74-14

NATIONAL TRANSPORTATION SAFETY BOARD
Washington, D.C. 20591

FILE NO. A-0004

AIRCRAFT ACCIDENT REPORT

IBERIA LINEAS AEREAS DE ESPANA [IBERIAN AIRLINES] McDONNELL DOUGLAS DC-10-30, EC CBN LOGAN INTERNATIONAL AIRPORT BOSTON, MASSACHUSETTS OECEMBER 17, 1973

ADOPTED: NOVEMBER 8, 1974

ERRATA

Make the following changes to the subject report:

In the TABLE OF CONTENTS, under APPENDICES, add the following:
Appendix 0 - Wreckage Distribution Chart
Appendix E - Safety Recommendations and Responses

Page 3, section 1.1, first paragraph, line 4: Change 903 to 0903.

Page 5, section 1.5, after last line: Add (See Appendix B.)

Page 5, Section 1.6, paragraph 2, line 1: Change to read; ---was about 223,141 kg. (492,026 lbs.). The calculated landing weight was about 162,341 kg. (357,962 lbs.) including 21,100 kg. (46,526 lbs.) of Jet A fuel on board.---

Page 8, section 1.11, paragraph 2, first line: Change Sunstrand to Sundstrand.

Page 8, section 1.11, paragraph 4, last line: Change heading to course.

Page 9, section 1.11, next to last line under column entitled Direction: (Magnetic)

Change 210° to 310"

J

Page 10, Section 1.12, first paragraph, last line: Change (See Appendix E.) to (See Appendix D.)

Page 21, (section 2.1), paragraph 2, last line: Change (See Appendix F.) to (See Appendix E.)

Page 22, section 2.1, paragraphs 2 and 3, last line of each: Change (See Appendix F.) to (See Appendix E.)

Page 25, (Section 3), first paragraph, last line: Change (See Appendix F.) to (See Appendix E.)

ADO THE ATTACHED PAGES 31 THROUGH 70 TO YOUR COPY OF THE SUBJECT REPORT.

February 26, 1975

REPORT NUMBER NTSB-AAR-74-14

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IBERIA LINEAS AEREAS DE ESPANA [IBERIAN AIRLINES] McDONNELL DOUGLAS DC-10-30, EC CBN LOGAN INTERNATIONAL AIRPORT BOSTON, MASSACHUSETTS DECEMBER 17, 1973

ADOPTED: NOVEMBER 8, 1974,

NATIONAL TRANSPORTATION SAFETY BOARD
Washington, O.C. 20591
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16. Abstract About 1543 e.s.t. on December 17, 1973, Iberia Lineas Aereas de Espana Flight 933, a DC-10-30, crashed while making an instrument landing system approach to runway 33L at Logan International Airport, Boston, Massachusetts.

Thirteen passengers were injured slightly; two passengers and one flight attendant were injured seriously during evacuation. The aircraft was substantially damaged.

The National Transportation Safety Board determines that the probable cause of this accident was that the captain did not recognize, and may have been unable to recognize, an increased rate of descent in time to arrest it before the aircraft struck the approach light piers. The increased rate of descent was induced by an encounter with a low-altitude wind shear at a critical point in the landing approach where he was transitioning from automatic flight control under instrument flight conditions to manual flight control with visual references. The captain's ability to detect and arrest the increased rate of descent was adversely affected by a lack of information as to the existence of the wind shear and the marginal visual cues available. The minimal DC-10 wheel clearance above the approach lights and the runway threshold afforded by the ILS glide slope made the response time critical and, under the circumstances, produced a situation wherein a pilot's ability to make a safe landing was greatly diminished.

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WASHINGTON, D. C. 20591

AIRCRAFT ACCIDENT REPORT

Adopted: November 8, 1974

IBERIA LINEAS AEREAS DE ESPANA
(IBERIAN AIRLINES)
MCDONNELL DOUGLAS DC-10-30, EC CBN
LOGAN INTERNATIONAL AIRPORT
BOSTON, MASSACHUSETTS
DECEMBER 17, 1973

SYNOPSIS

About 1543 e.s.t. on December 17, 1973, Iberia ~~Lineas Aereas de Espana~~ Flight 933, a DC-10-30, crashed while making an instrument landing system approach to runway 33L at Logan International Airport, Boston, Massachusetts.

Thirteen passengers were injured slightly; two passengers and one flight attendant were injured seriously during evacuation. The aircraft was substantially damaged.

The aircraft first struck approach light piers about 500 feet short of the threshold of the runway. The aircraft then struck an embankment and sheared its right main landing gear. The aircraft skidded to a stop on the airport about 3,000 feet beyond the threshold and 280 feet north of runway 33L.

At the time of the accident, low ceilings with obscurations and a visibility of 3/4 mile in rain and fog prevailed at **Logan** Airport.

The National Transportation Safety Board determines that the probable cause of this accident was that the captain did not recognize, and may have been unable to recognize, an increased rate of descent in time to arrest it before the aircraft struck the approach light piers. The increased rate of descent was induced by an encounter with a low-altitude wind shear at a critical point in the landing approach where he was transitioning from automatic flight control under instrument flight conditions to manual flight control with visual references., The captain's ability to detect and arrest the increased rate of descent

– was adversely affected by a lack of information as to the existence of the wind shear and the marginal visual cues available." The minimal DC-10 wheel clearance above the approach lights and the runway threshold afforded by the ILS glide slope made the response time critical and, under the circumstances, produced a situation wherein a pilot's ability to make a safe landing was greatly diminished.

As a result of this accident, the National Transportation Safety Board made eight recornendations to the Federal Aviation Administration.

1. INVESTIGATION

1.1 History of Flight

Iberia Lineas Aereas de Espana Flight 933, a DC-10-30 with Spanish registration EC CBN, was a scheduled international passenger flight between Madrid. Spain. and Boston, Massachusetts. It departed Madrid at 903 1/ (1403 Greenwich mean time) on December 17, 1973, with 153 passengers and 14 crewmembers aboard. The flight into the Boston area was routine, and no problems were reported with the aircraft or its systems.

At 1534, Flight 933 contacted Boston Approach Control. The approach controller cleared the flight to descend to 3,000 feet and provided radar vectors to intercept the instrument landing system (ILS) lo'calizer course for runway 33L at Logan International Airport.

At 1538, the approach controller informed the flightcrew that they were 9 miles from the outer marker (OM) and cleared the flight for the ILS approach to runway 33L. Two minutes later, the controller cleared the flight to contact the Boston control tower.

Flight 933 contacted the Boston tower local controller who at 1540:30, advised " . . . runway . . . visual range is out of service, the visibility is three quarters, the wind is three one zero at ten, report the lights in sight." Flight 933 responded, "Roger."

RWY 33L

The captain of Flight 933 flew the ILS approach with the No. 1 autopilot coupled and both autothrottle systems (speed mode) engaged. All prelanding checks were completed at the appropriate times, and the aircraft was properly configured for landing. The indicated airspeed over the runway threshold was to be 140 kn., and the automatic speed control was set at 145 kn.

At 1541:44, the local controller cleared Flight 933 to land and informed the flightcrew that the braking action was reported to be fair to poor.

According to the flightcrew, the aircraft was on the ILS glide slope until the captain disconnected the autopilot. When the flight engineer called, "300 feet," the first officer saw the approach lights to his right, "about the 1 to 2 o'clock position." He reported, "Lights to 'the right," and the captain responded, "Ok, lights in sight." The captain then disconnected the autopilot and banked the aircraft to the right to align it with the runway. He did not disengage the autothrottle system.

According to the captain, the aircraft was aligned with the runway when the flight engineer called "minimum decision height." The

1/ All times herein are eastern standard times, based on the 24-hour clock.

captain knew that the aircraft was low, but he thought there was no problem. He then overrode the autothrottle system to advance the throttles and simultaneously increased slightly the back pressure on the control column. He recalled that after the first officer and flight engineer told him that the aircraft was still low, he advanced the throttles farther, but felt that the aircraft was continuing to descend. The flight engineer then rapidly called out, "50, 40, 30, 20, 10," and the aircraft struck the approach light pier.

Members of the flightcrew stated that when the "lights in sight" call was made, only the approach lights were visible. According to the first officer and the radio operator-navigator, 1/4 to 1/3 of the runway could be seen when the flight engineer called "minimum decision height."

At 1542:22, the radio operator-navigator on Flight 933 reported to the tower, " . . . runway in sight." Nine and one-half seconds later, while the local controller's transmitter was activated, the sound of the approach lighting system audio alarm was recorded in the tower. The tower local controller stated that as he reached toward the monitor panel to silence the alarm, he heard the transmission:. "Iberia nine three three, we have an accident." The ground controller also heard the alarm, which was followed by an explosive noise. He saw a trail of fire along runway 33L and notified the airport fire department that an accident had occurred.

The captain and first officer of an Air Canada flight, which was parked on the taxiway adjacent to the threshold of runway 33L, saw Flight 933 when it emerged from the fog, less than a mile from their position. They stated that Flight 933 was low-- "too low to recover" and "desperately low." They saw the aircraft strike the approach light piers and then the embankment between Boston Harbor and the airport. After losing its right main landing gear, the aircraft bounced into the air, settled back to the runway, and skidded to a stop off the right side of the runway. A fire erupted on the left side of the aircraft as it skidded along the runway.

Following impact with the embankment, the captain's seat slid to its aft limit of travel, and he could not see the runway. He pushed forward on the control column, and the aircraft struck the runway--hard. The aircraft then slid down the runway and off to the right. The captain declared an emergency and ordered the evacuation of the aircraft.

The accident occurred at 1542:31.5, on December 17, 1973, and during daylight hours. The sky was obscured by fog and moderate rain. The geographic coordinates of the accident site are 42° 21' 48" N. latitude and 71° 00' 18" W. longitude.

Injuries to Persons

Injuries	Crew	Passengers	Others
Fatal	0	0	0
Nonfatal	1	15	0
None	13	138	

1.3 Damage to Aircraft

The aircraft was substantially damaged.

1.4 Other Damage

Two approach light piers were destroyed and two others were heavily damaged. In addition, ALS lights, threshhold lights, runway lights, and about 175 feet of walkway were destroyed.

1.5 Crew Information

. The captain, first officer and flight engineer were trained and qualified in the DC-10 aircraft at the McDonnell Douglas facility in Long Beach, California. They were certificated for their respective duties according to the laws and regulations of the Spanish Government. Before the flight, the flight crewmembers received rest periods required by the Spanish Government.

1.6 Aircraft Information

The aircraft was a DC-10-30, manufactured by the McDonnell Douglas Corporation. The aircraft had been maintained according to company procedures and government requirements.

The takeoff gross weight of EC CBN was 490,910 lbs. (233,141 kg.) with about 182,000 lbs. (162,341 kg.) of fuel on board. The landing weight and center of gravity were within prescribed limits. (See Appendix C.)

1.7 Meteorological Information

— Specialsurface weather observations taken at Logan International Airport at the times indicated showed that the following conditions existed:

Overcast

1541 - Indefinite ceiling at 300 feet, sky obscured, visibility-3/4 mile in moderate rain and fog, wind-290° at 9 knots, altimeter setting-29.25 inches, runway 4R visual range-3,500 feet variable to 4,500 feet.

1545 - Similar conditions existed except the surface winds were from 300° at 7 knots. The temperature and dew point were 41° F. and 38' F., respectively.

Moderate rain began at 1529 and continued until after the accident.

The 1900 winds aloft observations at the following locations and altitudes were as follows:

Chatham, Massachusetts

(60 miles southeast of Logan)

Altitude (feet) 2/	Direction (true)	Speed (Kn.)
1,000	220°	39
2,000	220°	43
3,000	220°	43

Portland, Maine

(83 miles north of Logan)

1,000	185°	30
2,000	185°	35
3,000	185°	37

— Earlierobservations (0700) at these locations and altitudes were similar except the winds were from southeasterly and easterly directions.

A radar weather observation taken at Chatham at 1533 showed a precipitation area 250 miles in diameter centered 25 miles east of Chatham. The area was moving east-northeastward at 50 knots.

There was no meteorological equipment for measuring winds aloft at the Logan Airport. Also, no meteorological or pilot reports were available regarding the existence of adverse wind conditions on the final approach path to runway 33L.

Before departing Madrid, the flightcrew received a folder of international meteorological data, including terminal forecasts for the Boston area. The data, however, did not include either existing or forecast winds aloft reports for the Boston area.

2/ All altitudes herein are mean sea level, unless otherwise indicated.

1.8 Aids to Navigation

Logan International Airport is equipped with approach surveillance radar and ILS. There were no reported difficulties with either the radar or ILS.

At the time of the accident, the No. 1 localizer transmitter and the No. 2 glide slope transmitter were in operation on runway 33L. These components were flight tested the following day, and they operated within prescribed tolerances.

The ILS glide slope angle for runway 33L is 3°. The lowest decision height (DH) is 216 feet, and the glide slope is unusable below 200 feet. The threshold crossing height (TCH) of the glide slope beam is 34.3 feet. Neither the Iberian approach chart nor the official U. S. approach chart displayed the TCH; they did, however, contain a notation that the glide slope was unusable below 200 feet. The height of the glide slope beam is 51.1 feet above the approach light pier first struck by the aircraft. The approach light pier is 25 feet above the mean water level of Boston Harbor. It is located 492 feet from the threshold of runway 33L.

Runway 33L was not equipped with a visual approach slope indicator (VASI).

The captain's restrictions for the ILS approach (all components operating) to runway 33L were: DH 216 feet and visibility minimums of 1/2 mile or a runway visual range of 2,400 feet.

1.9 Communications

Air-to-ground communications were normal.

1.10 Aerodrome and Ground Facilities

The Logan International Airport is located on a peninsula that extends eastward into the Boston Harbor. Two sets of parallel runways and a single runway are available. The airport elevation is 19 feet, and the elevation of the touchdown zone for runway 33L is 16 feet.

Runway 33L is 10,080 feet long and 150 feet wide, and surfaced with bituminous concrete. It is equipped with high-intensity runway lights and a standard configuration "A", high-intensity approach light system with sequenced flashing lights. The runway threshold is about 200 feet from the shore of Boston Harbor. The approach light system is mounted on wooden piers set into the waters of the harbor.

According to Boston tower personnel, the runway lights were set for maximum intensity. They could not recall the intensity of the approach lights, but stated that the existing weather conditions would have dictated a maximum setting.

1.11 Flight Recorders

EC CBN was not equipped with a cockpit voice recorder, and none was required.

EC CBN was equipped with a Sunstrand Data Control digital flight data recorder (DFDR), serial No. 2201. The recorder uses tape as a recording medium, which requires electronic processing to retrieve the parameters of flight information. The recorder case was slightly damaged, but the tape was intact. Printouts of all 96 parameters were made from a computer tape, which was generated from the DFDR tape.

At 1543:41, the No. 1 radar altimeter read 20 feet. The approach light audio alarm sounded at 1542:31.5, indicating a difference of about 1 minute 10 seconds between the DFDR time and the recorded air traffic control time.

The processed data from the DFDR were examined for abnormalities in the aircraft's approach profile and flight characteristics. These data indicated that as the aircraft neared the OM, it was configured for landing with the gear down and flaps extended to 50°. The aircraft was established on the glide slope and localizer centerlines when it passed the OM. The radio and pressure altimeter altitudes corresponded to the published glide slope crossing altitude of 1,457 feet. The aircraft's magnetic heading was 318°, or 11° left of the published localizer heading. The computed (indicated) airspeed was 148 kn.

After passing the OM, the aircraft remained on the localizer and glide slope centerlines for 62 seconds while descending to 500 feet. During this period of time, the average values recorded for pitch attitude, airspeed, thrust, and heading were 1.3° aircraft noseup (a.n.u.) 148.9 kn., 72.8 percent N_1 3/, and 321.5°, respectively. The rate of descent averaged 911 feet per minute (fpm). Calculated values for a similarly configured DC-10 of the same weight, on a 3° descent profile with no wind conditions, were 4.2° a.n.u., 145 kn., 76.2 percent N_1, and 770 fpm.

As the descent continued below 500 feet, the aircraft began a gradually increasing deviation to the left of the localizer centerline. At the same time, the aircraft rose slightly above the glide slope, the airspeed increased 4 to 6 kn., and both the pitch attitude and thrust decreased. The recorded values for longitudinal acceleration were negative.

3/ A measurement of thrust expressed in terms of the percentage of N_1 (low pressure) compressor rotational speed.

The aircraft passed the middle marker (MM) left of the localizer course about 110 feet, and was about 3 feet below the glide slope. The pitch attitude, airspeed, and heading were 0.9° a.n.u., 153 kn., and 329°, respectively. The thrust settings were about 56 percent N_1.

The autopilot command mode was disengaged within 3 seconds after the aircraft passed the MM. Thrust settings at that time were about 54 percent N_1 on engines Nos. 1 and 3 and 48.5 percent on engine No. 2. The aircraft's pitch attitude was 0°. Within 3 seconds after the autopilot was disengaged, an aircraft noseup pitch change began; 3 seconds later thrust began to increase.

Nine seconds after the autopilot was disengaged, the pitch attitude was 5.4° a.n.u., and the thrust was increasing through 77 percent N_1. Steep increases in both the vertical and longitudinal acceleration were recorded. During that 9 seconds, the aircraft's rate of descent averaged 1,060 fpm. The signal which indicates that the landing gear are extended was interrupted 12 seconds after the autopilot was disconnected.

The DFDR data were also used to derive winds aloft along the aircraft's final approach path. This was accomplished by comparing a no-wind plot of the aircraft's position with a plot of its known position throughout the approach profile. The no-wind plot was established from the heading, airspeed, and altitude data. The plot of the aircraft's known position was established from altitude, glide slope, and localizer deviation data.

The winds derived are as follows:

Altitude (Feet)	Direction (Magnetic)	Speed (Kn.)
1,000	191'	35
900	191°	32
800	193'	31
700	195°	30
600	197°	28
500	200°	24
400	205'	20
300	225°	15
200	260°	12
100	210°	8
Surface	315'	8

1.12 Wreckage

The aircraft struck light piers and then the embankment along the edge of the harbor. The right main gear was sheared. The aircraft then became airborne for about 1,200 feet, landed on runway 33L, veered off the runway to the right, and skidded to a stop about 3,000 feet from the threshold and 280 feet north of the runway. (See Appendix E.)

The aircraft stopped in an upright position. The fuselage aft section had partially separated near station 1811. The aft section was twisted to the right and was resting on the tail cone with the right horizontal stabilizer touching the ground.

The leading edge slats and trailing edge flaps on both wings were fully extended. The right inboard flap had separated from the wing and was found near the runway threshold.

The inboard and outboard ailerons on both wings were intact. The left stabilizer contained numerous perforations, and the right stabilizer was damaged extensively.

The left main gear had separated from the aircraft, and it was located along the wreckage path about 150 feet from the aircraft. The nose gear assembly failed rearward and was embedded in the fuselage at station 735. The drag support for the centerline gear failed; the gear rotated aft about its upper pivot and was embedded in the fuselage.

The No. 1 engine pylon separated from the left wing. The engine and pylon assembly rotated outboard about 45°, but remained under the wing.

The No. 2 engine remained intact and in place on the fuselage pylon. The No. 3 engine pylon separated from the right wing. The engine and pylon assembly rotated inboard about 90°. The assembly remained under the right wing.

Examination of the aircraft's structure, engines, flight controls, and instruments revealed no evidence of preimpact failures or malfunctions.

Examination of the captain's seat disclosed that the rack drive pinion and needle bearing, which was mounted on the pedestal above the dual electric actuator and clutch assembly, disengaged from the gear sector and gear rack support, which was mounted within the seat bottom support pan. This allowed the seat to move freely in the horizontal plane.

1.13 Medical and Pathological Infonnation

Thirteen passengers were treated for minor cuts, abrasions, and bruises. They were not hospitalized.

A female flight attendant and two female passengers were hospitalized. The flight attendant, who jumped to the ground from the top of the fuselage, sustained pelvic fractures. One of the passengers fractured her right ankle. The other passenger, who slid off the top of the fuselage, fractured her left ankle and suffered compression fracture of the second lumbar vertebra.

1.14 Fire

The aircraft caught fire while it skidded along and off the runway. The Massachusetts Port Authority Fire Department located on the Logan Airport, responded immediately and arrived within 3 minutes of the crash alarm that was activated by the Boston Tower ground controller. The City of Boston Fire Department was also notified. Department firemen responded and assisted in the rescue operations.

According to the firemen, fire was burning under the left wing, around the left engine, and along the left side of the fuselage when they arrived at the aircraft. Fuel from a ruptured left wing fuel tank was feeding the fire. The firemen extinguished the fire and spread a protective foam cover on the leaking fuel.

1.15 Survival Aspects

This was a survivable accident.

The aircraft was equipped with eight floor-level escape exits, four on each side of the fuselage. All exits were equipped with automatic escape slides. The exit doors could be opened electrically, pneumatically, or manually.

The flight attendants reported that they could not open the right forward (R-1), right aft (R-4), and left aft (L-4) doors. They did not attempt to open the left No. 3 (L-3) door because of fire near that exit.

The R-1 door could not be opened in the pneumatic, or emergency mode, because a backstop, which holds the striker assembly against the valve arm of the air bottle, was bent. The bent backstop prevented activation of the air bottle valve. When the system was properly rigged, the door operated pneumatically.

Inspection of the L-3, L-4, and R-4 doors revealed that the actuating mechanisms operated freely and were properly rigged.

The floor failed in the aft cabin area between fuselage stations 1530 and 1850. The floor was displaced upward about 3 feet, causing many failures of seat tracks and seat restraint components. None of the seats, however, completely detached. The floor and seat displacement obstructed both aisles in the cabin.

Five persons were trapped in the aft fuselage, because the aisles were blocked and they could not open the L-4 and R-4 exits. Four of these persons escaped through a break in the top of the fuselage. They slid or jumped to the ground. The fifth person was later rescued by the flightcrew.

The remaining 162 persons escaped through the four open exits. The R-2 exit slide did not inflate automatically, but it was successfully inflated manually. The evacuation was completed in about 2 minutes.

According to the flight attendants, the cabin lights went off after the first impact. No one could recall having seen the emergency lights illuminate; however, several firemen reported that some of the emergency exit lights were on. The battery packs which power the cabin emergency lights were tested; they were depleted.

1.16 Tests and Research

Tests were conducted in a McDonnell Douglas DC-10 simulator equipped with a Redifon Electronics, Inc., Visualator System. The simulator was programed to reproduce the aircraft's characteristics and the approach and environmental conditions that existed at the time of the accident. The objectives of the simulator tests were to: (1) Further evaluate the DFDR data obtained from the accident aircraft, (2) observe the performance of the DC-10-30 autopilot/approach coupler, and (3) examine the flight conditions that confronted the flightcrew of Flight 933 during the transition from automatic to manual flight.

Five pilots who were qualified in the DC-10-30 aircraft participated in the tests. Forty-eight approaches were flown using the autopilot/approach coupler and autothrottle systems to an altitude of 200 feet or below. All of the approaches began when the aircraft was established on the localizer and glide slope centerlines, outside the OM, and at an altitude of 1,500 feet. The automatic speed control was set at 145 kn.

The winds aloft, which were derived from the DFDR data, were programmed into the simulator for the initial tests. Variations in pitch attitude, airspeed, and thrust induced by these winds were evident throughout the approaches flown. The most noticeable variations were the reductions in thrust and pitch attitude that occurred when the aircraft descended through 200 feet.

The average rate of descent from the OM to an altitude of 400 feet was 840 fpm. The rate of descent decreased to 780 fpm as the aircraft neared 200 feet. When the autopilot was disengaged at 200 feet, the pitch attitude and thrust conditions caused the rate of descent to increase to 1,170 fpm within 7 seconds. If a substantial pitch attitude increase was not initiated within 6 seconds after disengagement, the aircraft descended to runway elevation, before reaching the runway threshold, in about 9 seconds. The pilots were unable to recover from the high descent rate by adding thrust alone. When the autopilot was left engaged, it made pitch and thrust corrections that resulted, without flare, in wheel contact on the runway, 130 feet beyond the threshold.

Simulator data recorded for the initial tests differed only slightly from that recorded on the DFDR. Through trial and error, the programmed wind data were changed to produce traces more consistent with those from the DFDR. The wind values which' produced the most consistent traces are:

Altitude (Feet)	Direction (Magnetic)	Speed (Kn.)
1,000	191°	35
900	192°	34
800	191°	34
700	191°	33
600	192°	32
500	194°	29
400	199°	21
300	211°	13.5
200	278°	5
100	310°	6
Surface	308°	5

After resolution into longitudinal and lateral components, these winds are as follows:

Altitude (Feet)	Longitudinal (Kn.)	Lateral (Kn.)
1,000	23.0 tailwind	26.0 left crosswind
900	22.6 "	25.7 "
800	22.15 "	25.4 "
700	21.7 "	25.1 "
600	20.4 "	24.3 "
500	18.0 "	23.0 "
400	11.8 "	17.3 "
300	5.8 "	12.1 "
200	3.3 headwind	4.1 "
100	6.0 "	2.0 "
Surface	4.0 "	2.0 "

These winds were used for all subsequent tests. The tests demonstrated that immediately following autopilot disengagement, the pilot had to increase the pitch attitude significantly to prevent a touchdown short of the runway threshold. The autopilot, when left engaged, increased the pitch attitude; however, the no-flare wheel contact on the runway occurred only 21 feet from the threshold.

Each pilot flew at least two approaches that required a transition from automatic flight control with instrument references to manual flight control with visual references. The transition was made between 180 and 160 feet above the runway elevation. All of the pilots successfully landed on the runway. However, on several approaches, the wheel clearance above an imaginary approach light 250 feet from the threshold was 10 feet or less. On most of the approaches, the pilots applied elevator control inputs within 4 seconds after the autopilot was disengaged to increase the aircraft's pitch attitude to about 6° a.n.u. within 10 seconds. All of the pilots had observed the first tests and were aware of the action required to prevent a high rate of descent from developing after the autopilot was disengaged.

The deviation to the left of the localizer course that began as Flight 933 neared 500 feet could not be reproduced in the simulator. Consequently, a lateral offset was produced by offsetting the localizer course 125 feet to the left of the Visulator runway centerline. None of the pilots had difficulty realigning the aircraft with the runway after the autopilot was disengaged.

The pilots agreed that the runway picture they saw from 200 feet was not alarming enough to cause them to initiate a missed approach. Several pilots commented on the subtle increase in the rate of descent that followed autopilot disengagement. They also commented that it was difficult to judge the pitch attitude and descent profile from the visual cues available because of the programed, 4,000-foot runway visual range.

1.17 Other Information

Iberian operational procedures specify that the captain may, at his discretion, keep the autothrottle system engaged during landing.

In November 1973, the Douglas Aircraft Company issued all operators letter (AOL) No. 10-515, which stated that one DC-10 operator had reported a bent backstop bracket on the air bottle striker arm assembly. The bent bracket prevented emergency operation of the exit door. Douglas noted that the bracket deformation may have occurred during the incorporation of the provisions of Service Bulletin 52-26. However, since the Service Bulletin had been complied with on EC CBN during production, the Douglas AOL did not identify the aircraft as one which might have been affected.

The glide slope antenna in the DC-10-30 is mounted in the nose section of the aircraft. Under mid-range c.g. conditions, the vertical distance between the path of the antenna and the path of the bottoms of the aft landing gear wheels is 26.5 feet when the aircraft is flying a 3° glide slope at recommended final approach speeds. Excluding allowances for installation tolerances, beam irregularities, and tracking errors, the nominal clearance of the aft wheels of EC CBN would have been 24.6 feet above the approach light stanchion and 7.8 feet over the threshold of runway 33L, had the aircraft remained on the 3° glide slope.

In 1968, the Convention on International Civil Aviation 4/ recommended that the TCH for ILS facilities be established at 50 feet ± 10 for category I facilities and 50 feet, + 10, -3 feet, for Category II facilities. These values were based on an assumed maximum vertical distance of 19 feet between the path of the aircraft's glide slope antenna and the path of the lowest part. of the wheels. This combination would provide a nominal wheel clearance of about 30 feet at the runway threshold.

In 1970, the Aerospace Industries Association of America, Inc., conducted a study to evaluate minimum wheel clearances at the threshold and to assess the effects of increasing the vertical distance to 29 feet between the paths of the glide slope antenna and the wheels on typical wide-bodied aircraft. The study concluded that a nominal wheel clearance of 20 feet would prevail, with a clearance of at least 10 feet when a reasonably probable combination of adverse tolerances was applied to a glide slope having a TCH of 47 feet. This study led to the FAA's approval of glide slope antenna installations that exceeded the 19-foot criteria.

On February 24, 1972, the FAA issued Order 8260.24 establishing standards for the relocation of Category I glide slope facilities and the installation of new facilities. The maximum and minimum TCH's for those facilities authorized for category D 5/ aircraft were specified as 60 feet and 47 feet, respectively. The minimum TCH was based on a nominal wheel clearance of 20 feet above the threshold. This height was considered sufficient to account safely for deviations from the glide slope because of system and flight technical errors. The runway 33L glide slope facility at Logan International Airport had not been relocated to comply with this order because of a lack of funds.

4/ Annex 10, Second Edition, Volume 1, April 1968, International Standards and Recommended Practices Aeronautical Telecommunications.

5/ An approach category of aircraft — the approach speed is 141 kn. or more, but less than 166 kn., and the maximum landing weight is more than 150,001 pounds.

On April 10, *1973,* the Douglas Aircraft Company issued the following information on ILS approaches in a letter to all DC-10 operators:

"<u>ILS Approach</u>

If ILS is available, it should be used whenever possible regardless of the weather conditions, because it affords the most accurate flight path control. Glide slope angles for the ILS vary from 2.5° to 3°. The ILS generally establishes a safe touch-down point down the runway beyond the threshold; however, it does not always provide margins as large as we would like. The minimum glide slope beam height above the threshold for a Category II ILS is *47* feet. For this minimum Category II case the wheel height over the threshold will be at least 20 feet (no flare) . . . . By FAA recommended standards, a Category I beam can have a minimum height over the threshold as low as *40* feet. The no flare wheel height over the threshold will be down to 13 feet when the airplane is on a 2.5° glide-slope that crosses the threshold at *40* feet, however; a normal flare will raise this clearance by several feet. Touchdown distance (no flare) in this case would be 200 feet from the threshold.

"Some Category I beams have a glide slope height over the threshold that is below the FAA recommended minimum height of *40* feet which could result in even lower wheel heights over the threshold and shorter touchdown distances.

"The above ILS approach examples are predicated on the fact that the airplane is on the glide path at a stabilized pitch attitude with no windshear. Momentary increase in pitch attitude, the effect of windshear and ILS beam bends and tolerances are all adverse items that can result in wheel heights over the threshold that are lower than those stated above.

"<u>Under no circumstances</u> should a 'duck under' maneuver be executed. The tendency to 'duck under' the glide slope in the latter stages of the approach can be obviously dangerous. One of the reasons for locating the glide-slope antenna in the nose of the DC-10 was to position the airplane on the glide slope such that the pilot would feel comfortable with the airplane in the proper slot as determined by visual cues (pilot's sight picture of the approach lighting, threshold, and runway lighting, visual aim point, etc.) when the pilot transitions from instruments to visual. <u>Nothing</u>

but trouble in the form of a short landing can result from a 'duck under' maneuver in the DC-10 or any other large jet aircraft.

"It can be seen that the airplane must not be flown below the glide slope when approaching the threshold on an ILS approach. This is especially true on some Category I beams that have glide slope heights over the threshold that are below the FAA recommended minimum height of 40 feet. Autopilot coupled approaches on these runways must not be continued below 100 feet, because it will be necessary to fly above the glide slope when approaching the threshold to ensure adequate wheel height clearance. It is imperative that operators survey their route structure and inform their pilots about the runways having low glide slope heights over threshold." (Emphasis supplied.)

Iberia provided each pilot with a copy of the above letter, shortly after receipt, and incorporated the information into its training program. Also, the captain of Flight 933 received similar information during his DC-10 transition training.

Before the accident, Iberia had not conducted a survey of the airports on its routes to determine which of them had ILS runways with low TCH's.

2. ANALYSIS AND CONCLUSIONS

2.1 Analysis

The crewmembers were trained, qualified, and certificated for their respective duties according with the laws and regulations of the Spanish Government. There was no evidence that medical factors or fatigue affected the flightcrews' performance.

The aircraft was certificated, equipped, and maintained according to regulations and approved procedures. The gross weight and c.g. were within prescribed limits during the approach. With the exception of the bent backstop bracket on the air bottle sticker arm assembly, there was no evidence of preimpact failure or malfunction of the aircraft's structure, powerplants, or systems.

The National Transportation Safety Board, therefore, directed its attention to the meteorological and operational factors that could have caused the aircraft to develop a high rate of descent which led to impact short of the runway.

The Wind Shear Phenomenon

The weather conditions that existed in the Boston area at the time of the accident suggested that a low altitude wind shear was present.

The problems associated with wind shear have been examined in several theoretical analyses and analog simulations. However, most studies have been confined to the effect of the shear on the aircraft's touchdown point, assuming no control or thrust changes. Apparently, little research has been done to consider the effect of the pilot's performance on the aircraft's flight profile during and subsequent to the aircraft's passage through a wind shear. This more complex subject, however, has been discussed hypothetically. 6/

When encountering a wind shear on final approach, the pilot or autopilot must make coordinated pitch attitude, thrust, and heading changes to minimize deviations from the optimum flightpath and airspeed. The direction and extent of the deviations will depend on the characteristics of the shear and the response of the flight control system servo loops.

During a precision instrument approach through a wind shear characterized by a diminishing tailwind, the higher-than-normal ground speed produced by the initially stable tailwind necessitates a higher-than-normal rate of descent for the aircraft to remain on the glide slope. Under these conditions a lower pitch attitude and less thrust are required than would be required during the more common no-wind or headwind approach. As the descent continues, the effect of the shear induced by a rapid decrease in the tailwind component is a rapid increase in the velocity of the aircraft relative to the air mass in which it is moving. The increased velocity causes the indicated airspeed to rise, and the resultant increase in lift causes the aircraft to rise above the glide slope. Both pitch attitude and thrust must be decreased further to limit deviations from the glide slope and the target airspeed. As the aircraft intercepts the glide slope again, the pitch attitude and thrust must be increased to reestablish the desired rate of descent and airspeed. As the tailwind continues to diminish, or becomes an increasing headwind, readjustments of pitch attitude and thrust must be made continuously. Ideally, the attitude and thrust, at any instant, should be that required to decelerate the aircraft at a rate equal to the rate of change of the longitudinal wind component, while establishing a rate of descent compatible with the instantaneous ground speed and the glide slope angle. After passing through the wind shear and into wind with a constant longitudinal component, the aircraft will descend below the glide slope, because of the continuous deceleration and resultant loss of lift. Prompt pitch control changes and throttle

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6/ W. W. Melvin, "Wind Shear on the Approach," Flight Safety Facts and Analysis, Vol. 5, No. 3 (March 1974).

corrections are required to prevent an increase in the rate of descent. In addition to attitude and thrust changes, heading corrections are required to minimize deviations from the localizer course that are caused by the diminishing speed of the crosswind component.%

The hazard presented by a diminishing tailwind-type shear on final approach is the continuous need for pitch attitude changes and additions to thrust. If the shear persists to a low altitude, the aircraft can be placed in a high rate of descent, thrust-deficient condition close to the ground. Under these conditions, the response of the control servo loops can be critical.

<u>How Wind Shear Affected Flight 933</u>

At 1541, the surface wind at Logan was from 290° at 9 kn. Since surface winds are usually representative of the winds within the earth's friction layer, which extends from the surface to elevations of 200 to 300 feet, these winds probably extended to approximately those elevations.

At 1900, however, the winds aloft from 1,000 to 3,000 feet at Chatham and Portland were from a southerly direction at about 40 kn. Also, the 0700 observations at these locations and elevations showed winds of a similar speed from a southeasterly direction. Consequently, the wind velocity in the Boston area at altitudes as low as 1,000 feet was near 40 kn. from a southerly direction at the time of the accident. These winds would have produced a tailwind component of about 30 kn., at these altitudes, for an aircraft flying the runway 33L localizer course.

The examination of DFDR data, including the data reproduced in the DC-10 flight similator, provided more positive evidence of the wind conditions along Flight 933's final approach profile. The Safety Board believes that the wind conditions derived from the simulator tests are the most representative of those affecting the aircraft.

The DFDR data show that the flight descended from 500 feet to 200 feet in 20 seconds. During the 20-second period, the longitudinal wind component changed from an 18-kn. tailwind to a 3.3-kn. headwind, and the left crosswind decreased from 23 to 4 kns. Between these altitudes, therefore, the longitudinal wind shear was about 7.1 kn. per 100 feet, and the lateral wind shear was about 6.3 kn. per 100 feet.

DFDR data clearly indicate the effects of the wind shear on Flight 933. During the initial portion of the higher-than-normal rate of descent, the lower-than-normal pitch attitudes and thrust setting were consistent with a fairly constant tailwind. An 8° to 10° difference between aircraft heading and localizer course was established to correct for the left crosswind. These flight conditions were essentially stable, and the localizer and glide slope deviations were minimal until the aircraft reached about 500 feet. Thereafter, a rapid increase in indicated airspeed, a rise above the glide slope, and a deviation left of the localizer course occurred. To compensate for these deviations, the aircraft pitched down about 1°, the thrust was reduced, and a heading correction to the right was begun.

The aircraft returned to the glide slope and pitched up slightly as it descended through 260 feet. The effect of the thrust reduction was evident by a negative longitudinal acceleration. However, the indicated airspeed remained essentially constant, indicating that the aircraft's deceleration approximated the rate of change of the longitudinal wind component.

The pilot, upon passing through 200 feet, was required to discontinue the coupled approach because the glide slope was not usable below that altitude. At 300 feet, he saw the approach lights, and he disengaged the autopilot about 7 seconds later at an altitude of 184 feet. At that time, the aircraft was at a low pitch attitude, a low thrust condition, and slightly left of the localizer course. Also, the autopilot was disengaged about the same time that the aircraft descended below the altitude of the wind shear band.

The Safety Board believes that the wind shear condition alone was not severe enough to create an unmanageable problem for the captain of Flight 933. However, when combined with the need to change from automatic flight control to manual flight control, the poor visual cues and the low wheel clearance afforded by the combination of airborne and ground ILS equipment serious difficulties were created.

As demonstrated in the flight simulator tests, the concurrent transition from automatic to manual flight control and the emergence of the aircraft from the wind shear produced a serious problem. The simulated aircraft quickly and subtly developed a high rate of descent, which required significant increases in pitch attitude and thrust to arrest. Had the captain of Flight 933 been able to retain autopilot coupling, these corrections might have been made. However, because he had to disengage the autopilot, he became the control element in the control servo loop; therefore, he required a sensory signal to alert him to the need for control changes.

Although the captain had the runway threshold in sight, he could not see enough of the runway to derive an accurate perception of his attitude, Moreover, because the aircraft was established on the glide slope when the captain began his transition to visual flight, and because his first visual observation was not alarming, he probably was not anticipating the need for an immediate pitch or thrust correction. Finally, the subtle increase in the rate of descent and the more obvious need for a lateral correction undoubtedly prolonged his recognition and reaction time.

The captain applied back pressure to the control column and overrode the autothrottle system to increase the thrust 4 to 5 sec. after he had disengaged the autopilot. However, the pitch attitude and thrust changes were not sufficient to reduce the rate of descent adequately. During the simulator tests, judgment of pitch attitude was difficult because of the limited visual cues available. Furthermore, because of the low pitch attitude, the change required was greater than changes associated with normal approach corrections. The captain of Flight 933 undoubtedly felt he had made sufficient correction. However, by the time he received oral warnings and recognized and reacted to the continuing descent, impact short of the runway was inevitable.

Another factor in this accident was the low wheel clearance afforded DC-10 aircraft by the TCH of the runway 33L glide slope beam. Had Flight 933 been able to remain on the glide slope, the main landing gear wheels would have passed only 24.6 feet above the light pier, which they struck, and 7.8 feet above the runway threshold. The Safety Board believes that these clearances are too low for the existing ILS weather minima. Moreover, the TCH was not published in official U. S. instrument approach procedures and was unknown to the captain of Flight 933. (See Appendix F.)

The Safety Board recognizes the difficulties associated with locating the glide slope receiver antenna in wide-bodied aircraft. However, primary emphasis has been placed on optimizing the antenna location for automatic approaches conducted on Category II facilities, where the specifications require a minimum TCH of 47 feet, a usable glide slope to a DH of 100 feet, and a glide slope interception point on the runway of not less than 950 feet from the threshold. Under these conditions, a glide slope which provides a nominal wheel clearance of 20 feet above the threshold, or 10 feet with a reasonably probable combination of adverse tolerances, may afford an adequate margin of safety.

Approaches on Category I facilities, however, are a different matter, and although the FAA and the aircraft industry have recognized the hazards of approaches on these facilities, the Safety Board believes that the hazards should be eliminated. A combination of airborne and ground equipment which, when used properly, can lead a pilot into a precarious situation is inherently unsafe. Also, since the merits of a stabilized approach are too well known for dispute, a practice that requires the pilot to change his flight profile near DH, and actually fly the aircraft above the glide slope to the point of flare in order to prevent a short landing, does not provide a safe solution.

If ILS glide slope transmitters are relocated in accordance with FAA Order 8260.24, a greater margin of safety will be provided to the pilots of wide-bodied aircraft using Category I facilities. Where it is impractical to relocate the transmitters, the Safety Board believes that decision heights and visibility minimums should be raised substantially for Category D aircraft. Additionally, the TCH's for all ILS facilities should be published in the official U. S. instrument approach charts.

As confirmed by the simulator tests, one of the most serious problems during transition from instrument to visual references near DH is the availability of adequate visual cues to provide vertical guidance. These cues should provide the pilot with instant recognition of his position relative to the safe approach slope. A VASI system is capable of providing this information and should be installed with all ILS facilities used by air carrier aircraft. (See Appendix F.)

Currently, operational equipment that is capable of accurately and frequently measuring and reporting winds aloft over or near an airport is not available. Likewise, operational equipment capable of measuring and reporting wind shear is not available, although an acoustic doppler system for measuring wind shear has been developed and tested with favorable results. Consequently, the Safety Board believes that the development of systems capable of accurately measuring and reporting winds aloft, including wind shear, should be emphasized. (See Appendix F.)

Survivability Aspects

The aircraft and passengers seat restraint mechanisms remained intact throughout the crash sequence. These factors, in conjunction with relatively low deceleration forces, permitted the occupants to survive the crash with only minor injuries. The low injury rate, in turn, proved significant in enabling the occupants to evacuate the aircraft quickly. The quick and efficient evacuation, the relatively slow propagation of the fire, and the rapid response of the fire department reduced the post-crash fire hazard substantially.

The Safety Board could not determine positively why the captain's seat came loose after the aircraft struck the embankment. However, the impact forces probably distorted the gear rack support sufficiently to disengage the rack drive pinion and needle bearing from the seat support mechanism. After the impact, the high noseup attitude and positive acceleration of the aircraft would have forced the seat to its aft limits of travel.

Three major factors combined to reduce the severity of the fire: (1) Type A kerosene fuel with a high flashpoint, (2) fuel did not collect in puddles because of the slope of the terrain, and (3) the low temperature of the fuel caused by the long flight at high altitude.

The right forward exit door failed to function because of the deformed backstop bracket. The manufacturers had issued a letter to bring the problem to the attention of all DC-10 operators. However, the letter did not apply to EC CBN since the Service Bulletin changes had been accomplished during production. Consequently, it is likely that the backstop was deformed before delivery of EC CBN to Iberia Air Lines. The FAA has since issued an airworthiness directive requiring replacement of the bracket with one made of stronger material.

The reason the two aft exit doors failed to open could not be determined. Both doors were properly rigged, and they operated pneumatically when tested later. It is possible that, under the stress of the situation, the flight attendant did not apply sufficient force (35 pounds) to the door control handle to actuate the emergency system.

2.2 Conclusions

(a) Findings

1. There was no evidence of a malfunction or damage to the aircraft's structure, flight instruments, flight controls, or powerplants before impact with the approach light piers.

2. When Flight 933 approached Logan International Airport, the weather conditions were: Indefinite ceiling at 300 feet, sky obscured, and visibility-3/4 mile in moderate rain and fog.

3. Flight 933 was conducting a coupled ILS approach to runway 33L; the autothrottle system was engaged.

4. Flight 933 encountered a mean longitudinal wind shear of about 7.1 kn. per 100 feet and a mean lateral shear of about 6.3 kn. per 100 feet between 500 and 200 feet.

5. The effects of the wind shear on the aircraft were most pronounced at a time when the captain had to transition from automatic flight with instrument references to manual flight with visual references.

6. The poor visual cues available because. of the low ceiling and visibility made the visual detection of the aircraft's pitch attitude and rate of descent difficult; runway 33L was not equipped with a visual approach slope indicator.

7. Flight simulator tests showed that, under the existing flight conditions, a significant pitch attitude increase and thrust addition were required within 6 seconds after the autopilot was disengaged to arrest the high rate of descent induced by the wind shear.

8. The captain of Flight 933 made significant pitch attitude and thrust corrections within 9 seconds after he had disengaged the autopilot. These corrections were made too late to avoid collision with the approach light piers.

9. The runway 33L glide slope was unusable below 200 feet.

10. With a DC-10-30 aircraft on the glide slope, the low TCH of the runway 33L glide slope beam (34.3 feet) provided only 7.8 feet of aircraft wheel clearance over the runway threshold and only 24.6 feet of clearance over the approach lights which were struck first.

11. The runway 33L glide slope transmitter had not been relocated in accordance with FAA Order 8260.24.

(b) Probable Cause

The National Transportation Safety Board determines that the probable cause of this accident was that the captain did not recognize,., and may have been unable to recognize, an increased rate of descent in time to arrest it before the aircraft struck the approach light piers. The increased rate of descent was induced by an encounter with a low-altitude wind shear at a critical point in the landing approach where he was transitioning from automatic flight control under instrument flight conditions to manual flight control with visual references. The captain's ability to detect and arrest the increased rate of descent was adversely affected by a lack of information as to the existence of the wind shear and the marginal visual cues available. The minimal DC-10 wheel clearance above the approach lights and the runway threshold afforded by the ILS glide slope made the response time critical and, under the circumstances, produced a situation wherein a pilot's ability to make a safe landing was greatly diminished.

3. RECOMMENDATIONS

The Safety Board made a recommendation (SR A-74-55) to the FAA on July 10, 1974, to continue to install VASI's on all ILS runways used by air carrier aircraft with first priority to Category I approaches.

On October 3, 1974, the Safety Board made seven recommendations to the FAA (SR A-74-77 through 83.) These recommendations involved the relocation of ILS glide slope transmitters, changes to ILS approach procedure charts and ILS weather minima, modification of pilot training and information programs to include wind shear phenomenon, and the development of equipment and systems to measure and report wind shear. (See Appendix F.)

On April 4, 1974, the FAA issued an airworthiness directive to correct deficiencies in the backstop bracket that prevented emergency operation of the exit door. The airworthiness directive required periodic inspection of the bracket until it is replaced with one made of stronger material.

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

/s/ JOHN H. REED
Chairman

/s/ FRANCIS H. McADAMS
Member

/s/ LOUIS M. THAYER
Member

/s/ ISABEL A. BURGESS
Member

/s/ WILLIAM R. HALEY
Member

November 8, 1974

APPENDIX A

INVESTIGATION AND HEARING

1. Investigation

The National Transportation Safety Board was notified of the accident at 1605 on December 17, 1973. The Safety Board immediately dispatched an investigative team to Boston. The team established investigative groups for operations, air traffic control, witnesses, weather, human factors, structures, powerplants, systems, and flight data recorder.

Parties to the investigation were: The Federal Aviation Administration, Iberia Airlines, International Federation of Airline Pilots Association, McDonnell Douglas Corporation, and General Electric Company.

2. Hearing

No public hearing was held.

APPENDIX B

CREW INFORMATION

Captain Jesus Calderon Gaztelu

Captain Jesus Calderon Gaztelu, 53, was employed by Iberian Airlines on April 29, 1953. He holds Piloto Transporto License No. 172, which had been renewed on July 17, 1973. He passed a medical examination before his license was renewed. License renewal must be accomplished each *b* months.

Captain Calderon had accumulated 21,705 flight-hours, including 426 hours in the DC-10. In the 90, 30-, and 1-day periods before the accident, he flew 148, 78, and 7 hours, respectively. He had completed refresher training on October 19, 1973.

First Officer Alfredo Perez Vega

First Officer Alfredo Perez Vega, 54, was employed by Iberian Airlines on November 18, 1946. He holds Piloto Transporto License No. 408, and he had passed a medical examination to renew his license on December 15, 1973.

First Officer Perez accumulated 34,189 flight hours, including 403 hours in the DC-10. In the 90-, 30-, and 1-day periods before the accident, he flew 165, 68, and 7 hours, respectively. He had completed refresher training on October 9, 1973.

Flight Engineer Celedonio Martin Santos

Flight Engineer Celedonio Martin Santos, 42, was employed by Iberian Airlines on December 13, 1952. He holds Mecanico License No. 175; it must be renewed annually, which was last accomplished on May 14, 1973. He passed the prerequisite medical examination.

Flight Engineer Martin had 15,317 flight-hours, including 263 in the DC-10. During the 90-, 30-, and 1-day periods before the accident, he flew *164*, 74, and 7 hours, respectively.

Radio Operator-Navigator Candido Garcia Bueno

Radio Operator-Navigator Candido Garcia Bueno, 51, was employed by Iberian Airlines on December 9, 1941. He holds Radio Operator License No. 204, which had been renewed September 2, 1973. He passed the medical examination for renewal of his license.

Radio Operator-Navigator Garcia had accumulated 14,562 flight-hours, including 384 hours in the DC-10, During the 90-, 30-, and 1-day periods, before the accident, he flew 164, 74, and 7 hours, respectively.

APPENDIX B

Flight Attendants

The 10 flight attendants were qualified for their duties according to Iberian Airline procedures and the laws and regulations of the Spanish Government.

APPENDIX C

AIRCRAFT INFORMATION

EC CBN was owned and operated by Iberian Airlines. Its date of manufacture and manufacturer's serial no. were March 20, 1973, and 1,073, respectively. The aircraft had accumulated 2,016:29 hours time in service including 568:26 hours since the last major inspection.

EC CBN was powered by three CF6-50 turbofan jet engines manufactured by the General Electric Company.

The engine serial nos. and times in service were as follows:

Engine No.	Serial No.	Time
1	455,255	1,028:15
2	455,142	912:45
3	455,313	406:35

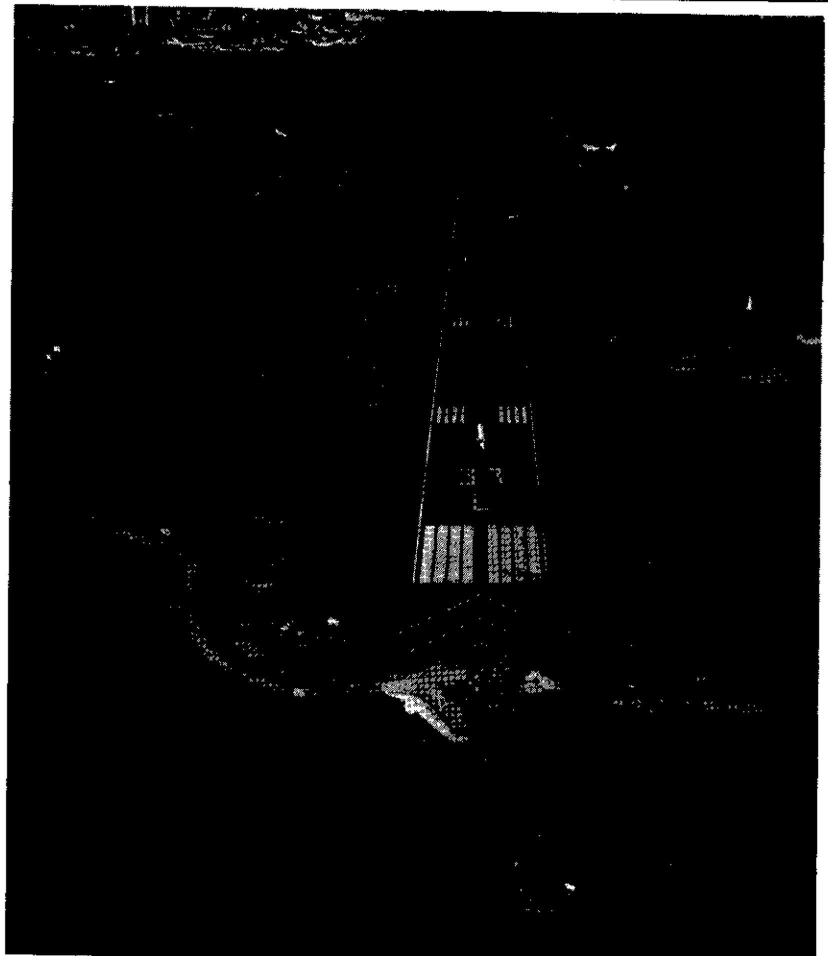
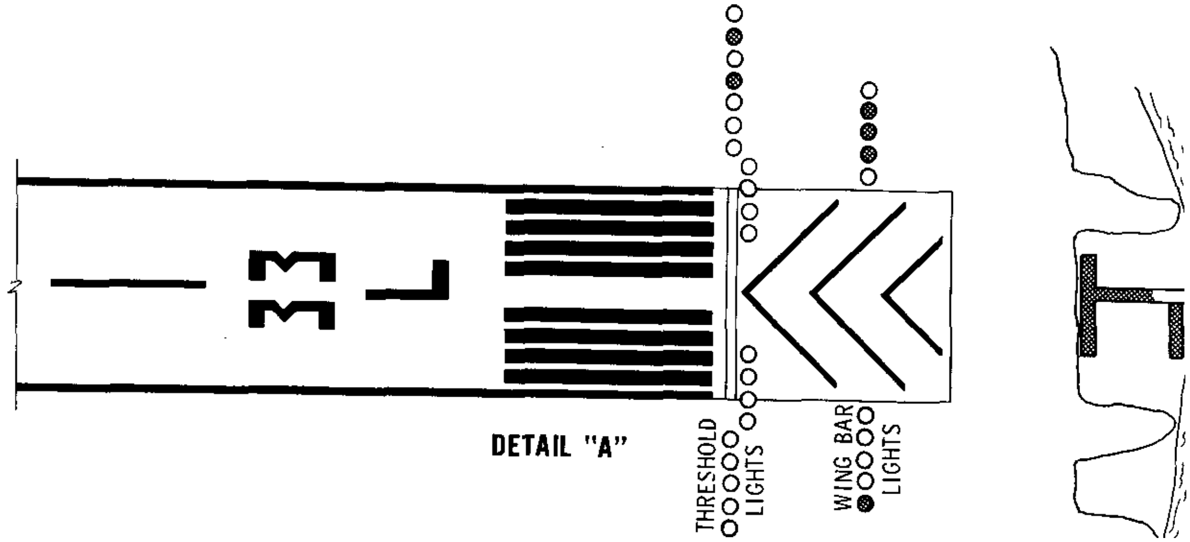


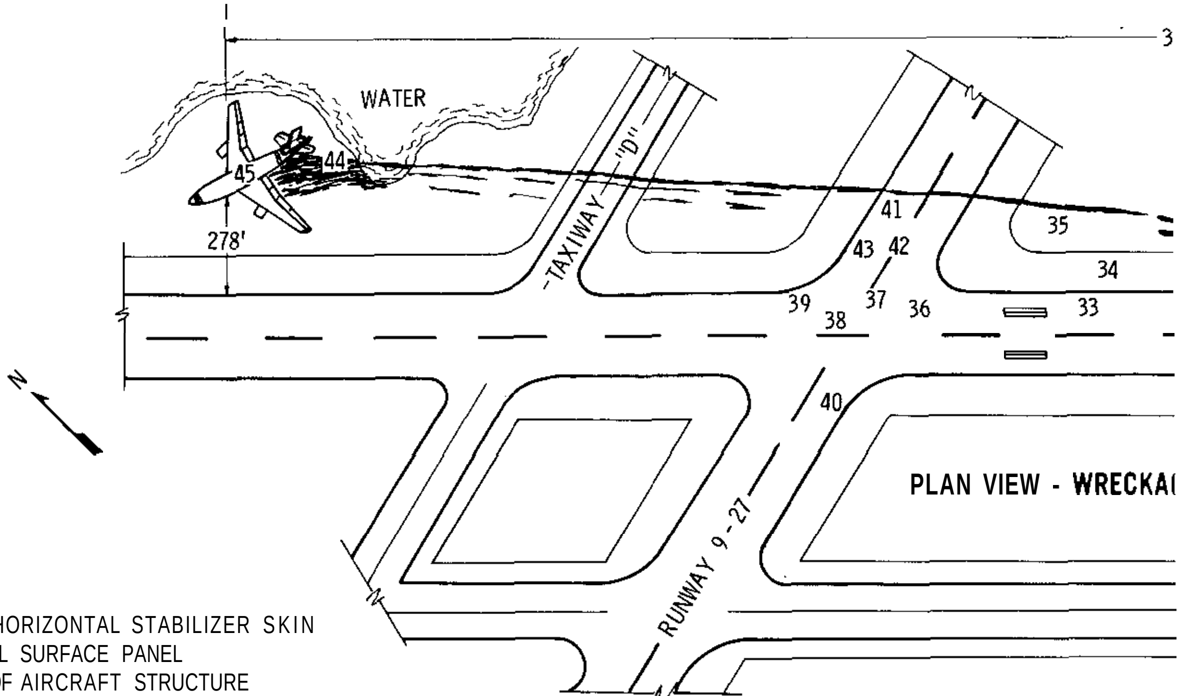
PHOTO A

PHOTO B

LEGEND:

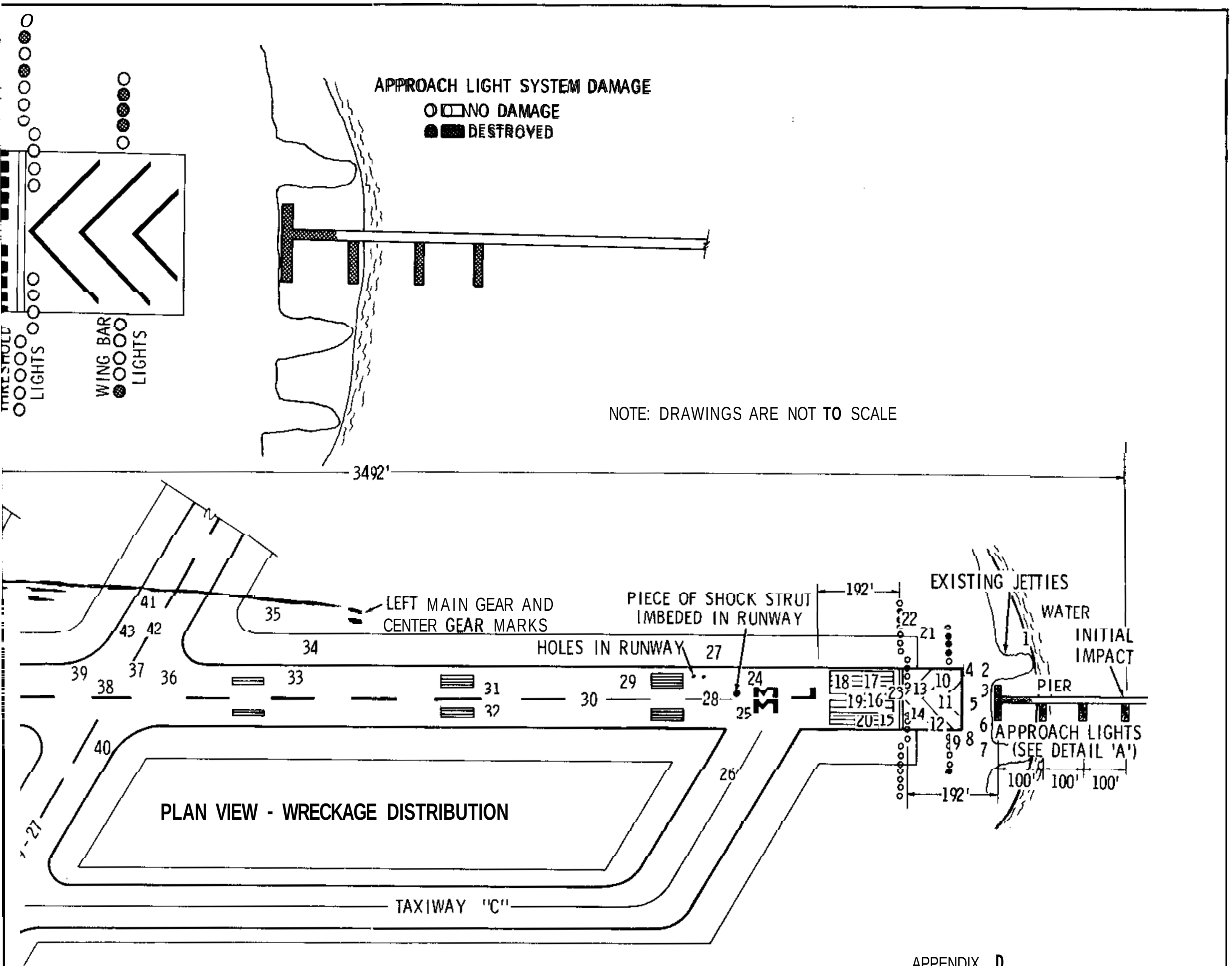
1. RIGHT HORIZON
2. CONTROL SURFA
3. PIECE OF AIRCF
4. MAIN GEAR SEG
5. PIECE OF CONTF
6. PIECE OF CONTF
7. TRANSFORMER (
8. LAM? HOLDER (
9. SECTION OF AIF
10. SEGMENT OF FLA
11. TRANSFORMER (
12. LAMP HOLDER (
13. LAMP HOLDER (
14. LAM? HOLDER (
15. LAMP HOLDER (
16. CENTER LINE GC
17. AFT ENGINE COV
18. LIGHT SOCKET (
19. TRANSFORMER (





LEGEND:

1. RIGHT HORIZONTAL STABILIZER SKIN
2. CONTROL SURFACE PANEL
3. PIECE OF AIRCRAFT STRUCTURE
4. MAIN GEAR SEGMENT
5. PIECE OF CONTROL SURFACE PANEL 1'x3'
6. PIEC: OF CONTROL SURFACE PANEL 2'x8'
7. TRANSFORMER (AIRPORT FACILITY)
8. LAM? HOLDER (AIRPORT FACILITY)
9. SECTION OF AIRCRAFT SKIN
10. SEGMENT OF FLAP AND VANE
11. TRANSFORMER (AIRPORT FACILITY)
12. LAMA HOLDER (AIRPORT FACILITY)
13. LAMP HOLDER (AIRPORT FACILITY)
14. LAMP HOLDER (AIRPORT FACILITY)
15. LAM? HOLDER (AIRPORT FACILITY)
16. CENTER LINE GEAR DOOR
17. AFT ENGINE COWL DOOR
18. LIGHT SOCKET (AIRPORT FACILITY)
19. TRANSFORMER (AIRPORT FACILITY)
20. LAMP HOLDER (AIRPORT FACILITY)
21. SEGMENT OF FLAP AND VANE 8'x18'
22. PIECE OF AIRCRAFT STRUCTURE
23. PIECE OF GEAR STRUCTURE
24. SEGMENT OF MAIN GEAR CYLINDER
25. SEGMENT OF GEAR STRUCTURE
26. SEGMENT OF GEAR STRUCTURE
27. RIGHT MAIN GEAR DUAL WHEEL ASSEMBLY
28. PIECE OF FLEX HOSE 1.5 DIA.
29. PIECE OF MAIN GEAR
30. RIGHT MAIN GEAR DUAL WHEEL ASSEMBLY
31. MAIN GEAR HUB SEGMENT WITH 18" BRACE
32. CONTROL SURFACE TRAILING EDGE 2'x5'
33. AIRCRAFT STRUCTURE
34. COWL ATTACH LUG
35. FORWARD ENGINE COWL D
36. COWL ACCESS DOOR
37. AIRCRAFT STRUCTURE
38. GEAR STRUCTURE SEGMEN
39. FORWARD ENGINE COWL D
40. WING FUSELAGE FAIRING
41. ENGINE CONTROL WITH HC
42. PIECE OF AIRCRAFT STRU
43. AIRCRAFT STRUCTURE
44. LEFT MAIN GEAR
45. MAIN WRECKAGE



APPENDIX D

ITY)
'x18'
E

IDER

ASSEMBLY

ASSEMBLY
H 18" BRACE
DGE 2'x5'

35. FORWARD ENGINE COWL DOOR
36. COWL ACCESS DOOR
37. AIRCRAFT STRUCTURE
38. GEAR STRUCTURE SEGMENT
39. FORWARD ENGINE COWL DOOR
40. WING FUSELAGE FAIRING
41. ENGINE CONTROL WITH HOUSING
42. PIECE OF AIRCRAFT STRUCTURE
43. AIRCRAFT STRUCTURE
44. LEFT MAIN GEAR
45. MAIN WRECKAGE

NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C.

WRECKAGE DISTRIBUTION CHART
IBERIA LINEAS ARERAS de ESPANA
DOUGLAS DC-10-30 IB 933, EC CBN
LOGAN INTERNATIONAL AIRPORT
BOSTON, MASSACHUSETTS
DECEMBER 17, 1973
DCA 74-A-14

NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C.

APPENDIX E

ISSUED: July 10, 1974

Forwarded to:

Honorable Alexander P. Butterfield
Administrator
Federal Aviation Administration
Washington, D. C. 20591

SAFETY RECOMMENDATION(S)

A-74-55

On October 28, 1973, Piedmont Air Lines Flight 20, a B-737, was involved in an accident at the Greensboro-High Point-Winston Salem Regional Airport, at Greensboro, North Carolina. The flight was attempting a precision approach (ILS) to runway 14. The accident occurred during darkness, a heavy rainshower, and restricted visibility.

Two similar accidents have also occurred recently. On November 27, 1973, a Delta Air Lines DC-9-32 was involved in an accident at Chattanooga, Tennessee, and on December 17, 1973, an Iberian DC-10-30 was involved in an accident at Logan International Airport, in Boston, Massachusetts. Both aircraft were making precision approaches during meteorological conditions that included low ceilings and limited visibility. The investigations of these accidents revealed an area in the approach-to-landing phase of flight that can be made safer by additional approach guidance.

Although vertical guidance was provided in each case by an electronic glide slope, no visual approach slope indicator (VASI) system was installed for any of the approaches. Therefore, the crew had to rely only on visual cues during the final critical stage of the approach. The Safety Board realizes that a VASI is not required; however, the Board believes that the installation of a VASI in conjunction with a full ILS should not be considered a duplication of equipment, as these accidents indicate that additional vertical guidance is needed to complement the electronic glide slope.

APPENDIX E

Honorable Alexander P. Butterfield (2)

The installation of a VASI on a precision approach runway would not replace the glide slope as the primary means of vertical guidance, nor would it change the intent of 14 CFR 91.117 regarding descent below decision height (DH). A VASI would, however, do much to enhance the safety factor by allowing the pilot to transfer to the visual portion of the approach and still retain a display of his approach path, since during periods of low visibility, the visual cues available from the approach lights and the approach end of the runway may be inadequate.

In replies to previous NTSB recommendations concerning altitude and ground warning systems, the Administrator apparently agreed in stating: "The VASI would provide vertical guidance at normal descent rates for the visual segments of the approach. This result would be a greater degree of altitude awareness through the procedure."

The captain of the Delta E-9 stated that he believed the approach was normal until just before impact, when his sight picture suddenly flattened. Possibly, he was experiencing an optical illusion caused by the heavy rain on the aircraft windshield. Had there been a VASI available, the captain would have been warned that the aircraft was descending below glidepath.

Several major airports have been certificated which have precision approaches where the glide slope is unusable below DH. Logan International Airport and Los Angeles International Airport are only two of these airports. If a VASI were available for approaches of this type, more positive vertical guidance Would be available from DH to landing. In addition, VASI could also be used when the approach becomes visual before the aircraft reaches DH. The pilot who knows that the glide slope will exceed tolerances below DH should integrate the VASI into his normal scan pattern and use the VASI to monitor the final stages of the approach.

The Safety Board believes the VASI can be a valuable supplement to any ILS approach, even under minimum weather conditions, and therefore recommends that the Federal Aviation Administration:

> Continue to install VASI's on all ILS runways, but with the first priority being assigned to runways where the glide slope is unusable below DH and to those runways used by air carrier aircraft.

REED, Chairman, McADAMS, THAYER, and BURGESS, Members, concurred in the above recommendation. HALEY, Member, was absent, not voting.

John H. Reed

By: John H. Reed
Chairman

AUG 5 1974

Mr. James C. Worcester, Jr.
1511 Circle Drive
Annapolis, Maryland 21401

Dear Mr. Worcester:

This letter is in response to your correspondence of July 16, 1974, concerning the installation of VASI systems on nonprecision approach runways at airports served by air carriers.

In response to recommendations made by the Safety Board in 1972, the Federal Aviation Administration proposed new criteria ror nonprecision approaches. One criterion specified was establishing a final approach descent fix et a point on the final approach where a normal descent path of approximately 3" intersects with the MDA for that apprtmch. Another criterion the FAA proposed was to provide VASI for each runway served by a nonprecision approach. The FAA is assigning first priority for installation of these systems to nonprecision approach runways serving air carrier operations.

Although the VASI system is contingent upon budgetary considerations, the FAA has been installing about 90 VASI systems per year. In FY 75, 91 systems are scheduled for completion, two of which are programmed for Moline.

Your contention that VASI's should be installed on every nonprecision approach runway served by air carriers before installation on any ILS runways is well taken. However recommendation A-74-55 was intended to underline the need for positive vertical guidance during the visual portion of the ILS approach, especially when the glideslope is unusable below decision height. Since these approaches have lower minimums affording less reaction time to the crew, the Safety Board believes the position that the expanded employment of a VASI in conjunction with an ILS should be emphasized. The FAA's responsive program in regard to VASI systems on nonprecision approaches runways was instrumental in limiting the scope of the present recommendation to precision approaches. The Safety Board believes this recommendation will lend to an accelerated use of VASI under the circumstances cited in the recommendation, and not detract from the priorities of tho current program dealing with nonprecision approaches.

APPENDIX E

Mr. Jomes C. Worcester, Jr. 2

I appreciate receiving your views and comments on recommendations made by the Safety Board. If you should have any further areas of concern, please Peel free to contact me.

Sincerely yours,

Isabel A. Burgess

John H. Reed
Chairman

DThomas:dvh:7/31/74:BAS-14
cc: BOC-1(2), BOM-2, 3, 4, 5, BGC-1, BGM-1, BPA-1
BGM-201, BGM-221, BAS-1(2), 2, 10cc/incom., 14
20, 23, 30

MC 74-662

APPENDIX E

DEPARTMENT OF .TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

WASHINGTON, D.C. 20590

OFFICE OF
THE ADMINISTRATOR

AUG 8 1974

Honorable John H. Reed
Chairman, National Transportation Safety Board
Department of Transportation
Washington, D. C. 20591

Dear Mr. Chairman:

We have reviewed the Board's proposal to provide VASIs on all ILS runways with priority for those locations where the glide path is out of tolerance below the decision height.

Whil.. we agree in principle with the recommendation, we have an action pending to fund VASIs and marker beacons for installation first on all nonprecision approach runways. This will enable pilots to adjust their flight path to establish a stabilized rate of dsscent when conducting nonprecision approsches to those runways where no electronic glide slope is installed. Accordingly, the provision of vertical guidance on nonprecision runways will take priority over the installation of VASIs on ILS runways.

Sincerely,

Alexander P. Butterfield

Alexander P. Butterfield
Administrator

APPENDIX E

AIR LINE PILOTS ASSOCIATION
1625 MASSACHUSETTS AVENUE, N.W. ☐ WASHINGTON, D.C. 20036 ☐ (202) 797-4000

August 15, 1974

Mr. John H. Reed, Chairman
National Transportation Sofety Board
800 Independence Avenue, S.W.
Washington, DC 20591

Dear Mr. Reed:

The Air Line Pilots Association's All Weather Flying Committee, in its continued investigation of low visibility landing accidents, has reviewed certain aspects of the December 17, 1973 Iberian DC-10 accident at Boston, Massachusetts. As a result of this review the Association is providing the NTSB with an analysis of the visual cues that were present during this accident.

The Association believes that this analysis supports the NTSB's Recommendation A-74-55 concerning the installation of VASI's on all ILS runways, particularly those runways which have unusable glide slopes below decision height. We believe that this accident, as well as the others mentioned in the NTSB Recommendation, clearly illustrates one of the major factors in many low visibility landing accidents - insufficient visual cues.

This material is provided for consideration in the Board's development of a report on this accident. We will appreciate any comments you wish to make on this analysis.

Sincerely,

J. J. O'Donnell, President

JJO'D:gw
Enclosure

APPENDIX E

IBERIAN DC-10 ACCIDENT - DECEMBER 17, 1973

Assessment of visual cues that were present during approach and landing for Iberia DC-IO Flight *933* at Boston, Massachusetts, December 17, 1973.

Surface Weather Observations

1545 local indefinite ceiling *300* feet obscured, visibility 3/4 mile, moderate rain, fog, temperafure 41°F, dewpoint 38°F, wind *300*° 7 knots, altimeter setting *29.2%* inches, runway 4R visual range 3,500 feet.

Significant Facts Taken From Captain's Statement

1. At 300'

  o F/E called *300'*

  o F/O called opprooch lights in sight to the right.

  o R/O-N reported to tower lights in sight.

  o Captain acknowledgr d lights in sight

* o Captain disconnected autopilot and maneuvered to right.

2. At 200'

• o Aircraft was aligned with runway centerline

  o F/E called "DH."

• o All crew recognized aircraft low.

• o Captain added power.

APPENDIX E

Significant Facts Taken From Captain's Statement, continued

3. At 100'

- F/E called 100'
- Captain observed and F/O called "continuing low."
- Captain again overpowered autothrust to go-around power.
- Sink rate continued.

4. General

- F/O confirmed we were below the glide slope by reference to his instruments.
- Aircraft not out of trim when autopilot was disconnected.

Significant Facts Taken From First Officer's Statement

1. At 300'

- I saw approach light system and told Captain "Lights to the right."
- Captain responded: "Lights in sight."
- Captain disconnected autopilot and initiated a slight right turn to align aircraft centerline approach lights.

2. At 200'

- When turn was completed, F/E called DH.
- Captain answered: "No problem."
- I saw by the instruments that we were low on the glide path and said: "Yes, but we are low."
- F/E said "Yes, we are low."
- Captain then advanced throttles, overriding autothrust system.

Significant Facts Taken From First Officer's Statement, continued

3. At 100'

- o F/E called 100'
- o I observed and called "we ore still low."
- o Captain again advanced throttles.

4. General

* o Just prior to autopilot disconnect, glide slope command bars were centered.

* o After disconnect, I observed less than one dot low glide slope deviation.

* o Runway not in sight until alignment correction completed. Could then see 1/3 of runway.

Significant Facts Taken From Flight Engineer's Statement

1. At 300'

- o I called 300'.
- o I heard F/O call approach light system in sight to the right.
- o Captain confirmed and disengoged autopilot and initiated alignment turn to right.

APPENDIX E

Significant Facts Token From Flight Engineer's Statement, continued

2. At 200'

- o I called "200', DH" and saw decision height light illuminate.
- o Captain responded: "I am slightly low, no problem."
- o I heard F/O say "we are going low on glide path."
- o I cross-checked pitch bars and raw data and told the Captoin "we ore low."
- o At this time Captain was advancing throttles.

3. At 100'

- o I called 100' and observed that Captain was still advancing power.

4. General

- o When F/O first-called "we are low" I observed we were less than one dot low on raw data.
- o At 200' we were less than one dot low.
- o The only time I saw the approach light system was when the F/O called lights in sight and I never saw it again. I never saw the runway itself, only the approach light system.

APPENDIX E

Significant Facts Taken From Radio Navigator's Statement

1. At 1,000'

   o F/E called 1,000'.

   o I looked out and saw nothing.

   o I cross-checked instruments and they were all normal.

   o FROM THIS POINT ON I WAS ONLY LOOKING OUTSIDE.

2. At 300'

   o I saw the approach light system to the right.

   o I remember hearing F/O advise "lights in sight."

   o F/E also said "lights in sight."

   o Captain confirmed that he had the lights in sight.

   o I immediately advised the tower that we had the runway in sight.

   o But I do not remember whether I had the runway or the apprwch lights in sight at that point.

* o I saw the Captain turn to right and align with centerline. There was light rain at the time.

3. General (In response to questions)

* o The first time I saw the runway was after we had rolled out of the turn and we were aligned with the runway. At that time the F/E called "200', DH" and I could see about 1/4 of the runway.

APPENDIX E

Significant Crew Testimony on which there is no Disagreement by any Crew Member

1. According to the Captain, First Officer, and Flight Engineer:

When the approach lights come into view, the Captain disconnected the autopilot and commenced a right turn for alignment.

2. According to the First Officer:

Prior to disconnect, the aircraft was on glide slope.

3. According to the First Officer and Flight Engineer:

After disconnect, the aircraft went below glide slope.

4. According to the First Officer and Radio Navigator:

The runway wos not in sight until the alignment turn was completed.

5. According to the First Officer and Radio Navigator:

When the alignment turn was completed, 1/3 to 1/4 of the runway was in view.

6. According to the Captain and Radio Navigator:

A radio tronsmissian was mode from the aircraft simultaneous with autopilot disconnect. The rodio navigator state: that he contacted the tower and informed them that they hod the runway in sight, however, he is not sure whether the runway or the approach lights were in sight at this point. Flight recorder data puts this rodio transmission simultaneous with autopilot disconnect at o rodio altitude of 175'.

APPENDIX E

Analysis of Pertinent Facts

1. According to the flight recorder, the autopilot was disconnected at a radio altitude of 175' which corresponds to 159' HAT. Because the glide slope transmitter is located in a depressed area, 5 feet lower than the TDZ, the radio altitude of 175' corresponds to a height above GPIP of 164'.

2. The 3^{o} glide slope rises above the GPIP on a 1:19 slope. Therefore, a point on the glide slope, at an altitude of 164' above GPIP is located 3,116' from the GPIP, i.e., 164 x 19.

3. The GPIP is located 750' beyond the threshold. Therefore the 175' radio altitude position of the glide slope centerline is (3,116' - 750') 2,366' from the runway threshold.

4. Therefore, it can be assumed that the aircraft was 2,366' from threshold at disconnect, and that the cockpit visual range was something less than 2,366' at that moment.

5. After autopilot disconnect an alignment turn was commenced with only approach lights in view. This is verified by flight recorder data and crew statements. The runway did not come into view until this alignment turn was complete. This is verified by crew statements. The flight recorder indicates this turn could not have been complete in less than 4 seconds after disconnect. During 4 seconds the aircraft would travel approximately 1,000'. Therefore, when the runway was first in view, the aircraft was

APPENDIX E

Analysis of Pertinent Facts, continued

approximately 1,400' from threshold. The runway is 10,080' long. The F/O and R/N could see approximately 1/3 to 1/4 of the runway at this moment (i.e., approximately 3,000' of runway was in view from a distance of 1,400' from the threshold). This would indicate a cockpit visual range of approximately 4,400' at the moment when the runway was first sighted.

6. Four seconds before the runway was sighted - that is at the disconnect paint - the aircraft was approximately 2,366' from the runway with a cockpit visual range less thon 2,366'.

7. As reasoned in (5) above, the aircraft was approximately 1,400' from the runway at the moment when the runway was first sighted. The aircraft was traveling at a velocity of approximately 250'/second. Therefore, it can be reasoned that one second prior to runway appearance, the aircraft was approximately 1,650' from threshold and the cockpit visual range was less than 1,650'.

8. Therefore, during the first four seconds after disconnect, the cockpit visual range was approximately 1,400' to 2,300'. This, of course, was during the critical period when the deviation below glide slope was not noticed nor adequate corrective action taken.

APPENDIX E

Conclusions

1. Aircraft deviation from the glide slope would have had to been detected immediately after autopilot disconnect by the crew in order to have prevented this accident.

2. After autopilot disconnect and the completion of an alignment turn the runway became visible to the crew. At this point, the visual cues necessary were present. However, by this time it wos impossible for the crew to prevent the aircraft from coming into contact with approach lights.

APPENDIX E

NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C.

ISSUED: October 3, 1974

Forwarded to:

Honorable Alexander P. Butterfield
Administrator
Federal Aviation Administration
Washington, D. C. 20591

SAFETY RECOMMENDATION(S)
A-74-77 through 83

On December 17, 1973, Iberia Air Lines Flight 933, a E-10-30, was involved in an accident at Logan International Airport in Boston, Massachusetts. The captain was conducting an ILS approach to runway 33L when the aircraft struck an approach light stanchion and crashed on the airport. The sky was obscured and visibility was restricted by moderate rain and fog.

The aircraft was equipped with a digital flight data recorder (DFDR) which recorded measurements or status for 96 parameters. These data provided a means for accurately determining the aircraft's flight profile and the winds which acted upon the flight during its final approach. The evidence indicated that the aircraft descended through a significant low altitude wind shear. The wind changed from southerly at 29 knots, to westerly at 5 knots; this change occurred between 500 feet and 200 feet altitudes.

The effect of such a wind shear on the performance of both the aircraft and the flightcrew was examined further in a McDonnell Douglas Co. DC-10-30 simulator. Wind and visibility conditions were reproduced. More than 50 approaches were flown by five pilots who were qualified in the DC-10 aircraft. Tests indicated that the wind shear condition combined with other circumstances to produce a situation conducive to an accident.

The approach of Flight 933 was flown using the autopilot/autothrottle system to the published decision height. An unusable glide slope below DH made it mandatory for the pilot to disengage the autopilot upon descent through 200 feet. DFDR data showed that the wind shear caused the autopilot/autothrottle system to establish a lower-than-normal pitch attitude and thrust setting during the descent. The aircraft was stabilized on the glide slope and slightly left of the runway centerline when the pilot disengaged the autopilot

Honorable Alexander P. Butterfield (2)

and transitioned from instrument to visual reference. Simultaneous with this action, the aircraft descended below the altitude band of the wind shear. The pitch attitude and thrust which had been established by the autopilot to compensate for the changing wind caused the aircraft to descend more rapidly when the longitudinal wind component stabilized.

When the situation was reproduced in the simulator, immediate recognition of the wind shear's effect and positive pilot action was required to prevent an impact short of the runway threshold. The pilots who participated in the tests agreed that the restricted visual cues hindered prompt recognition of the developing descent rate and accurate assessment of the pitch attitude change required to arrest the descent. Invariably, descent below glide slope occurred during the simulated approaches.

A deviation below the glide slope, whether induced by the pilot or by unusual environmental factors, is potentially dangerous during any approach; however, it is particularly hazardous on those approaches which have glide slope installations that provide threshold crossing heights (TCH) of less than the 47-foot minimum specified in FAA Order 8260.24 dated February 24, 1972.

The TCH for the Logan International Airport runway 33L extended glide slope is only 34.3 feet. Had Flight 933 been able to remain on the glide slope, the main landing gear wheels would have passed only 24.6 feet above the approach light stanchion and 7.8 feet above the runway threshold.

The Aerospace Industries Association of America, Inc. (AIA) conducted a study in 1970 to evaluate minimum wheel clearance when accounting for worse-case tolerances considering improved glidepath receiving and tracking equipment. The study assessed the compatibility of glide slope receiver antenna installations on the wide bodied aircraft with existing glide slope transmitter installation criteria. The study concluded that an antenna installation such as that on the E-10 would result in TCH of at least 10 feet when a reasonable probable combination of adverse tolerances was applied to a glide slope having a TCH of 40 feet.

The Douglas Aircraft Company recognized the potential hazard for those Category I approaches that have glide slope heights over the threshold that are below 40 feet. They recommended to all operators of DC-10's that the pilot change his flight profile near DH and actually fly above the glide slope to the point of flare in order to assure adequate clearance over the runway threshold. The Safety Board believes that such a recommendation is in conflict with the well-known merits of a stabilized approach. Furthermore, the TCH for the Logan 33L

APPENDIX E

Honorable Alexander P. Butterfield (3)

approach was not published in official U. S. instrument approach procedures and was unknown to the captain of Flight 933.

The Safety Board further believes that even with a 40-foot TCH, the clearance afforded to the wide-bodied aircraft is too low. The theoretical effect of a wind shear was considered in the AIA study, but only as it effected the aircraft flight profile during automatic landing operation. The study did not consider the glidepath deviation which can occur because of the pilot's response to wind shear effects, particularly during the critical transition from automatic to manual flight and visual reference, as required on Category I and Category II approaches. Research data for such an analysis is limited.

The Safety Board is concerned that the circumstances of this accident are not unusual and believes that positive action must be taken to minimize the possibility of future accidents. These actions must be directed toward ensuring adequate wheel clearance on all Category I approaches considering all adverse tolerances including flightpath disturbances caused by wind shear, and minimizing the effect of such disturbances by improving pilot performance through better training and hazard-alerting procedures. Therefore, the National Transportation Safety Board recommends that the Federal Aviation Administration:

1. Relocate as soon as possible ILS glide slope transmitter sites in accordance with FAA Order 8260.24 to provide a larger margin of safety for wide-bodied aircraft during Category I approaches.

2. As an interim measure, increase DH and visibility minimums for those approaches where the combination of the glide slope transmitter antenna installation and the aircraft glide slope receiver antenna installation provide a nominal wheel clearance of less than 20 feet at the runway threshold.

3. Pending the relocation of the glide slope facility to comply with FA4 Order 8260.24, expedite the modifications to official U. S. instrument approach procedures so that they display glide slope runway threshold crossing height for all approaches having a TCH of less than 47 feet.

4. Issue an Advisory Circular which describes the wind shear phenomenon, highlights the necessity for prompt pilot recognition and proper piloting techniques to prevent short or long landings, and emphasizes the need to be constantly aware of the aircraft's rate of descent, attitude and thrust during approaches using autopilot/autothrottle systems.

Honorable Alexander P. Butterfield (4)

5. Modify initial and recurrent pilot training programs and tests to include a demonstration of the applicant's knowledge of wind shear and its effect on an aircraft's flight profile, and of proper piloting techniques necessary to counter such effects.

6. Expedite the development, testing and operational use of the Acoustic Doppler Wind Measuring System.

7. Develop an interim system whereby wind shear information developed from meteorological measurements or pilot reports will be provided to the pilots of arriving and departing aircraft.

REED, Chairman, THAYER, BURGESS, and HALEY, Members, concurred in the above recommendations. McADAMS, Member, did not participate in the adoption of these recommendations.

John H. Reed

By John H. Reed
Chairman

APPENDIX E

THE SECRETARY OF TRANSPORTATION
WASHINGTON. D.C. 20590

September 24, 1974

Honorable John H. Reed
Chairman, National Transportation
Safety Board
Department of Transportation
Washington, D. C. 20591

Dear Mr. Chairman:

This is to acknowledge receipt of your letter of September 23 to the Federal Aviation Administrator enclosing a copy of a safety recommendation relative to the involvement of an Iberia Air Lines Flight 933, a DC-10-30, in an accident at Logan International Airport in Boston, Massachusetts.

The recommendation is receiving attention by the Department's Assistant Secretary for Environment, Safety and Consumer Affairs, as well as other appropriate Departmental officials.

Sincerely,

Claude S. Brinegar

Claude S. Brinegar

APPENDIX E

AIR LINE PILOTS ASSOCIATION
1625 MASSACHUSETTS AVENUE, N.W. □ WASHINGTON, D.C. 20036 □ (202) 797-4000

September 30, 1574

Honorable John H. Reed
Chairman
National Transportation Safety Board
800 Independence Avenue, S.W.
Washington, D.C. 20591

Notation 1354

Dear Mr. Reed:

Thank you for the advance copy of the Safety Recommendations A-74-77 through 83 relating to the Iberia Airlines DC-10-30 accident which occurred at Boston-Logan International Airport on December 17, 1973.

While the Board has done an outstanding job in the investigation of this accident, we were somewhat disappointed with the lack of a recommendation relative to the relocation of the glide slope receiver antenna on wide-bodied aircraft.

Several years ago ALPA became aware of the "waiver" given to the manufacturers of wide-bodied aircraft which allowed them to deviate from a recommended practice of ICAO which states that "the distance between the path of the glide path antenna and the path of the lowest part of the wheels should not exceed 19 feet." Over the objections of the FAA Western Region certification personnel, the manufacturers were granted approval for exceeding this ICAO criteria by FAA Headquarters in Washington. The basis of this "waiver" was a statistical analysis conducted by AIA which contains several invalid assumptions.

Our own analysis of the tolerances associated with ILS approaches was submitted to ICAO by Mr. Thomas G. Foxworth, Chairman of the ALPA Airworthiness and Performance Committee. A copy of this analysis is enclosed. While this analysis refutes many of the contentions contained in the AIA analysis, we have subsequently learned of additional deficiencies associated with the AIA analysis.

For example, FAA's criteria spells out in Advisory Circular 20-57A wind shear criteria to be used to show compliance with the rules for automatic landing system. Advisory Circular 120-29 spells out the wind shear criteria for autopilot and flight director systems for Category II approval. Both of these documents specify only the magnitude of the wind shear, but neither specify how the shear is to be applied. This is a very critical omission

/continued/

which the manufacturers have used to their advantage. Shown on the attached figure is the wind shear profile used by Douglas Aircraft Company in their analysis of the DC-10 performance. You will note that the manufacturer has chosen to use a wind shear model in which the headwind increases from 9 knots at 200 feet to 25 knots at the surface. Obviously, an aircraft descending into a continually increasing headwind condition would experience improved airplane performance and a tendency to go above the glide slope. The validity of any analysis which attempts to investigate threshold crossing heights and missed approach height losses based on a wind shear profile such as this is so ridiculous as to not require further comment. Nevertheless, it is clear that the manufacturer found a loophole in the FAA's criteria and used this loophole to justify its deviation from other recommended practices. Not only does this wind shear profile defy the laws of nature but its use casts serious doubts on the credibility of the manufacturer. It further raises a question regarding the FAA's technical competence to have been persuaded to relax the ICAO criteria on the basis of this data.

While ALPA is in agreement that some of the marginal ILS glide slope transmitters should be relocated further from the threshold, we believe another equally important part in the solution of this low wheel height problem must be the relocation of the glide slope receiver antenna on the aircraft. Relocation of the ILS transmitter antenna on Runway 33 at Boston from its present location (750 feet from the threshold) to a nominal distance of 1000 feet from the threshold would have moved the impact point closer to the threshold by a distance of 250 feet. Relocation of the glide slope receiver antenna an the aircraft to a nose position would have moved the impact point another 50 feet closer to the threshold. Both of these modifications would have placed the aircraft closer to the runway threshold at the time of the wind shear encounter and thus could have provided the pilot with earlier recognition and assessment of the limited visual cues.

While the Board recognizes the undesirability of having to "fly above the glide slope ... in order to assure adequate clearance over the threshold", the Board's recommendation (No. 2) is in conflict with this position. Obviously, the only benefit of increased decision height and visibility minimums would be to allow the pilot to fly above the glide slope. Furthermore, we take strong exception with the Board's attempt to perpetuate the arbitrary 20 feet nominal wheel clearance at the runway threshold. As pointed out in the attached paper, there is no basis for believing that the 20 feet nominal clearance will provide adequate safety for air carrier operations. It should be stressed that the narrow-bodied jets are currently provided with approximately 30 foot wheel clearance height on ILS approaches. We cannot believe that the Board would accept a lesser standard for wide-bodied aircraft on the basis of the outrageous analysis conducted by the manufacturers. Our members cannot! ALPA intends to pursue this deficiency at the highest levels. We would sincerely appreciate your support in our efforts to maintain a high level of safety far wide-bodied aircraft.

/continued/

As stated previously, we believe the Board has conducted a most commendable investigation. Through the use of the sophisticated flight recorder information, this is the first time wind shear has been proven to have a primary factor in the causation of an accident. While we suspect that several other accidents in the past have been caused by wind shear, the older flight recorders simply did not have the capability to make this determination. As a result of this investigation, we are confident that the Board will exert more emphasis on the subject of wind shear to prevent future accidents.

Sincerely,

J. J. O'Donnell

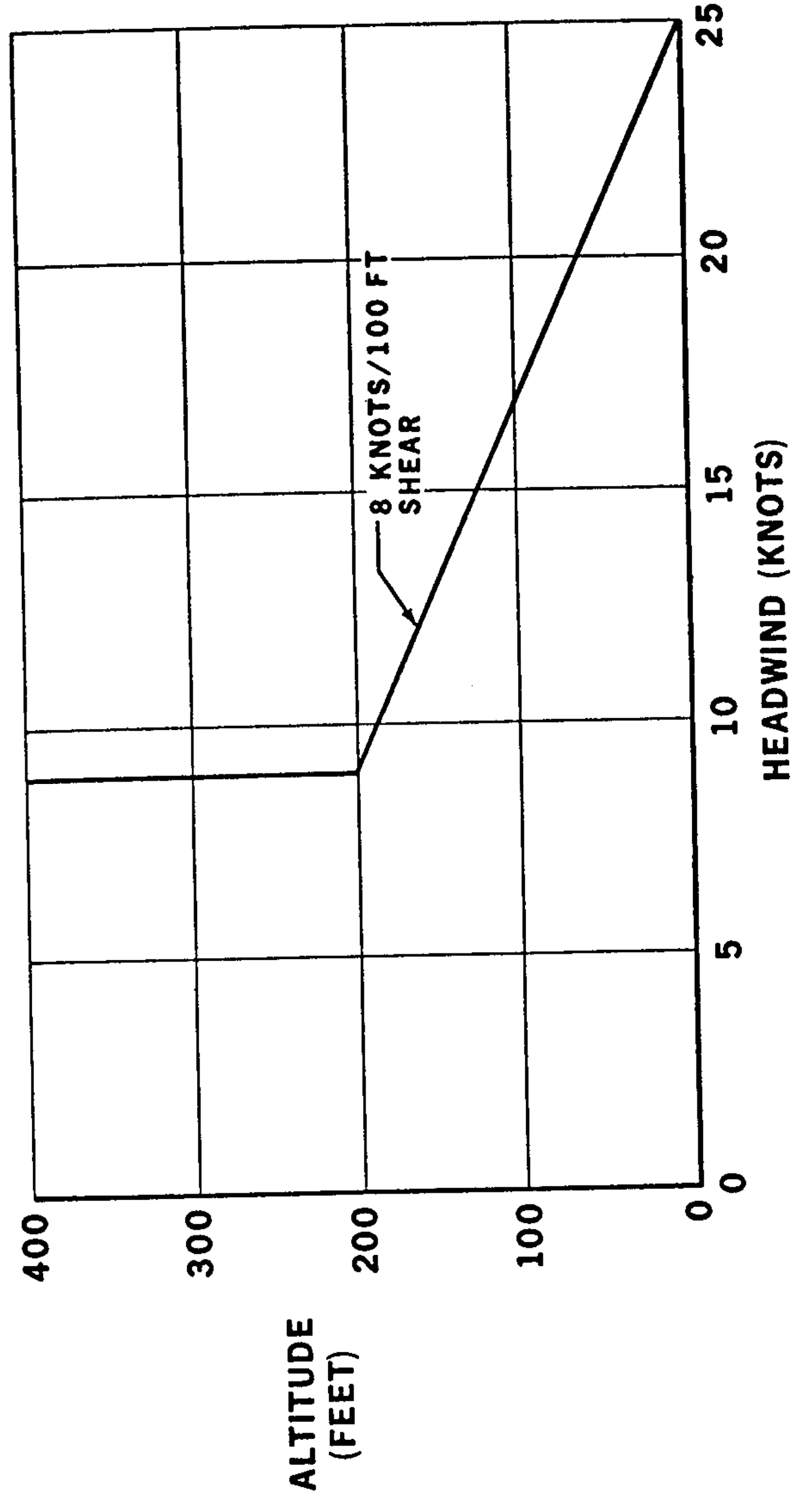
J. J. O'Donnell, President

JJO'D:aes

Enclosures

APPENDIX E

WIND SHEAR PROFILE



APPENDIX E

AIRWORTHINESS COMMITTEE

Presented by T. G. Foxworth

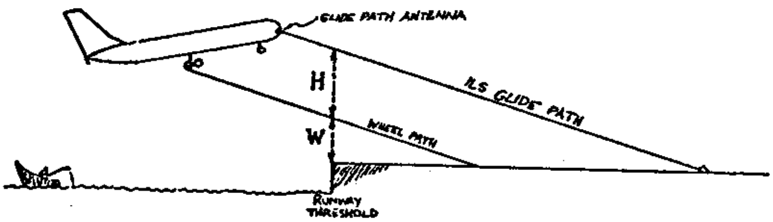
Ref. AIR C Memorandum 161

Date
11 December 1973

Subject: ILS glide path antennas

1. This is in response to paragraphs 5 a) and 6 of AIR C Memorandum number 161 dated 5 October 1973.

2. Reduced to its most simple form, the dilemma can be depicted:



and the pertinent requirements stated:

i) to determine the smallest acceptable value of W in order to assure an adequate level of safety, taking into proper account all tolerances that are allowed and anomalies that can be expected;

ii) in order to insure that the smallest acceptable W determined in i) is achieved and not infringed, to then determine the maximum value of H that is compatible, and to impose this as an airworthiness requirement in aeroplane design.

3. **ON THE QUESTION OF W**

3.1 I have noted with interest the history and increasing concern over this item. To my great dismay, there has been very little effort toward securing agreement over what rationally constitutes an adequate value of W--great disagreement still exists--and even less effort toward coordinating the various segments of the industry who maintain different views. Meanwhile, each segment with any authority seems to be rushing pell-mell to implement his particular opinion.

3.2 Perhaps the most important precedent was established in certification which, referring to the U.S. code, requires that the landing distance be determined "from a point 50 feet above the landing surface." (FAR 25.115) Without additional qualifying guidance or applicable caveat, this traditionally has been interpreted to mean that W is 50 feet (see diagram; i.e., that the wheel path crosses the threshold at 50 feet.) As far as airline pilots are concerned, this would be a wonderful state of affairs. If laposed, It would mean that the projected no-flare wheel impact point would be 954.02 feet from the threshsld for a 3° wheel path. and 1145.21 feet from the threshold for a 2.5° wheel path, which moreover is certainly not Incompatible with an allowable Touchdown Zone (defined as the first 3000 feet from the threshsld in Category II and III operations.)

3.3 Unfortunately, life is not so simple. Yet the beginning of the trend that has now resulted in such serious erosions of the margins intended by certification was insidious] subtle. Since no one gave much thought to the possibility that H (in the diagram) could ever grow to such mammoth proportions that we now see, the early ILS glidepath transmitters were sited such that the electronic glidepath crossed the threshold at about 50 feet. This seemed at the time to be reasonable — the wheel path couldn't be much different-and it also seemed to provide a degree of compatibility with the figures used in certification. However, it was nevertheless obvious that W must fall below 50 feet. even then. no matter how slightly.

3.4 The first definite lower value of W first adopted was 35 feet. The ICAO COM-7 redefined W for Jet transports to be 30 feet (ICAO Doc 8226) and this seemed to establish, for purposes of reference criteria. good precedent. The controversy that has intensified is whether a value of W less than 30 feet can be established as a criterion without raising to an unacceptable degree the risk of undershooting. Some insist not. Others say yes, on the basis that minimum levels of safety named in the standards can be applied as everyday operational specifications, arguing that pilots often infringe their margins. Even if we generously allow that a W of 30 feet provides the margin intended in the beginning, what are margins for but to prevent infringing something far worse. For the time being, W stood at 30 feet.

3.5 However, there were certainly tolerances to be expected in the actual ILS glidepath threshold crossing height (called ILS reference datum) achieved. For example, ICAO AWOP II formulated recommendations (Rec 3A 3/1 and 3A 3/2; ICAO Doc 8512, page II-14) relating to glidepath component siting criteria and tolerances for the ILS reference datum. For Category I ILS the recommended reference datum and tolerances are 15m ± 3m (50 feet ± 10 feet); for Category II and III ILS, they are 15m + 3m, with an extraordinary allowance for a maximum tolerance of one meter low (hence 50 feet + 10 feet, − 3 feet.) These recommendations were accepted by the Air Navigation Commission (9th Meeting of the 49th Session. 10/6/65) on the understanding that the ILS reference datum specified was "nominal." The matter was further referred to the 4th Air Navigation Conference (see ICAO Doc 8554, paras 5.6 and 5.7.) In defining the ILS reference datum, a straight-line glidepath extension was assumed. both for convenience in the geometry and to reinforce the intent that other specifications dependent on the ILS reference datum be based on this height. even if the actual glidepath extension were not a perfectly straight line at the threshold.

3.6 As far as I can determine, the nominal 15m ILS reference datum was based on the assumption that a minimum W of 30 feet (9.2m) and no lower would be maintained. This was further corroborated by the then relevant Jet transports in service, characterized by the B707-100 for which H was 5.8m (19 feet); 9.2m plus 5.8m equalled 15m and everything was cozy. It is significant to note that one AWOP panel member pointed out at AWOP II that the exception clause in Rec 3A 3/1 (i.e., allowing a minus one meter tolerance to the reference datum for Category II and III ILS) could result in a nominal W of less than 30 feet and he cautioned that "considerable experience and substantiating data were needed before this was justified." Despite this note of caution, the ILS reference datum criteria were carried into Annex 10, Volume 1, paragraph 3.1.4.1.4, with a Note that a maximum vertical distance of 5.8m (19 feet) for H was assumed. And this note has become the source, however weak, for subsequent accountability.

3.7 Notwithstanding this, in the U.S. FAA Order 8260.24 of 24 February 1972 noted, in respect of Category I ILS, that--even as late as 1972--no minimum threshold crossing height (reference datum) was specified!! The order therefore recommended that, in cases where "low threshold crossing height exists" the glidepath angle should be increased to 3° or the transmitter site relocated, but, acknowledging possible difficulties in implementing this recommendation, noted that "a low threshold crossing height, of itself, is not adequate justification for glidepath relocation... especially if paved underrun exists." It also provided another firm hammer-blow on the wedge forcing wheelpath height criteria lower by noting "the threshold crossing height should be such that with the aircraft antenna on the extended glidepath, the wheel clearance over the threshold is not less than approximately 20 feet." (underline supplied.) "Industry agreement" is cited, but let it be unmistakably clear that the airline pilots--the very people to whom the criteria have the most immediate and far-reaching significance--were not consulted.

3.8 The figure of 20 feet, now having crept in, was implanted even more firmly by ICAO VAP-5 which decided that a W of 6m (20 feet) is acceptable (ICAO Doc 8862, para 10.3.1) However, it should be vigorously emphasized that VAP gave justification--no data whatsoever--in support of its contention that the "present nominal height" is on the order of only 20 feet. It may very well be so in some cases...but it may also be that 30 feet was a much better figure to be applied as the standard as well. Obviously, the VAP coordination with other ICAO panels (AWOP and even the AHC Itself) was deficient in that VAP disregarded the by now well-established principle of retaining a minimum W of 30 feet.

3.9 Ominously, VAP-5 also took note that VASI siting tolerances can place the aeroplane in a "dangerous undershoot condition." Even VASIs, it seems, do not always insure satisfactory values of W; VAP pointed out--to our great concern--that even today's 707, if flown on the lower edge of the allowable "on slope corridor" would have a W as low as 1.1 feet! Larger aeroplanes would obviously undershoot.

3.10 Now that a "nominal" W of 20 feet as a criterion has gained credence--not by any rational means, but only by age--it would be presumptuous to hope to reverse it, as we would like to do. But even this figure is being eroded.

3.11 When the problem posed by excessive H first began to assume importance, the U.S. FAA, rather than holding the line on H in aeroplane design, also arbitrarily permitted a nominal W of 20 feet, allowing a minimum W of 10 feet to exist when "all operational tolerances are considered" in what they call "reasonable probable combination." It is entirely irrational to accept a minimum tolerable W of 10 feet (even in the "worst likely case") as the U.S. suggests--especially since the U.S. cannot satisfactorily document or corroborate that this figure is realistic. They have presented no statistical scientific substantiation to support the dangerously low criteria they propose. We note, with regret, that meaningful substantiating data has not been presented to ICAO in response to paragraph 5.(iv) of Memorandum 161. We recognize the very real problem of obtaining statistically significant and accurate data on actual wheel heights being achieved in day-to-day airline operations. The lack of such data is decidedly frustrating--especially since other standards (landing distance revisions, for example) are being formulated on assumptions as to what this data might be. The only attempt at an in-depth study to our knowledge (called Report 470 in the U.S.) has been bottled up on the basis of errors in the measurements. We suspect--on the basis of limited photo-theodolite data variously made available--that achieved values of W in service, under visual conditions, are often quite low--even under five feet.

3.12 Jut we hasten to emphasize that thls certainly does not prove that such low values are safe, which is what is belng contended. Rather, it is cleer indication that excursions well below the currently established glidepath crlterla are frequent, and that no further erosion of the standards is justified.

3.13 Yet the erosion dld not stop even' here! A joint FAA/AIA/ATA meeting held on September 11, 1970 in Washington (a meeting in which the air line pllots dld not participate) blessed an AIA report which attempts to justify extremely low values of W. This report formed the basis for the FAA rotlonale to adopt a W of 10 feet as a standard. Yet even thls report notes, significantly, that in cases sf "severe windshear" (defined as 25 knots/100 feet), a "poor bean" (undefined ...)that a go-around lnltlated "at the threshsld' will result In a W of 5.5 feet ... followed immediately by the reassuring statement that "go-around is perfectly safe 'rlth the wheels touching the runway!!"

3.14 So we have run the complete gamut: from a satisfactory W sf 50 feet, the industry--for whatever interests may exist--have, by tortuous logic and questionable precedent, whittled it down to absolutely zero. It would be difficult to imagine they would not like to go even further. Douglas cautions DC-10 pilots, "if you follow a 2.5° VASI and are on the lower edge of the 'on-slope corridor' the main gear will touch doxn short of the runway." (The Annex 14 Installation Crlterla and Tolerances for VASIs soberly presents distances for locating the downwind VASI wing bar to yield W of Zero feet; see AIR-C SID 42, Appendix A, page A-14.) We can just imagine what benefit this will have for landing distance determlnatlon!

3-15 Douglas also cautioned that the ILS "does not always provlde margins as large as we would like" (!) citing the ILS on Miami runway 9L (as of 5 October 1971) which produced an on-glide-slope (no error) W of 4.6 feet. (Quoted in Know Your CC-10 Letter 10. Significantly, thls implied criticism of Miami was excised from Letter 10A.) Douglas further notes that on automatic approaches, the autopilot must be disconnected no lower than 100 feet because "it rill be necessary to fly above the glidepath when approaching the threshold to lnsure adequate vheel height clenrance." IFALPA can verify thct some operntors have modified their standard procedures for the DC-10 by requiring the pllot, at an altitude of 300 feet, to disconnect the autopilot and fly above the glldepath by ½ dot in order to assure adequate vheel height clearance at the threshold. This means that, at least for this airline, automatic approaches are nsrmally discontinued at 300 feet which is an unfortunate restriction of operatlons. Douglas is pzrtlcularly vehement in denouncing the "duck-under,' and pllots are warned that if the threshold is still visible from the cockpit at a radio altltude of 50 feet, vheel clearance is not assured and to initiate a so-around. Airline pilots apply thls crlterla, typically using somewhat higher altitude figures.

3.16 Disregarding the obvious and flagrant infringement of the obstacle clearance surfaces such late go-arounds would produce (a problem currentlv being consldered in conjunction with the OCP which is knstty enough, even assuming go-arounds initiated at a height of 100 feet), we are appalled at the very prospect that today's large transports can be put in need of going around because expected values of W are insufficient. This is clear indication that the erasion has gone much too far. It is now lncunbent on ICAO and other authorities to put a stop to thls pervasive trend.

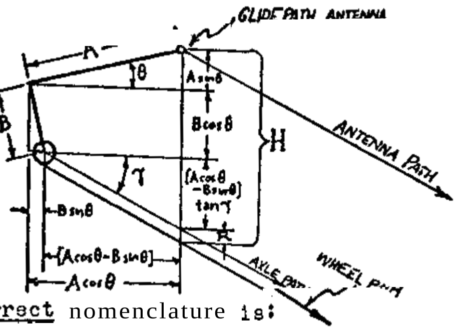
3.17 The AIA report mentioned absve purports to Justlfy thelr current design crlterla by an analysis of expected' tolerances in factors affecting the quality of the approach. They begin with their design criteria (which allows H to be well in excess of the ICAO assumed 19 feet) and work through to justify that fewer than 1 in 100 approaches would result in values of W less than 10 feet. The rational method, however, is to work through in the other direction: to establish the nominal criterion for γ, apply the tolerances, and determine the design criterion for H. In establishing the criterion for γ, it does not have to be nor should it be necessarily referenced to what airlines achieve in daytime visual operations, but should implicitly include sufficient margin to account for unexpected factors which do occur with sufficiently high frequency to warrant their consideration.

3.18 On the basis of early precedent and experience, based on ell the criteria described, we Peel that a nominal γ of 30 feet is xarranted and should be reimposed and retained. It proved to be an sdequate crlterlon for earlier Jet aeroplanes and certainly it is still justified to conslder it a valid standard for aeroplanes whose outsize geometry raise serious concern over assuring safe values of γ today. The minimum tolerable value of γ, under conditions of all tolerances, anomalies, and technical errors being applied adversely, should in no case be less than 20 feet.

4. ON THE QUESTION OF H

4.1 There has been no little confusion as to just what H is. Perhaps here it would be useful to outline the two commonly applied methods for defining terms and calculating H.

1) ~~Method 1~~



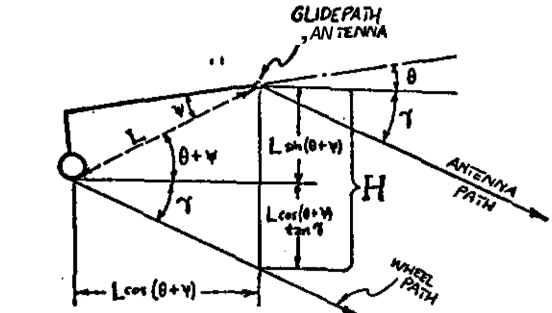
The correct nomenclature is:

- θ airplane pitch attitude or "body angle" (i.e., Inclination of the naterline reference to the horizontal. This was incorrectly called the waterline angle of attack by the VAP.)
- γ flight path angle--in this case, ~~electronic~~ glidepath angle Since the aeroplane is assumed to be following the glidepath--related to the horizontal.
- α aeroplane angle of attack (Inclination of the waterline reference to the flight path). Note: $\alpha = \theta + \gamma$
- A distence parallel to the waterline reference between the glidepath antenna and the axis of the rearmost wheel.
- B height difference between the glidepath antenna and rearmost wheel axis (perpendicular to the waterline reference)
- R radius of the rearmost wheel

$$\boxed{H = A\sin\theta + B\cos\theta + [A\cos\theta - B\sin\theta]\tan\gamma + R}$$

actually $R\sec\theta$ since the path is tangent to the wheel; but this difference is negligible.

ii) Method 2



This method is found also in AWOP II (ICAO Doc 8512)

L distance between lowest point of rearmost wheel and glidepath antenna, measured directly

ψ angle measured from waterline reference to the line connecting the glidepath antenna and the lowest point of the rearmost wheel

$$\boxed{H = L\left[\sin(\theta+\psi) + \cos(\theta+\psi)\tan\gamma\right]}$$

4.2 Method 1 is the most commonly used method, and the method for which dimensions are readily available. Dimensions supplied by the manufacturers (see AIR C BID 42) are listed. (Note: some manufacturers supplied θ; others supplied α.)

	A	B	R	θ	α	CALCULATED H	H (values from Memo 161 App B)
DC-10	1199" 1200" (1)	158.5" 162.407"	25" 25"		7.7° "	28.59' 28.93'	28.6'
DC-8-63	1128.5"	103"	21.5"		2.0°		6.3'-26.25'
707-320	742"	150.3"	23.25"		5.6°	20.46'	19.5'-23.7'
747-100	1003.99"	82.36"	24.375"	5.0° (2) 4.0° (3)		20.14'	11.25'-27.25'
L-1011-1	1191.5"	176.6"	25"		10.2° (4)	34.19'	21.3'-31.4'
S VC-10	1084.3" -536" (5)	161.9" 440.4"	25" 25"	3.5° "		25.36' 33.74'	14.96'-21.1'
Concorde (6)	379.248"	105.472"	23.5"	10.25°		17.65'	

Notes: (1) AIA dimensions for DC-10 listed in their 9/11/70 report. DC-10 approach angle assumes DLC operating, $V/V_s = 1.35$

(2) maximum listed

(3) typical

(4) also see Method 2 analysis below; AIA in their 9/11/70 report listed an α of 9.2°

(5) based on standby ILS antenna located in nose of tailplane bullet (not considered in appendix B of Memorandum 161)

(6) Concorde 5100 Specification para 12.3.1.2 mandates $H \leqslant 19'$ to conform with the ICAO assumption in Annex 10. IFALPA applauds this, and points to it as a model for other manufacturers to emulate.

4.3 The only aeroplane analyzed by Method 2 has bden the Lockheed L-1011; this analysis was contained in the AIA report of 9/11/70, and is the only reference which lists valuds for L end ψ.

$L = 1200''$

$\psi = 7.8^{\circ}$

$\alpha = 9.2^{\circ}$

These figuros yield H = 29.27 feet, somewhnt less than the H calculated from the figures listed in AIR C BID 42 and given above. (If we use the α of 10.2° listed in BID 42, we derive an X of 30.94'; thls suggests some slight discrepancies exist in the dimensions supplied.) Of course, L and ψ can be computed from the dimensions supplied:

$$L = \sqrt{A^2 + (B + R)^2}$$

$$\psi = \tan^{-1} \frac{(B + R)}{A}$$

(The only advantage to doing thls is that the Method 2 formula for H is much simpler)

From the figures supplied in BID 42. re derive L = 1208.44" and $\psi = 9.2^{\circ}$ for the L-1011, which casta doubt on the figures used by the AIA in thelr raport.

4.4 The ILS tolerances considered in the AIA analysis are:

γ	2.5°	2.75°	3.0°
Qlldepath error due to lateral shift (when the aeroplane is offset from the centerline, due to the transmitter offset)	.51'	.61'	.73'
Qlldepath beam bend (3σ variation)	2.40'	2.38'	2.40'
Glidepath ground monitor tolerance	3.75'	3.749'	3.748'
Receiver centering error (ARINC 578, page 12; 3σ variation)	.70'	.72'	.72'
Pilotage error (75 μa; one dot low)	6.00'	5.98'	6.00'

Errore acknowledged but for which no figures are assigned:

Glidepath displacement sensitivity

Situation display tolerance

Autopllot performance tolerance

Windshear, turbulence (FAA Advisory Circular 20-57(a) requires only 8 kts/100 feet. AIA variously assigns an error to thls of some ½ foot low.)

Beam dlstortlons caused by preceding aircraft

Total	7.56' 13.36'	7.55' 13.44'	7.58' 13.60'

4.5 The uppermost (smaller) of the two totals listed is based on the AIA contention that the "most probable error" can be deduced by the Root Mean Square (RMS) method; i.e., taking the square root of the sum of the squares of all factors listed. We are extremely skeptical of allowing an RMS analysis of all the factors with no attempt to analyze whether sone of the factors should not be fully additive. It seems more probable that not all factors are properly random, and in fact the likelihood of all the errors combining adversely is sufficiently high not to be ignored--especially for establishing criteria--and taking into account the high incidence of errors not considered numerically by the AIA. Therefore, the straight sum of all the factors is also listed:(the lower (larger) of the two totals.)

4.6 The AI.4 further attempts to buttress their case by applying a hyperbolic formula for beam rise at the threshold (reference IEEE Transactions on Aerospace and Electronic Systems, July 1968, page 638), in order to show that the actual electronic glldepath is raised above the straight-line extension, such that a beam of $\gamma = 3^{\circ}$ whose straight-line extension crosses the threshold at 47 feet in fact is situated 51.5 feet abave the threshold. Thls may be true to some extant--but it was neither a feature nor the lntent of the ICAO specification. For the purpose of establishing criteria, we must lnslst that the glldepath be consldered to be at its lowest assigned height, lrrespectlve of hyperbolic beam rise; the intent is clearly to provlde adequate wheel clearance when the actual beam crosses the threshold below 50 feet.

4.7 AIA also malntalns that the large aeroplane will have initiated its flare to land prior to reaching the threshold. and therefore will be provided wlth an additional margin of clearance (they assign 3.5 feet to thls.) Thls nay not always be the case in fact, and certainly cannot be counted on in all cases--especially when establishing crlterla.

4.8	The AIA therefore contends that:	Whereas IFALPA proposes:	
Acknowledged worst-case Y	10.00'	*20.00'*	
Worst acknowledged tolerance	+ *7.58*	+ 13.60'	
Minimum acceptable Y	17.58'	33.60'	(30.00' nomlns:
Diminished by flare	- 3.50'	0	
Lowest acceptable target Y	14.08'	33.60'	
Apply lowest allonable ICAO Category II ILS reference datum (50'-3'=47'); AIA applles hyperbollc beam rise	51.50'	47.00'	
Allowable maximum H (aeroplane geometry)	37.42' (11.4m)	13.40' (4.1m) (17.00' (5.2m) nominal)	

4.9 Since no aeroplanes have an H exceeding that derlved by industry, they are not unduly concerned, and contend that lower figures are too restrictive on deslgn. However, by taklng what we feel to be the more rational approach, IFALPA achieves a design criterion for H slightly less than the ICAO assumption in Annex 10. Thls is not necessarily to criticize the earller action of ICAO, but rather to reinforce the rationale behlnd its adoption. In fact, we continue to feel that the earlier ICAO derlvatlon (ILS reference datum of 50' minus nomlnal wheel height of 30' yields H of 20'--19' by rounding off 5.8m) was very close to being on target. More important, the IFALPA analysis supports not only retention of the conservative criterion, but upgrading of the ICAO Recommended Practice. H = 5.8m is a maximum and should not be compromised.

4.10 We also note with great misgiving the rationale of "equivalent safety" used by the U.S. FAA to Justify their adoption of the industry view and consequent degradation of the earlier margins. For aeroplanes whose H exceeds 5.8m (19'), "equivalent safety" is apparently achieved when the "nominal" Y is *20 feet* at maximum landing gross weight an an ILS reference datum of 47 Teet (see para 4.6 above); or when the minimum Y is 10 feet under the condition of all tolerances being applied in "reasonable probable combination"(see para 4.5 above) including "reasonable windshear"(8 kts/100 feet,;

and xhen the aeroplane is flown nanusll:: elong a path similar to that which would be followed by ths autopilot. presumably allowing for a nanusl takeover at any point (although how thls is quantified, or where it has been demonstrated under oondltlons when X 1s being measured has not been revealed.) It seems that one highly probable reason the pllot might takesver manually is that the autopilot was delivering hlm low on the glldepath. In any event. the FAA does not guarantee even the low W of 10 fret; they only assume it. We do not feel these condltlons are in any conceivable way "equivalent" to maintaining and requiring a nomlnnl W of 30 feet (that is, mandating a maximum H of 19 feet.) Aeroplanes are now regularly built in which H vastly exceeds 19 feet, yet the only steps taken are to warn pilots. The FAA concedes that "special attention" must be paid to aeroplanes with large values of H in order to assure "total system performance" but we can flnd no evidence of provlslons to upgrade the performance of elther the airborne or ground-based system components (certainly ground system components perform identically for all aeroplanes irrespectlve sf thelr glidepath antenna location.) Perhaps, if airborne component performance were upgraded, antennas could be relocated closer to the wheels--where they <u>should be</u>. *The* Concorde design proves there is no excuse for not doing so.

5. <u>CONCLUSIONS</u>

5.1 Strictly speaking, it is outside our purview to deal wlth purely oporatlonal matters. But we must again forcefully remind all diverse parties that the achievement of success depends on all aspects, operations, airworthiness, ground equlpnent performance, etc. We take nste of ARC Task No. 14.5.2-1/67 (ILS Technical Specifications) in AN-WP/4206 of 27/9/73; and of Recommendation 3/16 of the 7th ANC; we are gratified and heartened that, in framing Rec 3/16, the Air Navigation Conference conflrned that they share our very <u>deep concern</u> over thls matter, and we are pleased that the Airworthiness Committee has been asked for guidance. Since we are appalled at the extent to which the ICAO standard has Seen eroded, our part in the team effort *must* noa be to properly adjust the glidepath antenna site on the aeroplane (H is purely an aeroplane geometry problem, subject to deslgn crlterla) so that aeroplanes sent into international alr navigation can be freely operated xlth full assurance that reasonably expected system deeradation will not endanger life and property.

5.2 Furthermore, replies to ST 8/4.2-72/165 indicate that several States agree wlth us that thls is a proper airworthiness matter. Some States understandably have taken a passive view, expecting that to maintain H less than 19 feet in design "will not always be practicable." We take an <u>active</u> view. Concorde design has proven it is entirely practicable, and that a value of H can be imposed as a design requirement. We do not thlnk it is realistic to ask States to raise the ILS reference datum to accamsdate poor aircraft (Australla solution B.) Pilot experience with worldwide facilities demands tnat we take as much safety with us in the aeroplane as we can. We do not think nuts-flare equlpnent justifies decreasing the presently allowed values of W. Automatics are never 100% reliable (hardly ever 90% reliable) and human time delays are <u>not</u> adequately accomodated in the requirements for pllot assessment and override of their malfunction, especially in the critical phases (a failure sf the auto-flare to function, for example.) With Canada and the Netherlands, we feel strongly that H <u>must</u> be controlled in aeroplane design, that suitable material <u>must</u> go into the Airworthiness Technical Manual, and that the subject <u>must</u> be addressed properly in Annex 8. We also feel fhat all other relevant ICAO material having to do wlth thls matter should be upgraded instatus. In addition, we feel that aeroplanes on which H exceeds 27 feat today (based on an ILS reference datum of 47'; lowest allowable W of 20') should *have* operational restrictions; for example. such aeroplanes should *be* prohibited from conducting Category II or III approaches when using certain ILS installations conforming to the ICAO standards. States which have certified such aeroplanes for Category II and III approaches on xhatever basis should be properly admonished.

(End)

(Inadvertantly omltted--please insert on page 9):

4.11 Obvlously the sltuatlsn can be tremendously aggravated an a Category I ILS, far which the reference datum is allowed to be as low as 40 feet (and in practice even lover if we conslder the FAA Order mentlsned in para 3.7.) The very critical Category I case. which has pilots the mast worried, is totally ignored by the industry; thus, implicit in the entire AIA analysis la that pllots ehall not--and lndeed cannot--follow Category I ILS beams across the threshold. Yet Category I quality (and poorer) ILS comprise the vast bulk of the ILS pilots must use worldwide. If we imposed a design criterion thnt properly aocomodated these ILS, we would require values sf H on the order of not more than 10 feet (3m.) The reason given by the AIA for siting glidepath antennas in the nose vas to place the pilot's eye near the electronic glidepath so that he xsuld "feel comfortable with the aeroplane in the proper slot (sic) as determined by visual cues.. . when the pilot transitions from instruments to visual." *They* have in fact achieved exactly the opposite: we feel decidedly uncomfortable in thls situation! Moreover, this is totally fallacious reasoning. Not only would it almost certainly put the aeroplane in an undershoot condition if followed, but it is in direct contradiction to their warning against "duck under." Pilots duck under to find the visual cues they heve been used to in pest aeroplanes. Relocate tho glidepath antenna to the wheels to provide the H we need--in all cases, not Just Category II or III--make the pilot get used to the new (higher) visual cues. and experience proves ~~he will use them.~~

APPENDIX E

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

WASHINGTON, D.C. 20590

OFFICE OF
THE ADMINISTRATOR

OCT 4 1974

Honorable John H. Reed
Chairman, National Transportation Safety Board
Department of Transportation
Washington, D. C. 20591

Dear Mr. Chairman:

This is to acknowledge receipt of Safety Recommendation A-74-77 through 83.

These recommendations are being reviewed by the agency and a final response will be forwarded as soon as possible.

Sincerely,

Alexander P. Butterfield
Administrator

APPENDIX E

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

WASHINGTON, D.C. 20590

OFFICE OF
THE ADMINISTRATOR

November 19, 1974

Honorable John H. Reed
Chairman, National Transportation Safety Board
Department of Transportation
Washington, D. C. 20591

Notation 1354

Dear Mr. Chairman:

This is in response to Safety Recommendations A-74-77 through 83.

Recommendation No. 1.

Relocate as soon as possible ILS glide slope transmitter sites in accordance with Federal Aviation Administration (FAA) Order 8260.24 to provide a larger margin of safety for wide-bodied aircraft during Category I approaches.

Comment.

FAA Order 8260.24 is in the process of being revised to require the relocation of all ILS glide paths which provide a threshold crossing height below 47 feet at those airports at which Category D airplanes operate. The Boston glide path transmitter is scheduled for relocation during the first quarter FY-76.

Recommendation No. 2.

As an interim measure, increase DH and visibility minimums for those approaches where the combination of the glide slope transmitter antenna installation and the aircraft glide slope receiver antenna installation provide a nominal wheel clearance of less than 20 feet at the runway threshold.

Comment.

We do not concur. The present minimum visibility of ½ mile and decision height of 200 feet is considered adequate to enable a pilot to adjust the flight path by visual reference through threshold crossing and landing.

2

Recommendation No. 3.

Pending the relocation of the glide facility to comply with FAA Order 8260.24, expedite the modifications to official U. S. instrument approach procedures so that they display glide slope runway threshold crossing height for all approaches having a threshold crossing height of less than 47 feet.

Comment.

Action has been initiated to include ILS glide path threshold crossing heights on the instrument approach procedure charts. These are presently being revised coincident with other routine procedure changes. We will expedite action to complete the revisions to all ILS approach procedure charts.

Recommendation No. 4.

Issue an Advisory Circular which describes the wind shear phenomenon, highlights the necessity for prompt pilot recognition and proper piloting techniques to prevent short or long landings, and emphasizes the need to be constantly aware of the aircraft's rate of descent, attitude and thrust during approaches using autopilot/autothrottle systems.

Comment.

We have already initiated steps to emphasize the need for more understanding of the low level wind shear phenomenon. On September 26, we began a series of briefings at all major FAA Air Carrier and Flight Standards District Offices to emphasize the need for supplemental weather data relating to turbulence and low level wind shear, This effort should help in reducing the number of accidents and incidents attributed to these weather phenomenon. These briefings will be given to all Air Carrier Operations Inspectors, who, in turn, will evaluate each air carrier program and report the results. They will stress the importance of using the weather information provided, especially severe weather and low level wind shear.

Recommendation No. 5.

Modify initial and recurrent pilot training programs and tests to include a demonstration of the applicant's knowledge of wind shear and its effect on an aircraft's flight profile, and of proper piloting techniques necessary to counter such effects.

APPENDIX E

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Comment.

We plan to reemphasize to our inspector personnel the importance of proper flight techniques, including the continuous monitoring of rates of descent, thrust and altitude during approaches. They will also be asked to review the carriers' training programs and, where inadequate, request modification to include this material. When information is available on all aspects of wind shear, we will consider issuing an advisory circular.

Recommendation No. 6.

Expedite the development, testing and operational use of the Acoustic Doppler Wind Measuring System.

Comment.

We concur in the desirability of expediting the development, testing and operational use of an Acoustic Doppler Wind Measuring System. Our test of an experimental system at Stapleton Airport, Denver, Colorado, verified that our wind shear measuring system can operate in an airport environment and can produce wind measurements at 100-foot intervals up to about 2500 feet. These tests also indicate what improvements to the system are needed. We are working on the necessary improvements and will provide specifications for an operational system at the earliest possible date.

Recommendation No. 7.

Develop an interim system whereby wind shear information developed from meteorological measurements or pilot reports will be provided to the pilots of arriving and departing aircraft.

Comment.

Present air traffic control procedures require controllers to advise pilots of pertinent pilot reports. However, the National Weather Service does not forecast wind shear at present. When the capability of forecasting and measuring wind shear is developed, we will implement procedures for dissemination of the information to pilots.

Sincerely,

James E. Dow

Deputy Administrator for
Alexander P. Butterfield
Administrator