible that a drum-pointer altimeter misreading occurred, but in our view, not obvious, or probable, that the altimeter was misread in this specific case, as the report states.”

According to the NTSB letter, it appeared as “if there is no physical evidence that the captain had read a height below 1,000 feet as a height above 1,000 feet when he stopped the go-around maneuver. The comments on the CVR concerning the outer marker check at 1,250 feet and the first officer’s comment shortly thereafter, ‘Didn’t we pass the outer marker?’ indicate that the pilots were aware of their altitude during the approach but were very confused about their distance from the airport. In addition, the NTSB did not believe a captain with more than 10,000 hours of flying time (most of which probably involved drum-pointer altimeters) would overlook

the distinctive crosshatched scale only visible below 1,000 feet on his altimeter.”

In 1992, the NTSB issued the following safety recommendations to the U.S. Federal Aviation Administration (FAA):

“Issue an Air Carrier Operations Bulletin to Principal Operations Inspectors requiring that operators of airplanes equipped with the following navigation receivers include in their operating manuals procedures for detecting malfunctions that result in the display of disparate information: Collins model 51RV-1; Collins model 51RV-4; Wilcox model 806; King model KNR 6030; and some versions of Bendix model RNA 26C. Also notify formally foreign airworthiness authorities about the potential failure mode in such equipment.”

The report said that the NTSB recommended to the FAA that pilot handbooks of those airlines that use navigation receivers of the models specified should include an appropriate warning, and that the non-U.S. aviation authorities should be informed. Alitalia has already amended its books accordingly and has already complied with this recommendation, the report said.♦

Editorial Note: This article was adapted from *Final Report of the Federal Aircraft Accidents Inquiry Board Concerning the Accident of the Aircraft DC-9-32, Alitalia, Flight No. AZ404, I-ATJA on the Stadlerberg, Weiach/ZH of 14 November 1990*, Report No. 1990/57/1457, a special report prepared at the request of the Swiss Federal Aircraft Accidents Inquiry Board. The 95-page report includes illustrations and appendices.

### ***About the Author***

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