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Aircraft Descended Below Minimum Sector Altitude and Crew Failed to Respond to GPWS as Chartered Boeing 707 Flew into Mountain in Azores

Poor cockpit discipline, nonstandard phraseology and poor radio communications technique, nonadherence to company procedures, limited crew experience and inadequate training were among the facts cited in the Portuguese controlled-flight-into-terrain accident report.

Capt. Thomas A. Duke
with
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On Feb. 8, 1989, Independent Air 1851 (IDN 1851), a Boeing 707-331B, while in clouds and heavy turbulence and after seven seconds of "whoop whoop, pull up" from its ground-proximity warning system (GPWS), flew into Pico Alto, a mountain on the island of Santa Maria, Azores, Portugal. The aircraft was destroyed and there were no survivors among the 137 passengers and seven crew members.

U.S. Oversight Weak in International Operations

Independent Air was a small charter company based in Smyrna, Tennessee, U.S., that operated two Boeing 707s, according to the official accident report prepared by the Portuguese General Directorate of Civil Aviation, Department of Accident Prevention and Investigation. The company's traffic was generated primarily by tour operators, but the company also contracted unscheduled flights for the U.S. military.

The accident aircraft was manufactured in 1968 for Trans World Airlines, and was currently owned by IAL Air Services Inc., which leased the aircraft to Independent Air. At the time of the accident, the aircraft had logged 44,755.3 hours and 12,589 landings, with 186.9 hours and 48 landings since its last inspection.

The report said, "The [U.S. Federal Aviation Administration (FAA)] principal operations inspector (POI), [who was] responsible for Independent Air, was assigned in 1987 and was also responsible for two other operators. He was not qualified in the B-707. He spends about 25 [percent] of his time working Independent Air, by maintaining daily telephone contact, visits to corporation (headquarters) about three times a month and does flight inspections twice a year.

"He supervised instruction classes several times, not following them to completion. He also observes simulator training, but is not qualified to give check rides [which were performed by other FAA personnel from Dallas, Texas, and Miami, Florida, where B-707 simulators were located].

"From Jan. 1, 1988, to Feb. 8, 1989, the date of the accident, there were 118 inspections, covering flight operations, airworthiness of the aircraft, training and check rides of the flight crews, maintenance, aircraft records, weight and balance, etc.," the report said. The report noted that the number of inspections was typical for this kind of operation but "that it was not possible to determine [their] efficiency."

The report said that there were 12 checks on international operations from Dec. 14, 1986, through Jan. 15, 1989. Three

of those checks were on Atlantic Ocean routes, but Santa Maria was not among them.

The report said, "Although 12 line inspections on international routes were given, it is the belief that the inspectors did not have adequate experience and knowledge," the report said. It also noted the limited experience of the crew in international operations and in the airspace in which the crew was operating at the time of the accident.

The report added: "However, it was verified that the principal operation[s] inspectors were not given special training, which would allow them to adequately check international operations except for over-water navigation.

"It is a fact that, although there is almost universal adherence to ICAO [International Civil Aviation Organization] standards regarding air traffic control phraseology and procedures, there are several countries that use peculiar phrases and procedures.

"Navaids [navigation aids] are fewer and sometimes less reliable. The English used by [air traffic control], although fluent, can present an accent that is difficult to understand for [U.S.] pilots, especially if the international experience is limited.

"Sometimes some sounds are not pronounced the same as in English, such as 'th' in the word 'three.'

"On the other hand, the national language is used by domestic operators and is not understandable to North American flight crews, who can be taken by surprise by maneuvers of others [who have been communicating in their native languages, not English].

"Recognizing this situation, the NTSB [U.S. National Transportation Safety Board] recently issued, on a date prior to the accident, two recommendations with the purpose of having the FAA instructing their inspectors to pay more attention to air carriers involved in international operations [necessary] to increase flight crew vigilance when operating in airports outside the United States, and to verify if flight crew instruction programs [are] adequate for safe international operations.

"However, it was verified that the [POIs] themselves lacked specific training and experience to check this kind of operation and they do not receive any special training.

"It must also be added that the FAA does not supply any information that could be used as study material to its inspectors or to the air carriers involved in this kind of operation."

GPWS Training Excluded From Simulator Checks And Instruction Manuals

The report said that after the NTSB recommendations were made, the FAA issued on Aug. 12, 1987, changes to the *Air Carrier Operations Bulletin* (*ACOB*) that required "a review of flight manuals and training programs to assure compliance with [Federal Aviation Regulations (FARs) Part 121.360], which required that these manuals contain adequate information regarding the actions to take by the flight crews upon hearing the GPWS alarm, and that the flight training programs, initial and recurring, have the appropriate information for the instructors and examiners with respect to the response[s] of pilots facing the GPWS.

"… because the simulator's GPWS would activate during normal approaches, instructors usually disabled the system or instructed the students not to react when the GPWS would sound."

"However, it is verified that the inspectors in charge of Independent Air ignored this change to the *ACOB*, and there was no mention in the instruction manual of Independent Air of information on the response to the GPWS."

Independent Air's flight training was conducted in simulators that were owned by other airlines — one in Texas and one in Florida. During the accident investigation, it was learned that "the simulators were not programmed for the same approach speeds and flap settings as used by the accident aircraft, because [the simulators] had not been modified with the installation of 'hush kits.'" [Hush kits were installed on the B-707s operated by Independent Air.]

"Thus, because the simulator's GPWS would activate during normal approaches, instructors usually disabled the [GPWS] or instructed the students not to react when the GPWS would sound," the report said.

Independent Air's operations manual did require that "if a ground-proximity warning is observed or heard immediately execute a pull-up and apply go-around thrust. Maintain maximum rate of climb consistent with speed and configuration until warning ceases."

Captain Returned to Duty After Orthopedic Surgery

The captain, 41, had logged 7,766 total hours, including 766 hours (with 488 hours as pilot-in-command [PIC]) in the Boeing 707; 2,259 hours in the Boeing 727 (with 1,912 hours as PIC); and 2,000 hours of rotary-wing time, as well as other fixed-wing time. During the 30 days prior to the accident, he

had flown 22.6 hours. He held an Air Transport Pilot (ATP) certificate.

He had received his private pilot certificate in 1971. He later became a helicopter pilot in the U.S. Army. In 1975, he became an FAA air traffic controller and also became a helicopter pilot in the Tennessee Army National Guard.

From December 1979 to October 1980, he was employed as a pilot by two commuter/charter operators in the Caribbean. In October 1980, he was employed by a FARs Part 121 Supplemental Air Carrier as a flight engineer on B-727 aircraft. From October 1981 until May 1986, he was employed by a different Part 121 Supplemental Air Carrier and became a B-727 captain.

He was employed in May 1986 by a Part 121 Domestic Carrier until April 1987, when he joined Independent Air as a B-707 first officer. In July 1988, he became a B-707 captain.

The accident report said that the captain had "an unquestionable passion for flying," and often spent his off-duty time flying his personal aircraft or aircraft belonging to his friends. He was credited with having a "very professional behavior inside and outside the cockpit," said the report.

The captain had undergone orthopedic surgery on one foot in December 1988 to correct an injury incurred during his youth. The recovery required approximately six weeks. Because he did not require any medication, he was able to return to duty on Jan. 25, 1989.

Nevertheless, during the investigation, a friend of the captain reported that the captain had flown in a private aircraft a week before the accident and that he [the captain] was unable to use the rudder pedals [because of foot discomfort] when the aircraft was ready for takeoff. The friend also reported that during that same week, the captain had felt so much discomfort that he had sought relief by resting his foot on several pillows.

First Officer Frequently Self-medicated With Antihistamines

The first officer, 36, had logged 3,764 total hours with 64 hours in the B-707, including 37.6 hours in the 30 days before the accident. He was in his first month of Part 121 airline operations after initial training and held an ATP certificate.

He received his private pilot certificate in 1980. He was employed as a flight instructor, first officer, captain and chief pilot by several Tennessee companies from 1983 until October 1988. In his last position, which he held for 20 months before being hired by Independent Air, investigators reported that he was chief pilot for an air charter company and that he was a Piper PA-31 [reciprocating twin-engine aircraft seating six to eight passengers] check pilot. The report said that he was "highly motivated in his profession."

He was hired by Independent Air in October 1988. He completed a "707 Flight Training Initial Course," which began on Nov. 23, 1988, and "consisted of three simulator sessions (pilot time [five hours], observer time [six hours], with a check ride in the last session, [Nov. 26, 1988]." He completed 194 hours of ground school by Nov. 29, 1988. On Nov. 28, an examiner approved him to begin his initial operating experience (IOE). The IOE period began on Dec. 15, 1988, and included eight flights, nine takeoffs and nine landings during nearly 34 hours of operations. On Jan. 23, 1989, he was qualified as a first officer.

The report said that the first officer's pilot time in the simulator was insufficient, but recognized that it was "allowed under Part 121, which allows reductions in minimum times."

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In addition to the first officer's inexperience with the B-707, the report also noted that his line experience had begun 15 days before the accident and that he was flying to Santa Maria for the first time on the accident flight. The report said that the captain and the flight engineer had previously transited Santa Maria.

During the investigation, it was learned that the first officer's mother had died and that he had declared personal bankruptcy in the months before he had been employed by the company. The first officer's girl friend said that she believed that he had recovered completely from both events and that "he was very pleased with his new job with Independent Air." Investigators also learned that he often suffered from allergies and frequently used antihistamines for self-treatment.

Flight Engineer Was Undergoing Psychiatric Treatment

The flight engineer, 34, had logged 6,756 total hours with 1,056 hours in the B-707; 2,888 hours in the B-727; and 2,823 hours in the Lockheed Galaxy C-5A. He had logged 95.8 hours in the 30 days before the accident.

During the investigation, "the flight engineer was described by his colleagues as being an outstanding professional … ." He reportedly maintained a personal set of navigation charts

"so that he could monitor the approaches and supply the pilots with the required information," the report said.

Investigators learned that he was undergoing psychiatric treatment "due to serious family problems because of aggressions" but that he was making progress, the report said. The day before the accident, he contacted his wife to discuss a reconciliation. Investigators also learned that he "suffered from a chronic allergy, undergoing weekly treatments since April 1988, having received the last anti-allergy shot six days prior to the accident."

The accident report considered how the "psychic and physical" conditions of the crew members might have "interfered with the necessary 'availableness' of the psychic performance of their duties" and noted that these medical conditions were not on file with the FAA.

Delays Resulted in Crew's Assignment to Accident Aircraft

After traveling to Montego Bay, Jamaica, on Feb. 3, 1989, the three crew members flew on Feburary 4 from Montego Bay to Fort Worth, Texas, and then to Denver, Colorado. The route was reversed on the return trip and the crew arrived in Montego Bay on February 5. The three crew members were reassigned the same day to IDN 1851 because of crew duty-time problems caused by delays on their previous flight.

The crew arrived in Genoa, Italy, on Feb. 7, 1989, after a 10-hour and 40-minute overnight flight from Montego Bay. They were scheduled originally to land at Malpensa, near Milan, but the flight was diverted because of fog. They traveled by bus for three hours to Bergamo, northeast of Milan, for a 46-hour layover near their scheduled departure airport. Their activities in Bergamo are unknown, but they appeared cheerful when departing the hotel early in the morning of February 9, said the report.

Their return flight was rescheduled to depart from Genoa, because of forecasted fog. Nevertheless, after the fog cleared unexpectedly, the inbound flight was able to land at Bergamo at 0720 UTC [all times are Coordinated Universal Time]. The aircraft, scheduled for departure at 0800, departed at 1004 for its four-hour and 10-minute flight to Santa Maria.

The report said, "The operational flight plan supplied by Lockheed Data Plan, designated the arrival point as LPAZ with ground coordinates of N36756 [latitude] and W025096 [longitude] that . . . does not correspond to ground coordinates of any of the navaids of Santa Maria [Airport] or the airport reference point. Therefore this flight plan was not made according to the established procedures in the [Aeronautical Information Publication (AIP)-Portugal], which indicates as an entering route ECHO [a compulsory reporting point]-NDB [nondirectional beacon]-SMA [Santa Maria]."

The report said that the arrival point was identified as a point on the final approach of Runway 33 at a distance of [820 feet to 984 feet (250 meters to 300 meters)] from the runway threshold. The airport elevation on the operational flight plan was also shown as zero feet, but the actual elevation of the airport is 305 feet (93 meters).

There were other errors on the filed flight plan and the computed weight and balance that had no bearing on the accident, said the report.

Aeronautical Information Suffered from 27 Years of Handwritten Changes

The report said that during the investigation, it was discovered that "words from the ICAO phonetic alphabet were used to designate significant points of lateral limits of the Regional Terminal Control Area of Santa Maria, which contributed to the fact that the Oceanic Clearance was not clearly understood by the flight crew and that there were difficulties on the comprehension of the Selcal of the aircraft by the air traffic controller on duty." [Selcal (selective calling) enables ATC to make radio calls to specific aircraft by electronically using four-letter designations.]

The report added, "aeronautical information for this region, included in the AIP-Portugal, was not properly updated [since 1962], containing a number of errors, omissions and impreciseness (sic), not in conformity with international rules adopted by the Portuguese Republic.

"Regarding the [Santa Maria Aeronautical Charts and the Instrument Approach and Landing Charts, which were dated Feb. 1, 1962], for the last 27 years handwritten corrections were used without the proper registration and quality, which had not occurred with the remaining aeronautical charts of other airports, which had their charts reviewed between 1984 and 1988, with the exception of one chart of 1973. The accumulation of [handwritten] amendments and notes and the significant change of the procedures on instrument approaches required by itself the revision of these charts, which did not occur, in violation of the rules that determine the revision of aeronautical charts."

The report said that restrictions against using the Santa Maria very high frequency omnidirectional radio range (VOR) as a primary navigation aid were not published in the AIP-Portugal, and invited the VOR's use as a primary navigation aid in the terminal area. Moreover, citing ICAO's requirements, the report said the " primary navigational aid in a terminal region must be a VOR, that must be installed in a location that permits the most efficient possible approach procedures. The NDBs must be used for holds when it is not possible or practical to install a VOR for that purpose."

The report said, "Therefore, because it is usual in the United States and Europe to use a VOR to define ATS [Air Traffic

Services] routes and holds, and because there was no knowledge of the VOR restrictions and because there was not a clear perception of the Oceanic Clearance that was given, and because of the information given in the regional Jeppesen chart and in the operational flight plan, it created a scenario that could have [led] the flight crew to consider the Santa Maria VOR as the primary navigational aid in the terminal region.

"This procedure was frequently used by aircraft using the Santa Maria Airport ... that it was usual for aircraft to fly over Santa Barbara County heading for the airport, which would not occur if they were heading for the NDB."

The accident aircraft's overflight of Santa Barbara was unusual because of the aircraft's low altitude, which was determined by investigators to be 700 feet [213 meters] above ground level [AGL].

The crew's charts were not recovered after the accident, but the company provided two sets of Jeppesen charts for each aircraft, so investigators believed that those were the charts that the crew had been using. Although the investigators assumed that those charts would contain the same level of information as the Portuguese information, "it is verified that [Jeppesen] contains a better level [of] information ..." but that there were some errors in those charts too.

The report said that Jeppesen's depiction of "the [Santa Maria] VOR and NDB SMA were coupled in the same rectangle leading one to conclude that [the Santa Maria] VOR is also a navaid defining the structure of routes that serves Santa Maria [Airport]."

The report also said that a 98-foot [30-meter] high television antenna was about 656 feet [200 meters] from the accident site, which resulted in the top of the antenna being the highest point on the island at 2,025 feet [617 meters] and located less than five nautical miles (nm) from SMA NDB.

The antenna was not marked on the aeronautical charts and no license had been issued to permit its erection, although its existence resulted in minimum altitudes being too low and "jeopardized the safety of flights in this area."

Many other specific anomalies of the Santa Maria information were cited, but the report said "these did not contribute in any way to the accident."

Data Showed Difficulties with Routine Radio Communication

During the flight, the crew of IDN 1851 and air traffic controllers experienced reception difficulties on the high frequency (HF) channels [see transcript of excerpted communications, at right] used for communication during the flight; there were no indications of equipment problems on the aircraft or on the ground.

Excerpt of transcribed communications on 13,306 KHz. IDN 1851's communications with Santa Maria Aeronautical Station (SMARTF) began at 1222:18 and ended at 1330:30.

To	From	Time	Text
IDN 1851	SMARTF	1246:33	Santa Maria oceanic clears Independent one eight five one to proceed via MAKIN three eight north two zero west ECHO Sierra Mike Alfa flight level three five zero Mach decimal eight zero read back read back
SMARTF	IDN 1851	1247:05	Independent one eight five one is clear to MAKIN thirty eight north two zero west to ECHO maintain flight level three five zero
IDN 1851	SMARTF	1247:20	Independent one eight five one Santa Maria after two zero west will be ECHO point ECHO point then Sierra Mike Alfa flight level three five zero Mach decimal eight zero over
SMARTF	IDN 1851	1247:38	After thirty eight twenty it is ECHO point then Santa Maria
IDN 1851	SMARTF	1247:44	After — correction your Mach number is eight zero and I need your Selcal code Selcal
SMARTF	IDN 1851	1247:54	Mach number is eight zero Selcal is Echo Mike Alfa Lima
IDN 1851	SMARTF	1248:03	Confirm Echo Mike Alfa Lima
SMARTF	IDN 1851	1248:07	Negative negative Echo Mike Alfa Lima
IDN 1851	SMARTF	1248:12	Roger Echo Mike Alfa Lima coming up
		1248:15	Selcal
SMARTF	IDN 1851	1248:24	Negative Selcal will you try again Echo Mike Alfa Lima
		1248:28	Selcal
SMARTF	IDN 1851	1248:34	Roger Selcal checked this time
IDN 1851	SMARTF	1255:00	Independent one eight five one Santa Maria
SMARTF	IDN 1851	1256:47	Santa Maria Radio Santa Maria Independent one eight five one position
SMARTF	IDN 1851	1258:50	Santa Maria Radio Independent one eight five one position
IDN 1851	SMARTF	1258:55	Independent one eight five one stand by

IDN 1851 SMARTF 1301:09 Independent one eight five one Santa Maria go ahead

SMARTF IDN 1851 1301:35 Santa Maria Santa Maria Independent one eight five one

IDN 1851 SMARTF 1301:38 Independent one eight five one go ahead with your position report

SMARTF IDN 1851 1301:49 Santa Maria Independent one eight five one is MAKIN one two five five flight level three five zero estimating three eight north two zero west at one three two seven ECHO is next

IDN 1851 SMARTF 1302:10 Independent one eight five one MAKIN one two five five flight level three five zero estimating three eight north two zero west at one three two seven and ECHO next report two zero west on VHF one two seven decimal niner one two seven decimal niner and secondary eight eight two five Santa Maria

SMARTF IDN 1851 1302:40 One eight five one roger two seven point niner or eight eight two five

IDN 1851 SMARTF 1302:46 One one two seven decimal niner one two seven decimal niner

SMARTF IDN 1851 1302:52 Twenty seven decimal niner

IDN 1851 SMARTF 1302:55 Negative sir VHF one hundred twenty seven decimal niner Santa Maria

IDN 1851 SMARTF 1303:10 Independent one eight five one did you get

SMARTF IDN 1851 1303:16 Yes sir affirmative we got the frequency

SMARTF IDN 1851 1329:25 Santa Maria Radio Independent Air one eight five one position

IDN 1851 SMARTF 1329:36 Independent one eight five one Santa Maria go ahead

Source: Portuguese General Directorate of Civil Aviation

The report said that the first officer gave incomplete readbacks of the clearance [at 1247:05 and at 1247:38] regarding the route, ECHO Sierra Mike Alpha, "which ended up being accepted by the aeronautical station [controller], who only required the correction of the Mach number and the Selcal of the aircraft ... ."

The report said "the identification of the final approach fix was never clearly understood by the flight crew. The two readbacks omit the name of the final approach fix. The first [readback] ends on ECHO and the second [readback] refers '... ECHO point then Santa Maria." The report also suggested that the similarity between the Selcal (Echo Mike Alpha Lima) and the final fix (ECHO Sierra Mike Alfa) "might have contributed to an unclear understanding of the final route."

"It has been established by this [Inquiry] Committee that the aircraft was flying with great precision on the route from point ECHO to [Santa Maria] VOR, a route that is very close to the one shown on the flight plan. As a matter of fact, VSM [the three-letter Morse code identification for Santa Maria VOR] is registered in the cockpit voice recorder ... ," the report said. Thus, investigators believed that the aircraft was flying to the Santa Maria VOR instead of the Santa Maria nondirectional beacon (NDB).

"Although the route followed by the aircraft from ECHO point to the Santa Maria VOR and the route in the flightplan were within the protected airspace of the authorized and published route, it is the belief of this commission that if the aircraft had flown on the route to the SMA NDB with the same precision, . . . although still in a situation of lesser separation with the ground and in violation with the minimum safe altitude ... it would not have collided with the ground," the report said.

The report added, "On all the frequencies where there were communications with IDN 1851 or related to it, it is a fact that there were a large number of errors and inaccuracies on the language used and not following standard phraseology, as well as bad technique of communications both by ATC and the aircraft, with special emphasis on the aircraft.

"Thus, it is obvious that the use of irregular enunciation of numbers [and] expressions of courtesy are not recommended, as well as the nonuse of the word 'decimal' for separating numbers of radio frequencies."

The report said, "In regard to the communications transmitted by the aircraft, it must be said that in the frequency of 13,306 Kilohertz, the crew used the frequency for four periods of time for a total time of twenty three minutes during which 28 messages were broadcasted, correcting and checking the meaning of six messages, and 49 messages to establish, prolong or interrupt contact, which shows a bad communications technique probably caused by the inexperience of the copilot or perhaps by the lack of concentration regarding the job he was doing."

The report continued: "On HF and VHF [very high frequency] communications, it can be noted that [17] groups of numbers were transmitted with a maximum of four numbers of which eight of them had to be repeated due to lack of comprehension by the copilot revealing bad communications technique as well as the non use of standardized phraseology."

At 1343:57 [see cockpit voice recorder (CVR) transcript, page 8], the flight engineer contacted Santa Maria Approach and requested the current meteorological report. The report said that this was the only communication made by the flight engineer and that all other radio communication had been made by the first officer.

After establishing contact with the flight, at 1344:20 the trainee controller transmitted: "One eight five wind two six zero ... Fourteen ah fourteen knots maximum two four knots visibility more than ten kilometers one octa at one two zero zero feet six octa at three thousand feet ah temperature one seven QNH [altimeter setting to obtain mean sea level pressure of the airport] one zero one niner."

The report said that the meteorological information transmitted by the controller might have contributed to crew confusion because "the word 'at' was wrongfully used in the expression 'one octa at one two zero,' [and] on board the aircraft [CVR] it sounded like 'one octa two two zero,' leading the crew to assume that below two thousand feet they would be below the clouds as stated in the CVR [at 1403:55]."

At 1356:47 the trainee controller transmitted: "Independent one eight five one roger you're cleared to ... three thousand feet on QNH one zero two seven and ah runway will be one niner."

In that transmission, the trainee controller had transmitted an incorrect QNH that was 9 hectopascals [hPa] [one hPa equals one millibar] too high. The actual QNH was 1018.7 hPa, which should have been rounded down to the lower whole number — 1018 hPa — according to ICAO recommendations, the report said.

In regard to the trainee controller's error, the report said, "It was not possible to determine what [led] to this mistake. However, it must be said that using the decimals on the METAR [meteorological aeronautical radio code] could have contributed to [the error]. ... the fact that the decimal on the QNH was seven and the wind was two seven may have contributed to leading the controller to give a QNH of '1027.'... On the other hand, it is important to say that the METAR was broadcasted at 1354 and that it was transmitted [incorrectly] to the aircraft after two minutes and forty seven seconds."

The report said that the "operational personnel on duty at the airport control tower of Santa Maria, upon receiving meteorological information should compare the QNH … with the figures from the previous observation and the normal differences of those figures, and every time that there is a doubt about those figures, should check with the Santa Maria Meteorological Center. ... it was also mentioned that the supervisor controller had questioned the trainee controller why he had given the QNH when he had [transmitted QNH to IDN 1851] thirteen minutes before." The report said that this "revealed some concern about the normal following of procedures."

The report determined that, because of telephone calls that went unanswered at the control tower between 1300 and 1344:46, that "the tower had been abandoned until fairly close to the first contact with IDN 1851 ... and shows the existence of complacency on the functioning of their services."

Although it could not be corroborated by investigators, the attention of the supervising air traffic controller reportedly was diverted by telephone communication — on telephones that did not have recording devices attached to them — when the descent clearance was given to IDN 1851, the report said. Nevertheless, investigators did verify on other telephone recordings that "the controller supervisor believed that when she left duty IDN was descending to three thousand feet on QNH."

The report said that disruptions in normal procedures in communication with IDN 1851 might have occurred because the incoming shift was scheduled for 1400 and the outgoing shift would work until 1415, but "one cannot exclude the possibility of some rushing in anticipation [of] exiting ... ."

The report noted the flight crew's failure to recognize the QNH error: "Knowing that it is impossible for a variation for more than nine hPa of QNH, in such a short lapse of time, it is not understandable that the second QNH was not questioned by the copilot and was accepted and set in the altimeters and altitude alert, revealing once more a lack of concentration. ... the crew should have questioned the aeronautical station to eliminate any doubt, which was not done."

[The altitude alert (altitude reminder indicator) was not in the normal view of the flight engineer or of the left-seat pilot because the indicator was located forward of the throttles on the first officer's side, according to the author, who flew the accident aircraft into Bergamo the morning of the accident.]

The report also noted that the flight crew had informal conversations among themselves throughout the period recorded by the CVR, and that a feminine voice (believed to be one of the flight attendants) was recorded in the cockpit about 1348:30 and at 1404:09.

The report said that the crew did not follow procedures in company manuals and that "the crew did not show in the critical moments of the flight clear attention and concentration to what they were doing, leading [the commission] to wonder if the rest time they were given was used in the best way."

Moreover, during correlation of the ATS recordings and the CVR recording, two discrepancies were noted between the recorded data.

At 1356:47, while IDN 1851 was descending through flight level 220 (22,000 feet [6,705 meters]), Santa Maria Tower transmitted: "Independent one eight five one roger you're cleared to ... three thousand feet on QNH one zero two seven and ah runway will be one niner ... ." Then, at 1356:58, the trainee controller paused.

At 1356:59 the trainee controller continued speaking, "Expect ILS approach Runway one niner report reaching 3,000." The transmission ended at 1357:03, but it was not recorded on IDN 1851's CVR.

CVR Transcript of IDN 1851's Final Minutes of Flight

Legend

CAM — Cockpit area microphone
RDO — Radio transmission
1 — Voice identified as that of the captain
2 — Voice identified as that of the copilot
3 — Voice identified as that of the flight engineer
? — Voice not identified
APP — Santa Maria Approach Control
TWR — Santa Maria Control Tower
RD — Santa Maria Aeronautical Station
CT — Regional Control Center of Santa Maria
— — Unintelligible speech
— Nonpertinent speech
( ) — Questionable text

Time	Voice of	Cockpit Area Microphone	Radio Transmission	Sound or Alarm
1343:57	RDO-3		Santa Maria Independent Air one eight five one	
1344:07	RDO-APP		One eight five one Santa Maria go ahead	
1344:11	RDO-3		Good morning sir I would like to request your current met report Santa Maria	
1344:20	RDO-APP		One eight five one wind two six zero … Fourteen ah fourteen knots maximum two four knots visibility more than ten kilometers one octa at one two zero zero feet six octa at three thousand feet ah temperature one seven QNH one zero one niner	
1344:44	RDO-3		One eight five one ah say active runway please	
1344:48	RDO-APP		Say again	
1344:50	RDO-3		OK thanks	
1344:50	RDO-APP		Roger	
1344:50	CAM-?	It's raining to the south		
	CAM-?	How do like there …		
	CAM-?	Lorie its eyes good		
	CAM-?	… OK very good		
	CAM-?	Real strong cross wind gotta came in something like that		
		—		
		—		
1345:58	CAM-?	— Three zero zero – rain		
1346:13	CAM-?	Nobody ever told me anything – like this		
		—		
		—		
		—		
1346:26				... –/.../– – [VSM] Santa Maria VOR Morse code identification
1348:16	RDO-2		Santa Maria Control Independent Air on eight five one like to descend	
1348:23	RDO-CT		Independent Air one eight five one clear to descend to flight level four zero	
1348:30	RDO-2		Cleared to flight level four zero Independent Air one eight five one	
	CAM-?	— (Woman's voice)		
	CAM-?	You are #		
1354:09	CAM-?	Don't laugh #		
	CAM-?	About twelve #		
		—		Laughter
1354:16	CAM-?	Thank you #		
1354:22	CAM-?	Close that door it's a jungle out here		
	CAM-?	Don't set up		

CVR Transcript of IDN 1851's Final Minutes of Flight (continued)

Time	Voice of	Cockpit Area Microphone	Radio Transmission	Sound or Alarm
		—		
		—		
		—		
		—		
		—		
	CAM-?	First time in Azores # Always have these clouds hanging over like this #		
	CAM-?	Ya #		
		—		
		—		
1355:49	RDO-CT		Independent Air one eight five one what's your passing level	
1355:53	RDO-2		Passing flight level two two zero	
1355:57	RDO-CT		Roger report ECHO	
1356:00	RDO-2		Report ECHO Independent one eight five	
1356:15	RDO-2		Independent one eight five zero … one eight five one ECHO at present time	
1356:23	RDO-CT		Roger Independent one eight five one contact Santa Maria tower on one one eight decimal one	
1356:28	RDO-2		One one eight decimal one good day	
1356:35	RDO-2		Good afternoon Santa Maria tower	
			Independent Air one eight five one passing flight level two zero zero for level four zero	
1356:47	RDO-TWR		Independent one eight five one roger you're cleared to … three thousand feet on QNH one zero two seven and ah runway will be one niner	
1356:59	RDO-2		We're cleared to two thousand feet and ah… one zero two seven	
1357:05	CAM-1	Make it three [simultaneously with the "ah" in preceding communication]		
	CAM-?	—		
1357:12	CAM-2	Is that what he said ten twenty seven on the millibars		
	CAM-1	Yeap		
	CAM-1 or -3	Seat … belt sign		
	CAM-2	It's on		
	CAM-3	Window heat		
	CAM-2	Low		
	CAM-3	Anti-ice		
	CAM-2	Off		
	CAM-3	Logo lights		
	CAM-2	Off		
	CAM-3	Emergency brake pressure		
	CAM-3	Brake pressure		
	CAM-2	(OK)		
1357:37	CAM-3	Altimeters		
	CAM-1	Set and crosscheck		
	CAM-2	Set and crosscheck		
1357:43	CAM-3	Landing data EPR and airspeed bugs		

CVR Transcript of IDN 1851's Final Minutes of Flight (continued)

Time	Voice of	Cockpit Area Microphone	Radio Transmission	Sound or Alarm
	CAM-1	One twenty five		
	CAM-2	One twenty five on the right		
	CAM-1	Eighty-two seventy-nine		
	CAM-2	Set and crosschecked		
	CAM-3	Seatbelt and shoulder harness		
	CAM-1	On the left		
	CAM-2	Secured		
	CAM-3	( )		
1358:09	CAM-3	We're havin' fun now		
	CAM-1	Hey hey		
	CAM-2	We're havin' fun now aren't we		
	CAM-?	Yeah		
1358:16	CAM-3	Almost as much fun —		
	CAM-	I haven't heard heard that one		
	CAM-	I hadn't either		
	CAM-	Where'd you hear that … where'd you come with that		
	CAM-	Yeah		
	CAM-	—		
	CAM-?			Laughter
1358:49	CAM-1	#		
1359:02	CAM-2	Why is this DME a hundred and ninety eight miles we are closer than that		
	CAM-2	( )		
1359:08	CAM-2	I don't think they got a … I don't think they got a DME at Santa Maria		
1359:15	CAM-2	We got to be close to it		
1359:18	CAM-1	Seventy miles		
1359:32	CAM-2	Out of ten		
	CAM-			Unidentified sound
1402:14	CAM-2	Rudder Leon		
	CAM-2	Leon		
	CAM-1	(Whenever you're ready) maestro		
	CAM-	Maestro … ah ah		
1402:28	CAM-1	( ) Ain't too hot out here		
1402:31	CAM-?	Yeah we'll get down below … depends on what level those are		Trim sound
	CAM-?			Whistling
1403:18	CAM-2	OK I'm gonna go ahead and put the ILS in on mine Leon		
	CAM-1	OK		
	CAM-2	One ten three		
1403: 55	CAM-2	Ah after two thousand yeah we'll get below these clouds		
1404:19	CAM-1	In case we don't … one eight seven is the outbound		

CVR Transcript of IDN 1851's Final Minutes of Flight (continued)

Time	Voice of	Cockpit Area Microphone	Radio Transmission	Sound or Alarm
	CAM-2	Yeah		
	CAM-?	( )		Laughter
	CAM-?	Woman's voice ( )		
1405: 41	CAM-2	Ah thousand to go		
1405: 43	CAM-?	(One to go)		
1405:51	CAM-?			Sound of engine igniters
1406:01	CAM-3	There is the island		
	CAM-2	Where is the airport		
	CAM-?	On the other side of the island		
1406:15	CAM-?			Sound of altitude alert (steady tone sound of five hundred feet above selected altitude)
1406:17	CAM-2	(Four hundred) to go		
	CAM-2	(Don't know if we are going to get visual or not here)		
	CAM-?	(Gonna get rained on I know what)		
1406:46	CAM-3	Yeah		
	CAM-1			Control wheel? Sound of landing gear warning horn?
	CAM-?	(There is no place like Santa Maria it looks nice)		
	CAM-?	Is it		
	CAM-1	(To have a beer)		
1406:57	CAM-1	We are level at two		
	CAM-2	Yeah		Noise of windshield wipers
	CAM-1	— To the left		
	CAM-1	(At eight DME)		
	CAM	( ) Cliffs		
	CAM	Yeah		
1407:34	CAM-2	Starting to pass throughout layers here		
1407:52	CAM-1	Can't keep this SOB thing straight up and down		
1407:57	CAM-2	( ) Help you		
	CAM-1	No		
	CAM-?	( )		
	CAM-?	( )		
	CAM-?			Radio altimeter, whine
1408:05	CAM-?			WHOOP WHOOP PULL UP WHOOP WHOOP PULL UP WHOOP WHOOP PULL UP WHOOP WHOOP PULL UP
1408:12				Sound of impact

At 1356:59, as the trainee controller continued with the clearance, IDN 1851's first officer keyed his mike and read back: "We're recleared to 2,000 feet and ah ... ." The first officer paused from 1357:02 to 1357:04, then unkeyed the mike momentarily. This transmission was not recorded on the ATS tapes.

Simultaneously, as "ah" was uttered by the first officer, a voice in the background said, "Make it three." The report said the voice was "not identifiable, probably the captain."

At 1357:05, the first officer keyed the mike and transmitted: "One zero two seven." This was the final radio transmission from IDN 1851 recorded on the ATS tape and the only readback the tower received.

The report concluded that the tower controller and the first officer made simultaneous transmissions. Thus, the crew did not receive a complete clearance and the trainee controller did not receive a complete readback of the clearance.

In the cockpit, the first officer questioned aloud the QNH value, but the captain agreed that the first officer had correctly understood the controller.

The report said that after being cleared for the ILS approach at 1356:47, "the crew failed to accomplish an approach briefing, which would have included a review of the approach plate and minimum safe altitude. If the approach plate had been properly studied, they certainly would have noticed that the minimum safe altitude was 3,000 feet and not 2,000 feet, as it had been understood, and they would have noticed the existence and elevation of Pico Alto, clearly marked on the chart ... ."

The report added that under ICAO's "Rules of the Air and Air Traffic Services, Part II," the procedures "do not relieve the pilot of his responsibilities to ensure that any clearance that is received from Air Traffic Control is safe in this regard, except when under IFR radar vectors, which was not the case [in this accident]." [Underline emphasis is in the original report.]

The report also noted that company procedure required that "after receiving and reading back a clearance with ATC, the hands-on pilot, in this case the captain, should repeat loud and clear his understanding of the clearance so that all the crew will be aware of its contents, namely the sector altitude."

At 1402, the flight was 25 nm from the point of impact, and passing 6,500 feet (1,981 meters) in light turbulence at 260 knots indicated air speed (KIAS).

At 1403, the first officer said, "Ah after two thousand yeah we'll get below these clouds."

At 1406, the flight was 7.5 nm from the point of impact, and beginning to level at 2,000 feet (610 meters) in light turbulence at 250 KIAS.

At 1407, the flight was over Santa Barbara and entering clouds at approximately 700 feet (213 meters) AGL in heavy turbulence at 223 KIAS.

At 1407:52, the captain said, "Can't keep this SOB thing straight up and down" (Figure 1).

At 1407:57, the first officer offered to help but the captain said, "No."

At 1408:00, the report said that flight data recorder (FDR) information showed "a sudden drop from 1,751 feet [534 meters] followed by a sudden climb to 1,869 feet [570 meters]," which was caused by the turbulence.

At approximately 1408, the radio altimeter began to whine, followed by the GPWS alarm as the aircraft began to climb [because of turbulence], but the report said that there was no reaction on the part of the flight crew.

"The GPWS sounded its ... alarm for seven seconds, alerting the crew of a potentially dangerous situation. Strangely, the crew did not make any comment or try to remove this aircraft from this situation ... ," the report said.

"It must be pointed out that the crew had sufficient time to try to take the aircraft from this situation because the [median] reaction time to a GPWS alarm is about 5.4 seconds according to information from several airlines," the report said.

At 1408:12, the aircraft was level when it impacted the ridge of the mountain (Figure 2, page 14).

According to the report, the aircraft collided with a rock wall on the side of a road at the mountain top. The impact, at an altitude of approximately 1,795 feet (547 meters) AGL, was so close to the pinnacle of Pico Alto that most of the wreckage was found on the western slope.

The aircraft sliced at eye level through trees with diameters of 1.17 inches to 1.56 inches (30 centimeters to 40 centimeters), which were found "covered with human remains, clothes and pieces of the aircraft hanging on the branches." The fuselage was completely destroyed, and sections of the wings were scattered around the western side of the peak. Flaps and landing gear had apparently been retracted at the time of the accident.

Most of the wreckage of the engines was found on the eastern slope, and the report indicated that engines 2, 3 and 4 had hit the wall. Engine 1 had "crashed into the [eastern] slope, between five and seven meters [16.4 feet and 22.9 feet] from the top, and continuing its way on the [western] slope."

Investigators recovered from the aircraft wreckage two altimeters and the altitude alerter. Although the instruments were severely damaged, investigators were able to determine that one altimeter was set to 1028 millibars and the other

altimeter was set to 1026 millibars; the altitude alerter was set to 1027 millibars and the altitude was set to 2,000 feet (610 meters). Calibration records of the two altimeters indicated that "these altimeters showed +/- five feet [1.52 meters] at [2,000 feet]" with an indicated setting of 1027 millibars.

As a result of the incorrect QNH, when the aircraft was flying at an indicated altitude of 2,000 feet, the aircraft was actually flying at 1,760 feet — 240 feet [73 meters] lower.

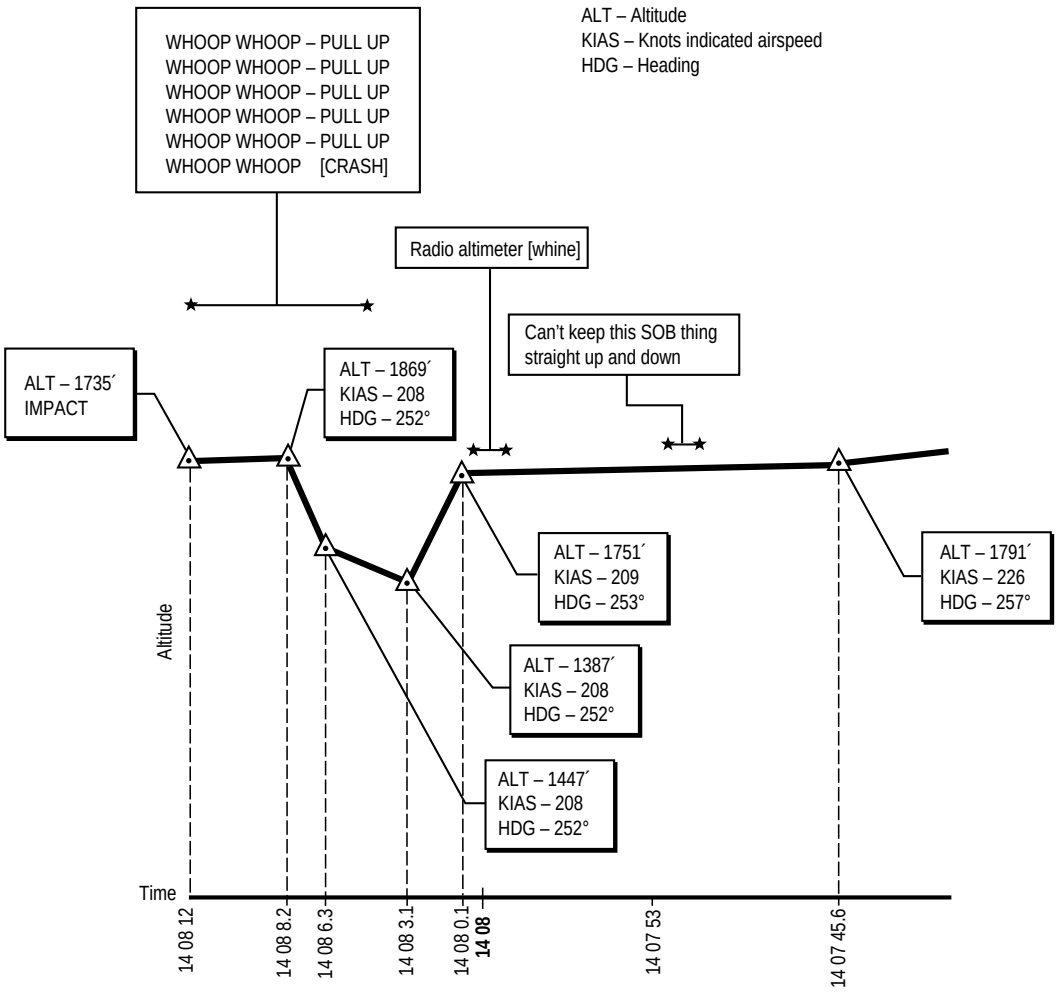
"The fact that the engines struck the wall that surrounded the road on the top of Pico Alto [1,795 feet (547 meters)] and that the trees on the west side of the mountain must have been at least [33 feet (10 meters)] above the ground, leads one to assume that this difference [240 feet (73 meters)] might have helped ... the accident to occur … . However, if the crew had respected the minimum safe altitude of 3,000 feet [914 meters], an error of 9 hPa in the QNH would not have had any consequences."

The Portuguese Inquiry Commission said that the accident was "due to the nonobservance by the crew of the established operational procedures, which [led] to the deliberate descent of the aircraft to 2,000 feet violating the minimum altitude of the sector that is 3,000 feet as published on the appropriate aeronautical charts and authorized by the control tower of the Santa Maria Airport."

The commission also cited 10 contributing factors:

1. "Transmission by the Santa Maria Control Tower of a QNH superior by 9 hPa to the real one which put the aircraft at an actual altitude 240 feet below that indicated on board;

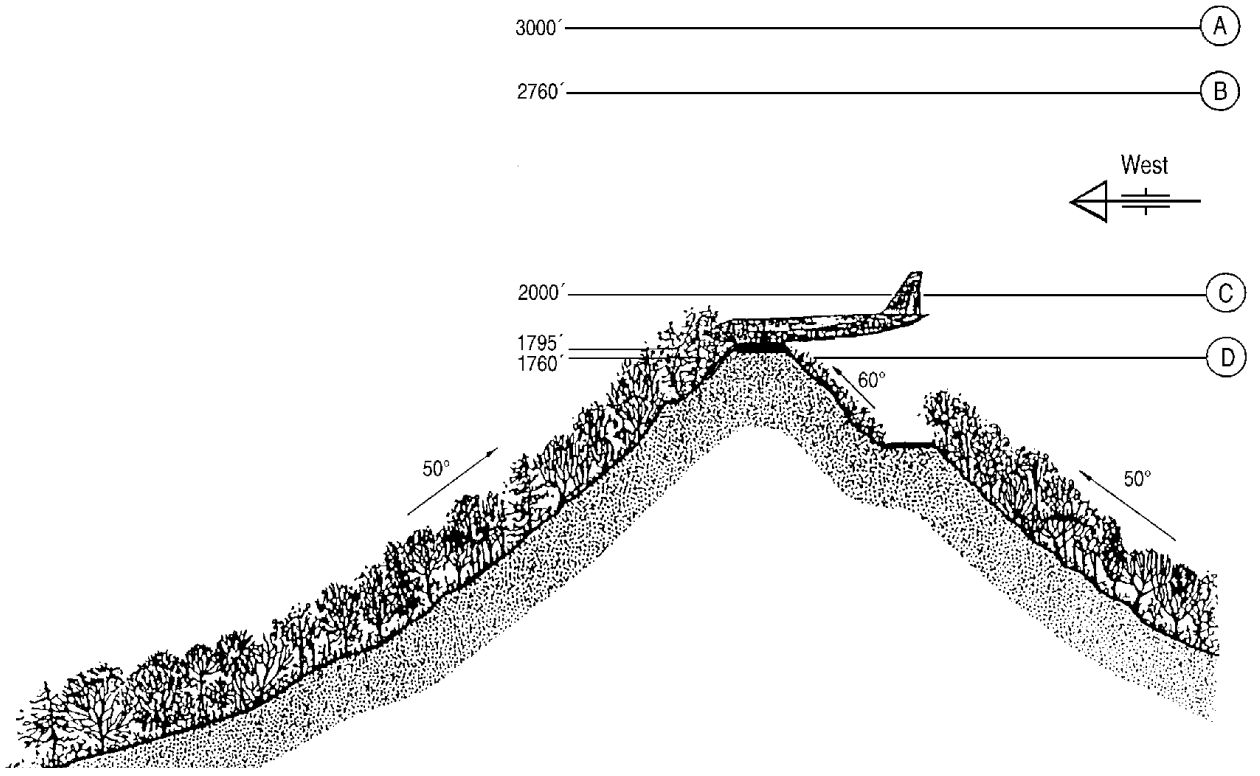
The Final Seconds of Flight IDN 1851



Source: Portuguese General Directorate of Civil Aviation

Figure 1

A Worst-case Scenario: Misunderstood Altitude Clearance and Incorrect Altimeter Setting Combined To Overcome Safety Margin



Ⓐ – Indicated altitute 3,000 feet (914 meters) with altimeter set at 1018 hPa

Ⓑ – Indicated altitude 3,000 feet (914 meters) with altimeter set at 1027 hPa

Ⓒ – Indicated altitute 2,000 feet (610 meters) with altimeter set at 1018 hPa

Ⓓ – Indicated altitude 2,000 feet (610 meters) with altimeter set at 1027 hPa

Source: Portuguese General Directorate of Civil Aviation

Figure 2

2. "Deficient communications technique on the part of the first officer who started his readback of the descent clearance to 3,000 feet given by the tower before the tower finished its transmission;

3. "Violation by the airport control tower when it did not require a complete readback of the descent clearance;

4. "[Nonadherence] by the crew to the procedures established in the appropriate company manuals, namely with respect to cockpit discipline, approach briefing, repeating verbally of descent authorizations and informal conversations below 10,000 feet [3,048 meters];

5. "Generalized apathy of the crew concerning the errors about the minimum altitude of the sector, which was at least known by one of the crew members, and also to the low-altitude terrain warning sound alarms;

6. "[Nonadherence] to the standard phraseology either by flight crew or by the air traffic controllers in some of the air-ground communications;

7. "Reduced experience of the crew in international flights, namely the first officer;

8. "Deficient training of the flightcrew, namely concerning the GPWS because it did not include emergency maneuvers to avoid collision with the terrain;

9. "Utilization of a [nonauthorized] route according to the AIP-Portugal; [and,]

10. "Deficient accuracy of the operational flight plan, whose final destination was not SMA beacon as established in AIP Portugal."

Recommendations were also made by the NTSB to the FAA with the concurrence of the Inquiry Commission. [The NTSB has reported that all the recommendations have been satisfactorily acted upon by the FAA.]

NTSB Recommendations A-89-44 through -49 asked the FAA to:

- Form a group with expertise in international operations to assist air carrier inspectors to better monitor international airline operations;
- Publish guidance to air carriers on international safety factors;
- Periodically review international air carrier operating procedures training programs to verify that they adequately address safety factors;
- Review Part 121 and Part 135 air carriers' training programs and FAA-approved manuals to ensure GPWS terrain-avoidance training is adequate;
- Establish minimum crew pairing standards for international operations and prohibit operations unless they are met; and,
- Encourage pilots to report problems in international operations to the U.S. National Aeronautics and Space Administration's (NASA's) Aviation Safety Reporting System (ASRS) program.

The Inquiry Commission made the following recommendations:

- Determine the proper minimum altitudes based on the height of the [television] antenna;
- Correct entry point names in accordance with ICAO rules;
- Publish a NOTAM [notice to airmen] concerning the restricted use of the [Santa Maria] VOR;
- Update and correct the AIP and navigation charts for Santa Maria;
- Publish an updated WAC [world aeronautical chart] for Santa Maria;
- Review and correct the procedures regarding using the [Santa Maria] VOR for airways use at Santa Maria; and,
- Revise METARs to comply with ICAO guidance on altimeter settings.♦

Editorial note: This article has been adapted from *Boeing 707-B-N7231T, Independent Air Inc., Final Accident Report Occurring on Pico Alto, Santa Maria, Azores on 8 February 1989,* which was prepared by the General Directorate of Civil Aviation, Department of Accident Prevention and Investigation, Portugal.

The report said, "Collaboration of the NTSB was requested in relation to flight operations of Independent Air and the training and medical history of the crew, as well as other documents related to the accident."

Pedro Ferreira, who holds a U.S. commercial pilot certificate, with multi-engine and instrument ratings, translated the Portuguese report into English. The translation was edited for accuracy by Col. Joao Letras, air attache, at the Portuguese Embassy in Washington, D.C.

The FAA's Aviation Safety Action Plan, a product of the special aviation safety summit called in January 1995 by the U.S. Department of Transportation Secretary Federico Peña, includes a number of initiatives that relate to some of the circumstances of this accident.

- Minimal operational performance specifications have been developed for equipment, and products are being tested, to prevent blockage of ATC communications that are caused by stuck microphones and simultaneous communications;
- Standards will be proposed to ICAO, regarding use and proficiency of spoken English. (No ICAO standard currently exists to identify English as the official international language of ATC.);
- Differences between ICAO phraseology and U.S. phraseology must be identified, and pilots must be made aware of any country's differences from ICAO phraseology; and,
- A user-friendly pamphlet should be developed to explain commonly used phrases and clearances by controllers and pilots to ensure common understanding and/or a basis for knowing the other party's intentions and expectations.

About the Author

Capt. Thomas A. Duke piloted Independent Air 1851 into Bergamo the morning of the accident in Santa Maria. He has more than 11,400 hours in military and civilian aircraft. He flew four-engine transports in the 1960s, and from 1977 to 1983 Duke was director of safety of the U.S. Air Force Reserve. He has more than 15 years experience as an accident investigator and flight safety officer. Duke also was a researcher for the U.S. National Transportation Safety Board.

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