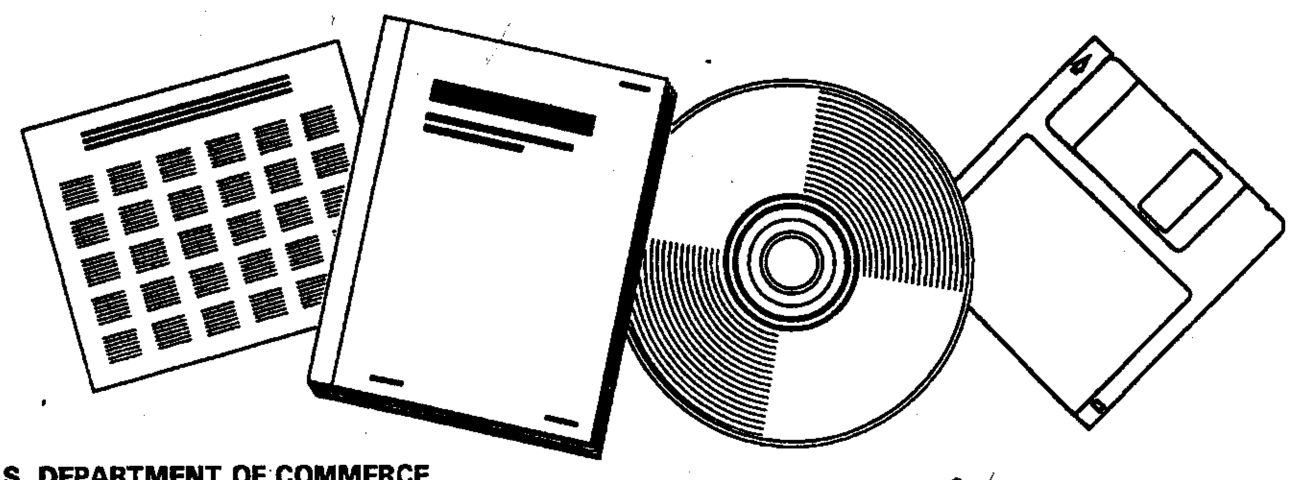
PB238479

DELTA AIR LINES, INC. MCDONNELL DOUGLAS DC-9-32, N3323L, CHATTANOOGA MUNICIPAL AIRPORT, CHATTANOOGA, TENNESSEE

NATIONAL TRANSPORTATION SAFETY BOARD,
WASHINGTON, D.C

27 NOV 1974



U.S. DEPARTMENT OF COMMERCE
National Technical Information Service

PB238479

TECHNICAL REPORT DOCUMENTATION PAGE

1. Report No. NTSB-AAR-74-13	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle Aircraft Accident Report - Delta Air Lines, Inc., Douglas DC-9-32, N3323L, Chattanooga Municipal Airport, Chattanooga, Tennessee, November 27, 1973		5. Report Date November 8, 1974 6. Performing Organization Code
7. Author(s)		8. Performing Organization Report No.
9. Performing Organization Name and Address National Transportation Safety Board Bureau of Aviation Safety Washington, D. C. 20591		10. Work Unit No. 1345 11. Contract or Grant No.
12. Sponsoring Agency Name and Address NATIONAL TRANSPORTATION SAFETY BOARD Washington, D. C. 20591		13. Type of Report and Period Covered Aircraft Accident Report November 27, 1973 14. Sponsoring Agency Code
15. Supplementary Notes		

16. Abstract About 1851 e.s.t. on November 27, 1973, Delta Air Lines Flight 516, a McDonnell Douglas DC-9-32, N3323L, crashed while making an ILS approach to runway 20 at Chattanooga Municipal Airport, Chattanooga, Tennessee. Seventy-four passengers and five crewmembers were aboard the aircraft. Thirty-eight passengers and four crewmembers were injured; there were no fatalities.

The aircraft struck the approach lights 1,600 feet from the runway threshold. After initial impact, the aircraft continued through the approach lights and struck a flood-control dike located 785 feet from the runway threshold. The aircraft stopped on the airport 450 feet beyond the approach end of the runway and 250 feet left of the runway centerline. The aircraft was destroyed.

The National Transportation Safety Board determines the probable cause of the accident was that the pilot did not recognize the need to correct an excessive rate of descent after the aircraft had passed decision height. This occurred despite two verbal reports of increasing sink rate by the first officer. The captain disregarded the reports of the first officer, possibly because of the influence of a visual illusion caused by the refraction of light through the heavy rain on the windshield. The excessive rate of descent was initiated by a wind shear condition which existed in the lower levels of the approach path and a glide slope that tended toward the lower signal limit.

17. Key Words Autopilot, coupled approach ILS glide slope, unusable below, wind shear, optical illusion, fire, excessive rate of descent verbal warnings, disregarded, no VASI Identifier: Douglas DC-9-32 Accident		18. Distribution Statement This document is available to the public through the National Technical Information Service, Springfield, Virginia 22151	
19. Security Classification (of this report) UNCLASSIFIED	20. Security Classification (of this page) UNCLASSIFIED	21. No. of Pages 45	22. Price

NTSB Form 1765.2 (Rev. 9/74)

FILE NO. 1-0028

AIRCRAFT ACCIDENT REPORT

DELTA AIR LINES, INC.
McDONNELL DOUGLAS DC-9-32, N3323L
CHATTANOOGA MUNICIPAL AIRPORT
CHATTANOOGA, TENNESSEE
NOVEMBER 27, 1973

ADOPTED: NOVEMBER 8, 1974

NATIONAL TRANSPORTATION SAFETY BOARD
Washington, D.C. 20591
REPORT NUMBER: NTSB-AAR-74-13

TABLE OF CONTENTS

File No. 1-0028

NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D. C. 20591
AIRCRAFT ACCIDENT REPORT

Adopted: November 8, 1974

DELTA AIR LINES, INC.
McDONNELL DOUGLAS DC-9-32, N3323L
CHATTANOOGA MUNICIPAL AIRPORT
CHATTANOOGA, TENNESSEE
NOVEMBER 27, 1973

SYNOPSIS

About 1851 e.s.t. on November 27, 1973, Delta Air Lines Flight 516, a McDonnell Douglas DC-9-32, N3323L, crashed while making an ILS approach to runway 20 at Chattanooga Municipal Airport, Chattanooga, Tennessee. Seventy-four passengers and five crewmembers were aboard the aircraft. Thirty-eight passengers and four crewmembers were injured; there were no fatalities.

The aircraft struck the approach lights 1,600 feet from the runway threshold. After initial impact, the aircraft continued through the approach lights and struck a flood-control dike located 785 feet from the runway threshold. The aircraft stopped on the airport 450 feet beyond the approach end of the runway and 250 feet left of the runway centerline. The aircraft was destroyed.

The National Transportation Safety Board determines the probable cause of the accident was that the pilot did not recognize the need to correct an excessive rate of descent after the aircraft had passed decision height. This occurred despite two verbal reports of increasing sink rate by the first officer. The captain disregarded the reports of the first officer, possibly because of the influence of a visual illusion caused by the refraction of light through the heavy rain on the windshield. The excessive rate of descent was initiated by a wind shear condition which existed in the lower levels of the approach path and a glide slope that tended toward the lower signal limit.

1. INVESTIGATION

1.1 History of the Flight

On November 27, 1973, Flight 516, a Delta Air Lines McDonnell Douglas DC-9-32, N3323L, departed Atlanta, Georgia, at 1757 1/, on a

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

regularly scheduled passenger flight to Chattanooga, Tennessee. The flight was dispatched on an instrument flight rules (IFR) computer-stored flight plan. The captain, who occupied the left seat, was flying the aircraft. No difficulties were reported during the en route portion of the flight.

The flight contacted Chattanooga Approach Control at 1817:05 and was cleared to hold at the Chattanooga VOR at 11,000 feet. 2/ The flight was advised by the approach controller to expect further clearance at 1830. This time was later amended to 1835.

At 1836:49, Flight 516 was cleared to descend to 6,000 feet and given vectors in preparation for an ILS approach to runway 20. This clearance was followed by additional vectors and descent clearances.

At 1842:51, the aircraft was at 3,500 feet when the approach control cleared the flight with, "...turn right heading one eight zero and you're 3 miles north, make that 4 miles north of Daisy 3/ beacon, cleared ILS runway two zero approach." This clearance was acknowledged by the first officer.

The Chattanooga weather, as reported to other flights on the approach control frequency, was 400 feet scattered, 1,100 feet overcast, visibility - 5 miles, and light rain. This weather information was not given specifically to Flight 516.

At 1846:10, the checklist was completed, and the captain placed the autopilot in the ILS mode for an automatic coupled approach. At 1846:53.5 the captain ordered, "Flaps fifty," which was acknowledged by the first officer.

At 1847:32, following a clearance from the approach controller, the first officer contacted the Chattanooga tower and reported the flight's position at the Daisy beacon. The local controller cleared the flight to land and reported the wind to be "one five zero degrees at four."

At 1849:35.5, the first officer commented, "Now we're at a thousand feet above minimums -- No flags." This report was followed by a comment from the captain, "Right on the glide slope."

2/ All altitudes are mean sea level unless otherwise noted.

3/ A nondirectional radio beacon 7.7 nmi NNE of the threshold of runway 20, Chattanooga Municipal Airport.

At 1850:05.5, the first officer reported, "I got the lights." The captain looked out of the aircraft and verified that the approach and runway lights were in sight and then returned to monitoring his instruments and the autopilot operation. He also ordered the first officer to turn the windshield wipers on at slow speed.

At 1850:41, the first officer reported, "Five hundred feet above (minimums)." 4/ The report was followed immediately by the captain's order that the windshield wipers be turned to the fast speed.

At 1851:03, the captain requested the local controller to, "kill the rabbit...." 5/ This was the last radio communication from the flight. Nine seconds after this request, the CVR recorded the first officer report, "Two hundred feet."

At 1851:26, the first officer reported, "One hundred above minimums," and 2.5 seconds later the sound of the middle marker (MM) was recorded. Coincident with the sound of the MM the first officer reported, "Plus ten, that's minimums." Three seconds later, he reported, "I gotta plus five, sinking to nine," and 6.5 seconds later, "Plus five sinking to ten." At 1851:42, the sounds of impact were recorded.

The captain stated that as he uncoupled the autopilot at decision height (DH), no out-of-trim pressures existed on the control column, and both the flight director and the raw data ILS displays were centered. As the captain looked out of the aircraft, the runway appeared normal to him and remained unchanged for, in his estimation, 5 seconds. The visual presentation of the runway then "flattened out" in "the blink of an eye." The captain immediately advanced the throttles and applied back pressure to the control column. However, the aircraft hit "something" before any reaction to the control inputs could be noted. After the aircraft struck the first approach light, a series of jolts occurred, including one heavy one, and the captain recalled seeing a fireball, or glow, on the left side of the aircraft. The aircraft stopped on the airport 250 feet left of the runway centerline and 450 feet past the threshold.

Ground witnesses said that heavy rain was falling while Flight 516 approached the airport; however, several persons, including the local

---

4/ The word in parentheses is difficult to distinguish on the cockpit voice recording and is subject to interpretation.

5/ High-intensity sequence flashing lights are mounted along the centerline of, and on top of, the approach lights. The phrase "kill the rabbit" is a request to turn these lights off.

controller in the tower, saw the aircraft lights 1 to 2 miles out from the runway.

The accident occurred at night and at latitude 35°02'30"N and longitude 85°12'02"W. The elevation at initial impact was 686.39 feet.

1.2 Injuries to Persons

Injuries	Crew	Passengers	Other
Fatal	0	0	0
Nonfatal	4	38	0
None	1	36	

1.3 Damage to Aircraft

The aircraft was destroyed.

1.4 Other Damage

The approach light system and a flood-control dike were damaged.

1.5 Crew Information

The captain, first officer, and flight attendants were trained and certificated according to current regulations. (See Appendix B.) This was the first night IFR approach this crew had made at Chattanooga Municipal Airport. Their previous approaches had been conducted in visual meteorological conditions.

1.6 Aircraft Information

The aircraft was certificated, maintained, and equipped according to Federal Aviation Administration (FAA) regulations. (See Appendix C.)

The aircraft's weight and center of gravity (c.g.) at the time of the accident were 85,800 pounds and 21.5 percent mean aerodynamic chord (MAC), respectively. Both were within specified limits.

The aircraft had been fueled with 8,200 pounds of Jet A-1 type aviation kerosene. About 10,600 pounds of fuel were aboard the aircraft at impact.

1.7 Meteorological Information

A thunderstorm and heavy rain showers were in progress at the Chattanooga Municipal Airport during the approach and accident. The prevailing visibility was 2 miles.

The pertinent surface weather observation follows:

1758 - Record Special, 400-feet scattered, measured ceiling-1,100 feet overcast, visibility-5 miles, light rain, wind-280° at 4 knots, altimeter setting-29.80 inches.

1845 - Special, measured ceiling 400-feet broken, 1,100-feet overcast, visibility-2 miles, thunderstorm, heavy rain showers, wind-160° at 5 knots, altimeter setting-29.79 inches. Thunderstorm began at 1842. Thunderstorm southeast, moving east.

The NWS rainfall record indicates that heavy rain showers occurred at the time of the accident. The rainfall rate was about 1.2 inches per hour.

Low level winds from the 1900 winds aloft observations made at Nashville, Tennessee, and Athens, Georgia, were:

NASHVILLE

Feet	Direction (True)	Knots
1,000	350°	23
2,000	330°	33
3,000	305°	33
4,000	280°	34

ATHENS

Feet	Direction (True)	Knots
2,000	180°	30
3,000	185°	32
4,000	190°	33

An estimate of the winds aloft during the time of the approach was based on the 1900 winds aloft observations at Nashville, Tennessee, and Athens, Georgia. Because there is no winds aloft reporting facility at Chattanooga, estimated winds were calculated and applied to the FDR approach profile. The surface wind was 160° at 6 knots. The winds aloft at 4,000 feet and below were calculated to have been:

Feet	Direction (True)	Knots
4,000	185°	41
3,000	185°	35
2,000	185°	32
1,000	180°	15

A radarscope photograph taken at Nashville at 1853 showed weak to moderate precipitation echoes over the area of the accident site.

The terminal forecasts for Chattanooga, which were issued by Delta Air Lines and the National Weather Service, called for thunderstorms and moderate rain showers. These forecasts were provided to the flightcrew of Flight 516.

The crew of a Learjet 24, which landed on runway 20, 6 minutes before the accident, stated "there must be a wind shear because we're experiencing gusty conditions . . . ." The tower advised that winds were calm at the airport. Another crew that landed about 20 minutes before the accident did not notice a wind shear.

The accident occurred in darkness below the clouds in heavy rains.

1.8 Aids to Navigation

The ILS approach to runway 20 at Chattanooga Municipal Airport incorporates a localizer with an inbound course of 196°, a glide slope, a nondirectional beacon (Daisy NDB) located 7.7 nmi from the end of the runway, an outer marker (OM) 4.1 nmi from the end of the runway, and a MM 0.7 nmi from the end of the runway. The glide slope crosses the NDB at about 3,000 feet, the OM at 1,918 feet (1,245 feet above ground), and the MM at 900 feet (227 feet above ground). The glide slope is unusable below 873 feet (200 feet above ground). The reference speed for this approach was 120 knots.

Flightcrews of this and other aircraft reported that all components of the approach system operated without problems.

The postcrash flight inspection of the ILS approach aids for runway 20 indicated that the ILS was operating within tolerances. However, during the analysis of the data from the CVR, the FDR, and the postcrash flight inspection data, the location of the MM was found to have been improperly charted.

The Safety Board requested another flight inspection of the ILS using a radio telemetering theodolite to monitor the tests. The flight inspection records indicate that the MM was about 300 feet closer to the runway threshold than indicated on the airport maps and approach charts for that runway. (See Appendix D.) The integral components of the ILS were within the tolerances specified for a category I ILS.

However, the reinspection of the facility revealed that, while within limits, the glidepath beam structure descended toward the maximum lower tolerance in the vicinity of the MM, the point just before the autopilot was disconnected.

The projected threshold crossing height was 39 feet.

The flight inspection aircraft followed the glide slope to the runway on each test. Although the beam structure exceeded tolerances below 873 feet, following the glide slope did not cause the test aircraft to land short of the runway threshold.

1.9 Communications

There were no difficulties with air-to-ground communications.

1.10 Aerodrome and Ground Facilities

Runway 20 at the Chattanooga Municipal Airport (Lovell Field), is asphalt surfaced, 7,400 feet long, and 150 feet wide. The runway is equipped with high-intensity runway lights. The approach lighting system includes the standard 3,000 feet of approach lights, high-intensity sequence flashers, and runway-end identifier lights. The runway and the approach lights are variable control, 5-step intensity lights. The runway lights and the approach lights were set at step 3 during Flight 516's approach. There is no visual approach slope indicator (VASI) on the runway. The high-intensity sequence flashers were operating until the captain asked the local controller to turn them off. No runway or approach lights were reported out before the accident.

The runway elevation at the threshold is 666.8 feet. The runway slopes up to 682 feet at the 4,500-foot point, slopes down to 677 feet at the 6,200-foot point, and slopes up to 681 feet at the departure end of the runway. The total runway gradient is less than 0.3 percent.

1.11 Flight Recorders

N3323L was equipped with a United Control Data Division (Sunstrand) Model FA-542, flight data recorder (FDR), serial No. 2626. The FDR and foil recording medium were undamaged. All parameters had been recorded, and there was no evidence of recorder malfunction. The readout covered the last 5 minutes of the recorded traces. (See Appendix E.)

The aircraft was also equipped with a Fairchild Model A-100 cockpit voice recorder (CVR), serial No. 1552. The CVR and tape were not damaged. The tape contained about 30 minutes of recorded information. The final 16.3 minutes of the tape were transcribed.

The recorders were installed in the aft section of the aircraft. Flight data recorder information, cockpit voice recorder information, radio communications, and meteorological data were combined to produce a computer profile of the approach. (See Appendix F.)

1.12 Wreckage

The wreckage area was about 400 feet wide and 2,095 feet long. The aircraft first struck approach lights 1,600 feet short of the runway threshold. The aircraft continued to descend, striking additional approach lights. The aircraft struck a dike 785 feet short of the runway threshold, and the left wing separated from the aircraft. The left wing tip imprint was about 8 feet below the top of the dike.

Numerous components and pieces of aircraft were strewn along a path from the dike to the threshold of the runway.

The fuselage with the right wing and empennage attached came to rest 250 feet to the left of the runway 20 centerline and 450 feet beyond the runway threshold. The left engine came to rest on the runway threshold. (See Appendix G.)

The landing gear had been fully extended. The three gear assemblies were separated from the aircraft, and the wing flap actuators were damaged. There were no impact marks to indicate the flap position. The flap followup was found in the neutral position, and the flap selector handle in the cockpit was positioned in the 25° detent.

Portable testers were used to check the operational integrity of the pitot/static and the VHF navigational systems in the wreckage. No significant discrepancies were discovered. Flight director, autopilot, VHF/NAV systems components, and the flight instrument panels were tested, and no discrepancies were detected.

The flight director mode selector switch was in the "VOR/LOC" position, and the captain's heading selector was set at 201°. The two pictorial deviation indicators were set at 196°, with both navigation receivers tuned to 109.50 MHz. The captain's radio altimeter was set at 200 feet, which was DH for the approach.

1.13 Medical and Pathological Information

The captain sustained a compression fracture of a thoracic vertebra, two fractured ribs, and chest contusions. The first officer sustained similar injuries of his thoracic vertebra and to his lumbar vertebra. He also suffered chest contusions and knee abrasions.

One flight attendant, who was seated in the rear of the aircraft, sustained a lumbar strain, a sprained right ankle, and an abrasion and fuel irritation to the left eye. A second flight attendant, who was seated in the same area, sustained contusions to the left ankle, left foot, and right knee. She was also treated for fuel vapor inhalation.

Passengers were injured when they struck seats, other passengers, or the aircraft walls. Their injuries included fractured vertebrae; fractured ribs; lacerations, contusions, and abrasions to the head, face, upper torso and the upper and lower extremities; and neck and back strains. Two passengers who were in seats 38-B and C reported minor face, leg, and head burns from a flash fire in the rear cabin. Some passengers were injured slightly during evacuation of the aircraft.

The captain, first officer, two flight attendants, and a passenger were admitted to the hospital. Five other persons were treated and immediately released.

1.14 Fire

About 1851, the control tower notified the airport fire department of the accident. A ground fire had erupted at the south side of the dike, 785 feet from the runway threshold. The fire died out before firefighting equipment arrived. (See Appendix E.)

Another fire erupted in the vicinity of the fuselage at the left wing root and near the left engine attach point. The fire ignited when the aircraft stopped; however, when airport firefighting equipment arrived, it too was dying out. The fire was extinguished in less than 1 minute.

Two firefighters entered the smoke-filled cabin without self-contained breathing apparatus in response to an erroneous report that a flight attendant was trapped inside. The firefighters crawled the length of the main cabin aisle in spite of the dense smoke.

Heat and soot damaged the coach section of the cabin. Except for minor heat damage at seat 31-A, most damage was near rows 37 and 38. In that area, the edges of head rest towels were burned, seatback trays were deformed, and plastic covers and bags were melted. The passenger service unit above row 38 was damaged.

The passenger in seat 38-C saw flames near the cabin floor that came toward him. Although he did not feel the heat, his hair was singed and his polyester suit was melted in places.

Two flight attendants, who were in the rear cabin jumpseats, reported that as the aircraft decelerated, a hole appeared in the floor in front of them, through which they were sprayed with mud, debris, and fuel. Shortly, thereafter, the cabin lights went off, and a flash fire erupted in front of the flight attendants and lasted momentarily. One of the attendants estimated that the fire extended from the floor to 15 inches above her head.

Some passengers reported no smoke, while others reported smoke so dense that they could not see beyond the next seat.

The rear baggage compartment was also damaged. The top liner was burned through, and the top and right side of the compartment near the right cargo compartment door was scorched. Baggage was melted and damaged. Fuel was found in puddles in the compartment.

1.15 Survival Aspects

1.15.1 Evacuation

Passengers opened all four overwing exits in the coach section without difficulty. A flight attendant opened the main cabin door with the assistance of a passenger. She reported that the girt bar was in place for the landing and that the evacuation slide fell from its case when the door was opened. Passengers, however, jumped from the doorway before the flight attendant could inflate the slide. The attendant said that the galley service door was blocked by debris. One galley compartment door and one galley drawer were found open. The galley service door operated normally during the investigation. Before leaving the aircraft, the flight attendant crawled through the first class cabin and up to the first few rows of the coach cabin to look and call for passengers.

A galley tray carrier fell to the floor in the rear galley striking one attendant on the foot. The floor also was covered with debris and two wire containers. This material restricted the initial movements of the flight attendants assigned to the rear cabin.

One of the flight attendants who was in the rear cabin went into the coach cabin aisle and shouted for passengers to open the overwing exits. Because of smoke and darkness, she became disoriented and fell over a seatback as she moved toward the exits. After assisting three passengers out of the aircraft on the right side of the cabin, she also evacuated the aircraft.

The other flight attendant assigned to the rear cabin attempted to open the rear exit, but it jammed. She also tried to remove a portable oxygen bottle and a megaphone, but she could not locate the release clips which restrained them. After assisting two passengers out of the aircraft, she determined that she was the last person in the rear cabin area and exited.

Seven persons had difficulty releasing their seatbelts because of darkness and nervousness. Passengers located toward the rear of the coach section reported that smoke and darkness hampered vision and breathing. Several passengers reportedly carried personal belongings when they left the aircraft. No obstacles were encountered by passengers escaping through the forward cabin door, and the door was illuminated slightly by lights from airport buildings.

The evacuation was orderly and rapid. It was completed in 2 to 3 minutes.

1.15.2 Interior Structural Failures

Witnesses agreed that the emergency lights either did not actuate, or where obscured completely by smoke. Emergency electrical power, although selected by the captain, was not available, because the aircraft batteries, battery bus cables, and the AC emergency inverter were damaged during the accident. The continuity of the emergency lighting system was intact, and the emergency lighting battery pack for each light was discharged.

The floor beneath the captain's seat was displaced upward. A puncture was located between the captain's rear inboard seat track and the pedestal. The cockpit door was half open and the upper door track follower pin was embedded in the cabin ceiling. The crew restraint systems were intact and operated normally.

The oxygen masks were deployed above rows 17, 20, 23, and 32. The sheet metal pans of seats 16-A, 26-C, 29-A, and 29-B were displaced downward from 2 to 3 inches. The rear edge of the seat pan of seat 39-B was completely separated from the rear support tube. The cabin wall adjacent to seat 31-A was punctured, and the arm rest was deformed downward. The seat track between rows 29 to 31 was fractured and separated. The cabin floor from rows 29 and 39 was displaced upward. The rear galley floor was displaced upward about 2 inches.

Dried mud was found on the forward surface of the tail cone door, the ceiling forward of the door, the galley surfaces, and the flight attendant's jumpseat.

1.16 Test and Research

Not applicable.

1.17 Other Information

The following procedures were extracted from the Delta Air Lines' Pilots Operating Manual:

" Approach

1. To execute an ILS approach in low ceiling and reduced visibility conditions, the approach should be properly planned to provide:

   a. Correct and constant speed control.
   b. Minimum thrust changes to assist in reducing out-of-trim conditions.
   c. Extension of gear and flaps at the proper time to minimize porpoising and pitch trim changes.

2. Policy - Both the approach coupler and flight director should be used on all CAT I approaches.

3. Procedure - Prior to the start of any CAT I or II approach the captain will determine that all required equipment is operating properly.

   a. CAT I - The pilot conducting the approach will position and configure the aircraft for an approach, establish the intercept angle, adjust power, maintain precise airspeed control and complete the landing. The decision to land or discontinue the approach will be made by the captain. As the aircraft approaches the DH, both pilots will bring the outside environment into their normal scan pattern. The pilot not conducting the approach will call out '200 feet above', '100 feet above,' and 'minimums.'

4. The pilot not flying will 'call or check any significant deviations, including airspeed.' "

2. ANALYSIS AND CONCLUSIONS

2.1 Analysis

The crewmembers were properly certificated, trained, and qualified for the flight according to FAA regulations. Both pilots had adequate rest periods before reporting for duty. There was no indication of any medical or physiological problems that would have affected the performance of their duties.

The aircraft was certificated, maintained, and equipped according to FAA regulations.

There was no evidence of in-flight fire, structural failure, or flight control or powerplant malfunction. The altimeters, airspeed indicators, and navigation equipment operated within prescribed specifications.

This was a survivable accident.

The fires which started during the impact sequence had the potential of incapacitating many of the passengers and crew. Several circumstances combined to reduce the magnitude of the fire as the aircraft hit the ground and slid to a halt. These factors were: (1) The heavy rainfall at the time of the accident, (2) the standing water on the ground, (3) the relatively intact condition of the cabin interior, and (4) the Jet A-1 type fuel has a high flashpoint.

Only moderate decelerative loads were placed on the occupants of the cabin by the gradual dissipation of aircraft energy with no severe motion.

The spines of three of the injured, the pilot, the first officer, and a passenger, were not in a position to react to vertical loads without injury. One passenger's ribs were broken when he struck the armrests.

Since only momentary flash fires occurred in the cabin and only a small fire existed at the left wing root and since the cabin interior remained intact, there was no panic or serious injury. The reactions of the flight attendants aided in the prompt evacuation of the aircraft. Finally, the immediate availability of the four overwing exits and the main boarding door allowed passengers to evacuate promptly.

The disruption of some of the contents of the forward and rear galleys created minor problems.

The forward flight attendant determined that the galley service door was not useable because of debris in front of the door. This determination was based on her observations, and she made no attempt to open the door. Access to the door might have been restricted by the drawer that came open; however, the door could have been opened and used if needed.

In the rear galley, the tray carrier that struck one flight attendant and the wire baskets and other debris ejected from the galley containers had to be cleared away before the flight attendants could gain access to the aisle and the passenger compartment.

The tail cone exit could not be used. The flight attendant was unable to open the door because of structural deformation caused by impact.

Numerous tears in the lower fuselage skin allowed fuel vapor from ruptured fuel lines of the left wing and the left engine to enter the rear cargo compartment. Fractures in the cabin floor allowed fuel vapors to enter the main cabin. The ignition of the vapors probably was caused by any one of the several aircraft electrical sources available.

The heat damage in the rear baggage compartment indicates that there was a substantial fire in that area. This fire, coupled with a fire in the tail cone, caused the smoke in the cabin during the evacuation.

The response of the firefighting equipment was timely and effective.

The Safety Board is concerned, however, that two firefighters entered the cabin without selfcontained breathing apparatus. While their efforts were courageous, the results could have been tragic.

The Safety Board believes that firefighters should have available and use equipment appropriate to the hazards encountered in the crash-fire environment.

Because the aircraft stopped within sight of the tower controllers, emergency notification was prompt. The FAA personnel responsible for monitoring and reacting to alarms on the monitoring system did not understand fully the operation and use of the equipment. Had this aircraft crashed off the airport, but within the confines of the approach light system, this lack of knowledge could have caused a delay in notifying emergency equipment and rescue personnel. (See Appendix .)

Although pertinent weather forecasts called for thunderstorms and moderate rain showers, the actual weather conditions were worse than forecast, and this information was not provided to the crew of Flight 516.

While the wind velocity shear at a specific altitude in the approach path is difficult to predict, shear did exist at the lower altitudes, especially from 2,000 feet to the surface. This wind shear had an influence on the approach of the aircraft.

The effect of a rapidly decreasing head wind on an aircraft is to cause a correspondingly rapid increase in ground speed. When the aircraft is in a coupled ILS approach, the autopilot increases the nosedown attitude to keep the glide slope signal constantly on course. In this case, there was no autothrottle installed, and it would have been necessary for the pilot to reduce the power to keep the airspeed from increasing. Such a power reduction was not made during the last stage of the coupled approach when the wind shear began to effect the ground speed significantly. There was an increase in the airspeed in the latter portion of the coupled portion of the approach, and a nosedown pitch change would have been necessary to keep the aircraft on the glide slope.

Both the wind shear and the increase in airspeed aggravated the downward trend induced by the glide slope. The coupler apparently trimmed out the significant forces before the pilot disconnected the autopilot. Thus, when the pilot disconnected the autopilot, the aircraft was established on a descent path that would result in touchdown short of the runway.

An interview with the crew, along with information received from the CVR and the FDR, established that the approach to the MM was conducted according to FAA and Delta Air Lines procedures. The captain stated that the descent from the OM to the MM had been at a "nominal rate," and that at OM and MM passage, the aircraft was on the glide slope, with no significant variation in airspeed.

The rate of descent published on the approach chart for runway 20 is 584 feet per minute for a ground speed of 120 knots. The actual rates of descent flown by Flight 516 can be related to this figure by examining the approach profile in specific segments.

Altitude Transversed	Velocity Feet/Second	Descent Feet/Minute
2,500 - 1,500	7.7	462
1,500 - 1,050	9.5	570
1,050 - 700	17.7	1,050
850 - 700	18.7	1,122

The approach profile indicated an acceptable and fairly stable rate of descent until about 1,050 feet. Movement of the flight controls was relatively constant because of autopilot control. The estimated head wind decreased 3 knots between 3,000 and 2,000 feet, but decreased 17 knots from 2,000 to 1,000 feet, which indicates that wind shear was increasing as the aircraft descended.

From 1,050 feet, or just before the point at which the captain began to fly the aircraft manually, to 700 feet, the rate of descent increased to about 1,050 feet per minute. The final portion of the approach, from 850 feet to 700 feet, was flown with a rate of descent of 1,122 feet per minute.

While the captain was monitoring the instruments and the autopilot was in control of the aircraft, the highest rate of descent was 624 feet per minute. The reliability and functioning capability of the autopilot was, therefore, established to the satisfaction of the captain. Since the downward trend of the aircraft occurred 6 to 8 seconds before the call of "that's minimums" and disconnection of the autopilot, it appears that the increasing rate of descent was not noticed by the captain.

Other factors which were considered in an attempt to determine the cause of the increased and excessive rate of descent were: (1) A diverging glide slope beam, and (2) visual illusions/refraction of light.

The analysis of the glide slope beam for runway 20 established that the ILS operated within acceptable and established standards. This was confirmed by two flight inspection tests, statements by air carrier crews using the facilities before and after the accident, and the FDR readout. The MM was not located at the point specified on available approach charts. However, the DH for this approach is based on the altimeter and not MM passage.

The glide slope beam approached the lower allowable tolerances for this facility in the vicinity of the MM. Since the glide slope beam caused a downward trend from the published glide slope, the autopilot in the autocouple mode would follow the beam, and thus start or establish a flightpath which could go below the published 2.75° glide-slope angle. If these conditions occurred as the aircraft approached the MM and if the pilot uncoupled at this time, it is possible that the aircraft could be in a less than perfect attitude to complete the approach. Evidence indicates that while this situation is possible, the magnitude of this trend would not cause an aircraft to exceed the safe lower limits of the glide slope. Although the aberration of the beam was most evident at a point just before the autopilot would normally be disengaged, the beam structure still remained within tolerances above DH.

The crew of Flight 516 was cognizant of the restriction on the use of the glide slope and was prepared to fly the aircraft using visual cues from DH to landing. Since there was no significant change in rate of descent until after the pilot disengaged the autopilot, the effect of the glide slope beam on the approach profile is judged to have been minor. However, this nosedown attitude coupled with the nosedown attitude generated by the autopilot as it corrected for the rapidly decreasing headwind component, placed the aircraft in a descent attitude that would cause the aircraft to touchdown short of the runway unless the attitude or power setting was changed.

Finally, another factor which could have contributed to this accident was the pilot's perception of the runway location. His perception may have been deceiving because of illusions or refraction of light through water on the windshield. Numerous studies conducted on the effects of this phenomenon have established that faulty visual perception contributes to disorientation and erroneous judgement of horizontal and vertical distance.

The most serious problem associated with water on the windshield is that the objects appear farther away than they actually are. The water on the windshield, the thickness of the windshield, and the amount of rain between the aircraft and the runway would cause a refraction of the pilot's line of sight to the runway in a downward direction. This bending of light rays would cause the approach and runway lights to appear lower than their actual elevation. The pilot would believe that he is higher and farther away from his planned touchdown point than he actually is.

Rain can also affect the pilot's perception of distance to the approach and runway lights by diffusing their glow and thus cause them to appear less intense. This too would lead the pilot to conclude that the lights were farther away than they actually were. On occasion, rain causes lights to appear larger (but not brighter), and the pilot believes that he is closer to the light than he actually is. In either case, the pilot would be prompted to descend to an altitude comparable to the perceived runway elevation.

Another visual illusion is created by rainfall which is not accompanied by additional visual obstructions, such as fog, smoke, or haze. In such a situation, the dangers of refraction of light are increased, since the pilot's visual cues are more defined. On the night of the accident, the only visual obstruction at the airport was heavy rain. Since the severity of this illusion is determined by the amount of rain deposited per unit area of windshield, the Board believes that the conditions conducive to a visual illusion were present when Flight 516 crashed.

Both pilots would have formed mental impressions of the runway environment during their previous approaches at Chattanooga. These impressions were based on visual impressions of the airport environment, light pattern, the apparent length of the runway and its projected shape. The location of the runway light pattern in the windshield and its relation to the other cockpit structure provides cues to the pilot which he relates to heading, attitude, and altitude, and from these cues the pilot determines when the aircraft is positioned properly in space during an approach. Peripheral light cues from ground lights aid in filling in this mental impression of a "correct" approach. The loss of these peripheral cues because rain-restricted visibility reduced the pilot's ability to assess correctly the aircraft position relative to the runway.

The cockpit voice recorder established that the crew was not alarmed with the progress of the approach until seconds before impact. Except that the first officer twice called out the increased sink rate after the aircraft had passed the MM, there was no concern by either pilot.

Therefore, the Safety Board believes that the captain probably experienced visual illusions, which caused him to misjudge the distance remaining to the runway. The Board's investigation established that the crew had conducted a well organized and well disciplined approach until they reached DH. Essential duties were accomplished, and the approach lights were visible about 1 minute 23 seconds before the aircraft passed the MM. The captain was aware that his airspeed and sink rate were aligned with his target values, and that the aircraft was on the glide slope and localizer at MM passage.

When the captain disengaged the autopilot at, or just before, the MM, he knew he was 200 feet above the runway touchdown zone, and about 0.7 nmi from the runway threshold. The rate of descent had ranged from 480 feet per minute to 640 feet per minute to the MM. The first officer reported, "I gotta plus five, sinking to nine" 3 seconds after the aircraft passed the MM and 10.5 seconds before impact. Six and one-half seconds later, the first officer again reported to the captain that the descent rate was increasing when he said, "Plus five sinking to ten."

Since Delta Air Lines procedures require that the pilot who is not flying call out significant deviations in airspeed, altitude, and descent rate, the first officer's calls should have alerted the captain that the descent rate trend was increasing with the aircraft less than 200 feet above the ground. Since the captain had noted the correct crossing altitude when the aircraft passed the MM, he needed to arrest the rate of descent of 900 to 1,000 feet per minute in order to land safely.

The significance of the report "... sinking to nine..." while clearly a warning to the captain, must be considered in light of the conditions existing at that moment. The approach had been routine, and the captain was receiving the sight picture he had anticipated.

Although the sink rate was reported at 900 feet per minute, it could have been corrected at a point before the landing flare. Finally, the first officer exhibited no overt signs of alarm as he monitored the instruments and the visual aspects of the approach and reported the rate of descent. The overriding consideration, however, was the apparently normal, constant sight picture both pilots observed. This allowed the captain to accept the increasing sink rate with the knowledge that at some point before the aircraft must flare, the sink rate of 900 to 1,000 feet per minute could be corrected. As a result of the visual illusion, this sink rate was maintained until the sight picture rapidly deteriorated at an altitude where the captain could not recover.

In analyzing the evidence, the Safety Board believes that the captain's visual illusion caused him to ignore the two reports from his first officer that the rate of descent was increasing too rapidly. The fact that the approach had been correct in every aspect up to that point, reinforced the captain's belief that he was in the proper position to complete the landing. Since no additional means of vertical guidance was available during the visual segment of the approach, the seriousness of these combined factors increased. However, the procedures to alert the captain to the problem that was developing were used, and the information was conveyed to the captain in the prescribed manner.

In detailing the interaction of wind shear, the glide slope structure, and a visual illusion with the performance of the flightcrew, this accident investigation illustrates the degree to which the presentation of essential elements affecting the approach can be distorted yet still appear to be within acceptable limits. As a result of their failure to question the conflicting information they were receiving, the flightcrew conducted a routine approach without recognizing the significance of the increasing sink rate.

The Safety Board believes that this accident emphasizes the continuing need for flightcrews to analyze aggressively each aspect of flight and to determine that not only does the entire segment appear normal, but that each element without question conforms to the expected standards.

The appearance of normalcy in the cockpit caused this crew to underestimate the significance of the calls delineating the increasing sink rate, thus masking the fact that the aircraft was departing from a normal descent path. However, had the crew properly assessed the information available to them, they could have evaluated the increasing rate of descent in the proper perspective and thus could have prevented the accident by accomplishing a missed approach.

2.2 Conclusions

(a) Findings

1. All components of the ILS for runway 20 were operating properly; although, the glide slope beam was within tolerance above 873 feet, it was affected by aberrations and trended down to the lower limit at the MM.

2. The crew was not advised that there was a heavy rain shower at the airport, or that a thunderstorm was in progress southeast of the field.

3. The flightcrew prepared for the approach thoroughly and conducted a normal approach until the aircraft passed the MM.

4. The required altitude awareness calls were accomplished at the correct altitudes.

5. The runway environment was acquired visually by the flightcrew before DH,and the captain believed that the aircraft was in the proper position to complete the landing.

6. The flightcrew gave no indication to the control tower that they experienced difficulty with any portion of the approach.

7. Significant horizontal wind shear existed in the final approach path of Flight 516.

8. The meteorological conditions were conducive to the creation of visual illusions.

9. The glide slope aberration, the wind shear,and the visual illusion combined to give the captain a false impression of the relative attitude and altitude of the aircraft after he passed the MM.

10. After the aircraft had passed the MM, the first officer twice informed the captain that the rate of descent was increasing.

11. As a result of the false impressions caused by the visual cues, the captain disregarded the first officer's reports of increasing sink rates.

(b) Probable Cause

The National Transportation Safety Board determines the probable cause of the accident was that the pilot did not recognize the need to correct an excessive rate of descent after the aircraft had passed decision height. This occurred despite two verbal reports of increasing sink rate by the first officer. The captain disregarded the reports of the first officer, possibly because of the influence of a visual illusion caused by the refraction of light through the heavy rain on the windshield. The excessive rate of descent was initiated by a wind shear condition which existed in the lower levels of the approach path and a glide slope that tended toward the lower signal limit.

3. RECOMMENDATIONS

The Safety Board reiterates its previous Safety Recommendation A-74-55, dated July 10, 1974. (See Appendix H and I.)

> "The Safety Board believes the VASI can be of 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."

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

Preceding page blank

APPENDIX A

INVESTIGATION AND HEARING

The Board was notified of the accident at 1910 e.s.t. on November 27, 1973, and an investigation team went immediately to the scene. Working groups were established for operations, air traffic control, witnesses, weather, human factors, structures, maintenance records, powerplants, systems, flight data recorder, and cockpit voice recorder.

Participants in the field investigation included representatives of the Federal Aviation Administration, Delta Air Lines, Inc., the Air Lines Pilots Association, and McDonnell Douglas Aircraft Corporation.

There was no public hearing held in connection with this accident.

APPENDIX B

CREW INFORMATION

Captain Ralph M. Hackley

Captain Ralph M. Hackley, 45, held Airline Transport Pilot Certificate No. 1244455 with an airplane multiengine land rating. He held type ratings in the Fairchild F27/FA 227, DC-3, 6, 7, and 9. He was originally employed by Northeast Airlines on February 14, 1951, and became a Delta employee when the two airlines merged. His first-class medical certificate was dated July 31, 1973, with no waivers or limitations. He was qualified initially as a pilot-in-command in February 1960. He received a type rating on the Douglas DC-9 aircraft on October 16, 1967. At the time of the accident, he had accumulated about 15,949 flight-hours of which 3,217 hours were in the DC-9 aircraft. He had completed his last proficiency check on April 3, 1973, and recurrent ground training August 10, 1973. During the last 2-year period, the captain satisfactorily completed all required training without rechecks or repeats.

He had a rest period of about 11 hours preceding the origination of DL 516 from Atlanta at 1757.

First Officer Thomas J. Barron

First Officer Thomas J. Barron, 37, held Commercial Airplane Certificate No. 1387181, with airplane single engine, multiengine land and instrument ratings. His first-class medical certificate was dated November 24, 1973, with no limitations. He was employed by Northeast Airlines on January 19, 1966, and became a Delta Air Lines employee when the two airlines merged. He completed initial training on the DC-9 aircraft on June 27, 1967, and was assigned as a first officer. First Officer Barron had accumulated 6,301 flight-hours, of which 4,000 hours were in the DC-9. He completed his last proficiency check in the DC-9 on June 1, 1973, and recurrent ground training April 19, 1973. Over the previous 2 years, the first officer had satisfactorily completed all required training.

Mr. Barron had a rest period of 11 hours before Flight 516.

Flight Attendants

Yolanda Salinas, 24, was hired on November 22, 1971. She completed her initial training on December 17, 1971. Her most recent recurrent emergency training was satisfactorily completed, with a score of 92, on September 24, 1973.

Nina Veckman, 23, was hired on May 30, 1972. She completed her initial training on June 23, 1972. Her most recent recurrent emergency training was satisfactorily completed, with a score of 96, on February 6, 1973.

Deborah Minton, 22, completed her initial training and was hired on October 23, 1972. Her most recent recurrent emergency training was satisfactorily completed, with a score of 96, on September 25, 1973.

All the attendants were qualified on the following aircraft: DC-9-31, -32; DC-8-33, -51, -61; B-727-100, -200. In addition, Y. Salinas was qualified on the B-747.

APPENDIX C

AIRCRAFT INFORMATION

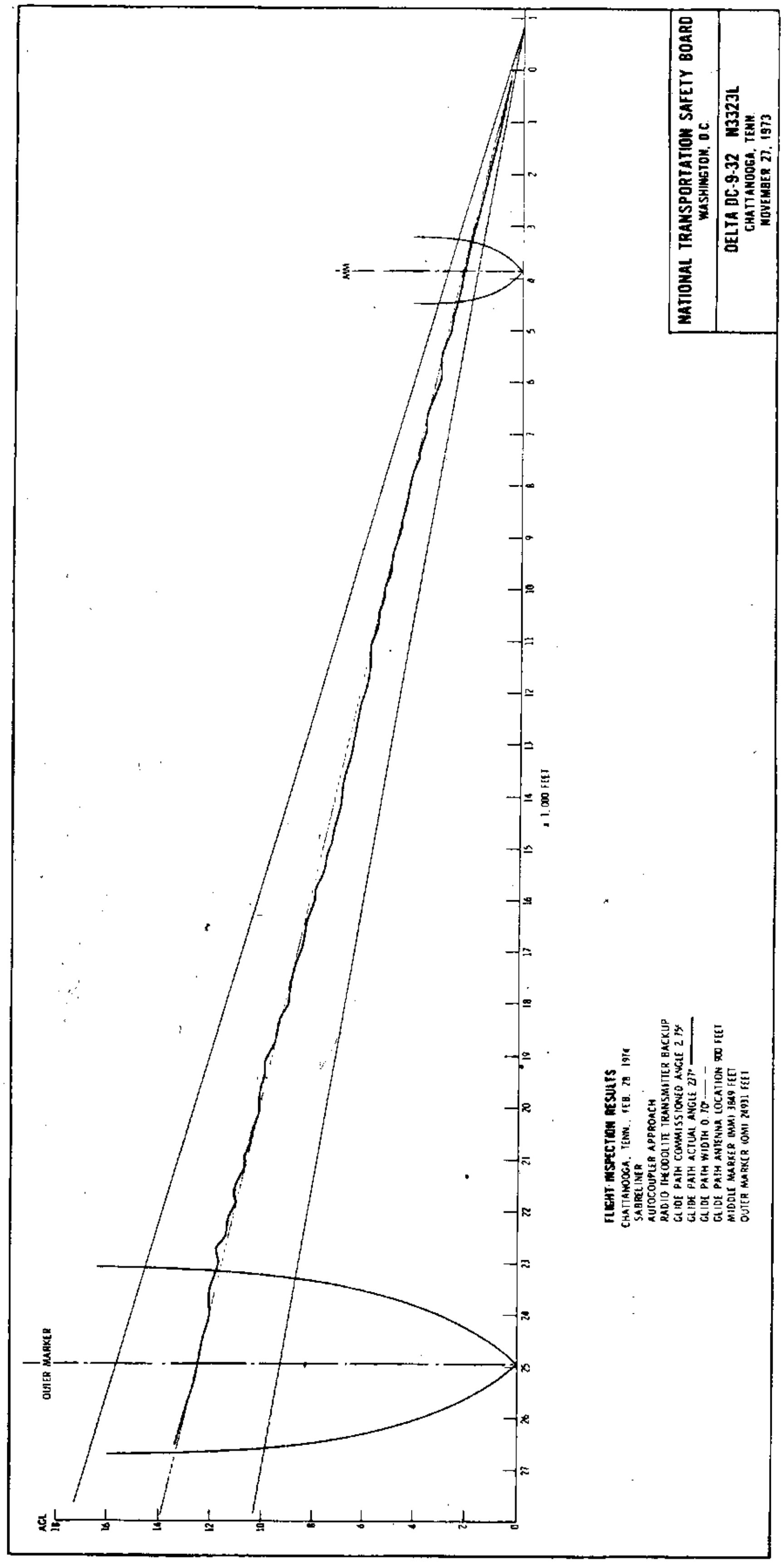
The aircraft was a McDonnell Douglas Model DC-9-32, N3323L, manufacturer's serial No. 47032. The aircraft was manufactured November 7, 1967, and an Airworthiness Certificate was issued by the FAA. This certificate was valid at the time of the accident.

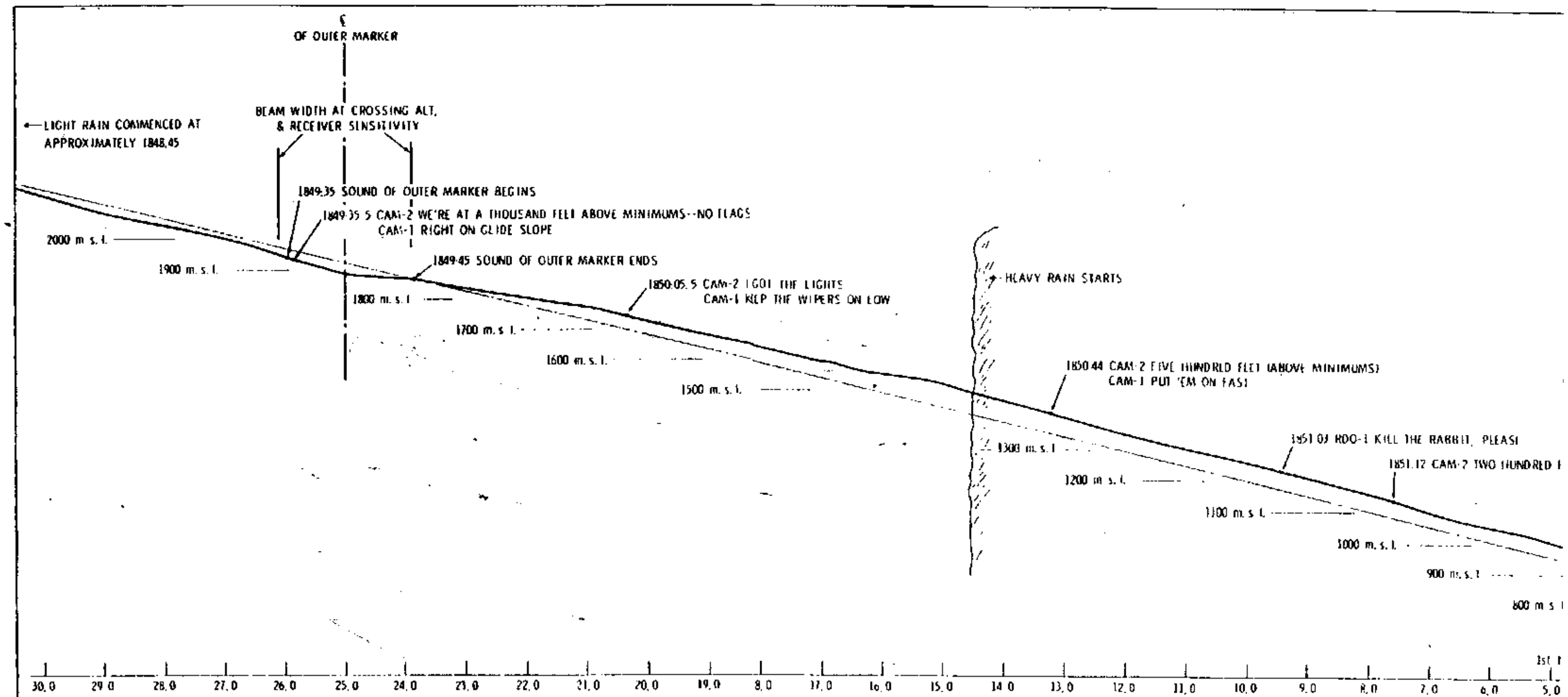
The aircraft had accumulated 18,233.7 hours total flying time, including 51.2 hours since the last letter inspection. The last letter inspection was an "A" Check and was accomplished on November 21, 1973, at Dallas, Texas. (There are 950 hours between these checks.) The required inspections had been performed and properly certified in accordance with established procedures of Delta Air Lines and accepted by the Federal Aviation Administration. The engines were being operated within their approved overhaul and inspection periods.

The aircraft was equipped with two Pratt & Whitney JT 8D-7A engines. Engine serial numbers and times were as follows:

	No. 1 Engine S/N 657673	No. 2 Engine S/N 656804
Date Installed	March 30, 1973	November 18, 1973
TSO Hours	10,117.9	7,950.4
Total Engine Cycles since last hot section check	2,541	94
Total Cycles	13,024	10,393

APPENDIX D


NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C.
DELTA DC-9-32 N3323L
CHATTANOOGA, TENN.
NOVEMBER 27, 1973
FLIGHT INSPECTION RESULTS
CHATTANOOGA, TENN., FEB. 28 1974
SABRELINER
AUTOCOUPLER APPROACH
RADIO THEODOLITE TRANSMITTER BACKUP
GLIDE PATH COMMISSIONED ANGLE 2.75°
GLIDE PATH ACTUAL ANGLE 2.77°
GLIDE PATH WIDTH 0.70°
GLIDE PATH ANTENNA LOCATION 900 FEET
MIDDLE MARKER (MM) 3849 FEET
OUTER MARKER (OM) 24931 FEET
OUTER MARKER
MM
x 1,000 FEET
AGL



EXCERPTS FROM C.V.R. PRIOR TO PROFILE

1845.43.5 CAM-1 HOW MANY MILES FROM DAISY?
CAM-2 OH, WE WERE FOUR WHEN HE SAID THAT
1845.46 CAM-1 GEAR DOWN
1846.11 CAM-2 IGNITIONS ON, NO SMOKING'S ON, GEAR IS DOWN, THREE GREEN LIGHTS, PRESSURE AND QUANTITY, FLAPS AND SLATS 'ER DOWN TWENTY-FIVE, SPOILER'S ARMED AND THE ANNUNCIATOR PANEL TO GO
1846.53.5 CAM-1 FLAPS FIFTY
1846.55 CAM-2 SET
CAM-1 CHECKLIST
CAM-2 IT'S COMPLETE

AIR-GROUND COMMUNICATION

1847.22 CHA APC DELTA FIVE SIXTEEN'S OVERHE DAISY BEACON CONTACT TOWER ONE ONE EHT POINT THREE.
RDO-2 EIGHTEEN THREE, SO LONG.
1847.32 RDO-2 CHATTANOOGA TOWER, DELTFIVE SIXTEEN, DAISY
1847.35.5 CHA-TWR DELTA FIVE SIXTEEN BY DAY, CLEARED TO LAND, THE WIND, AH, ONE VE ZERO DEGREES AT FOUR.
1847.40.5 RDO-2 CLEARED TO LAND.

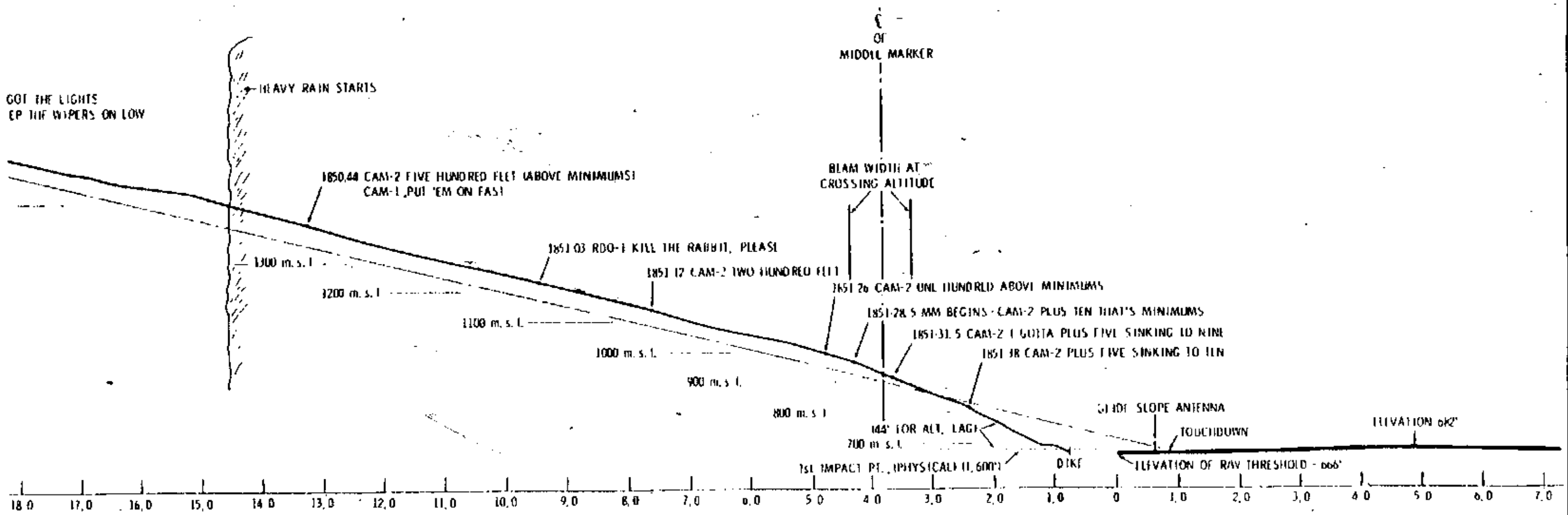
WIND		
ELEVATION	DIRECTION (TRUE)	VELOCITY (KNOTS)
4,000 FT.	185°	41
3,000 FT.	185°	35+
2,000 FT.	185°	32.5
1,000 FT.	180°	15.5
SURFACE	160°	1 TO 4

ELEVATION (m.s.l.)	AVERAGE	
	GROUND SPEED	AIR SPEED
3,000' to 2,000'	107 kts.	140 kts
2,000' to 1,000'	110 kts	134 kts
1,000' to IMPACT	117 kts.	130 kts.

LEGEND

CAM 1 CAPTAIN
CAM 2 FIRST OFFICER
RDO 2 FIRST OFFICER
CHA APC - CHATTANOOGA A
CHA TWR - CHATTANOOGA T

A



THE DAISY BEACON
GOT POINT THREE.

A FIVE SIXTEEN, DAISY.
ISY. CLEARED TO
FIVE ZERO DEGREES AT FOUR.

ELEVATION	WIND	
	DIRECTION (TRUE)	VELOCITY (KNOTS)
4,000 FT.	185°	41
3,000 FT.	185°	35.5
2,000 FT.	185° *	32.5
1,000 FT.	160°	15.5
SURFACE	160°	1 TO 4

ELEVATION (m. s. l.)	AVERAGE	
	GROUND SPEED	AIR SPEED
3,000' to 2,000'	107 kts.	140 kts
2,000' to 1,000'	110 kts.	134 kts
1,000' to IMPACT	117 kts	130 kts.

LEGEND

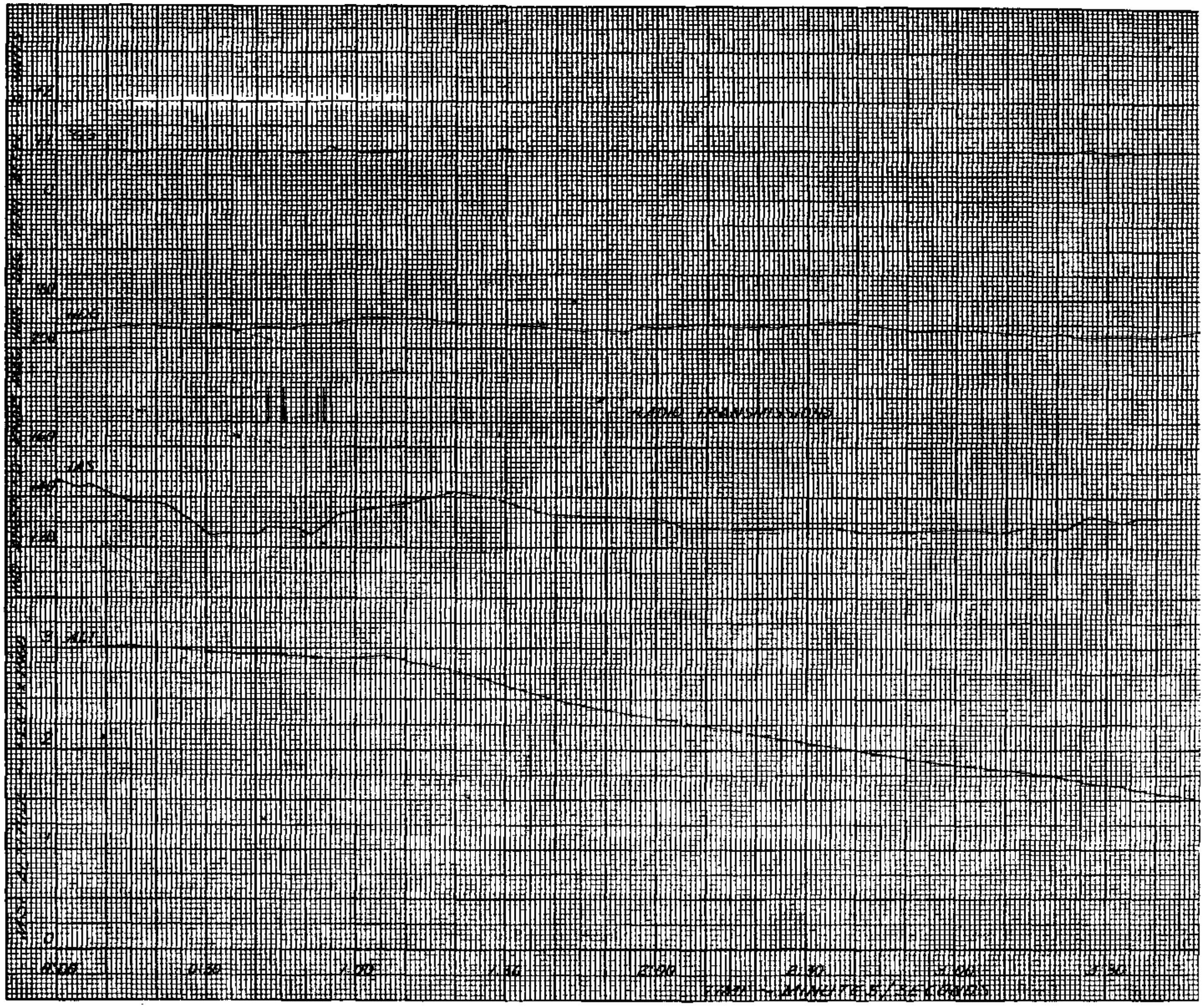
CAM 1	CAPTAIN
CAM 2	FIRST OFFICER
RDO 2	FIRST OFFICER
CHA APC	CHATTANOOGA APPROACH CONTROL
CHA TWR	CHATTANOOGA TOWER

APPENDIX E

NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C.

APPROACH PROFILE
DELTA AIR LINE, DOUGLAS DC-9, N3323L
FLT. 516, CHATTANOOGA, TENN.
NOVEMBER 27, 1973
(COMBINED F.D.R., C.V.R., COMPUTER PLOT)

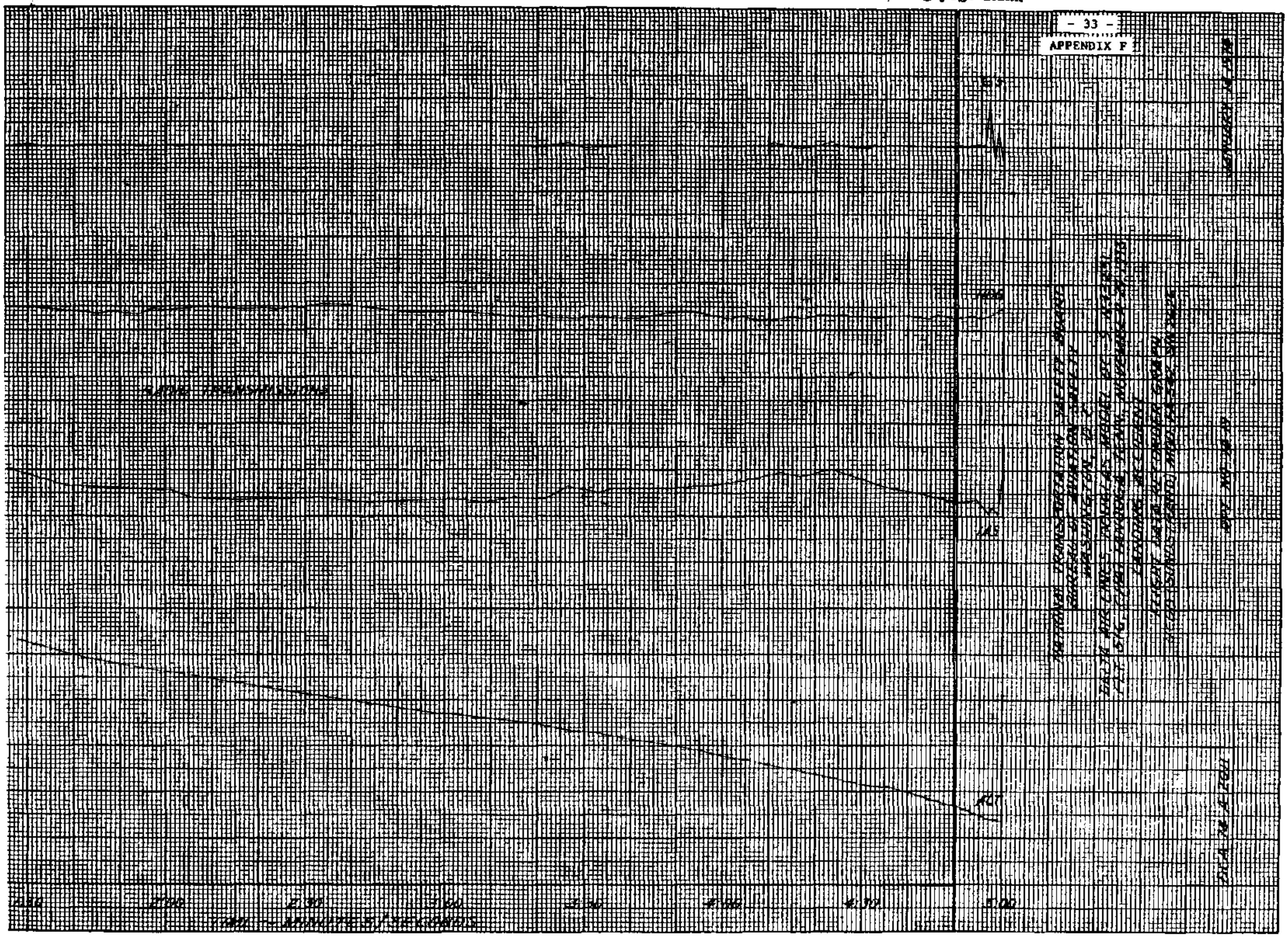
B

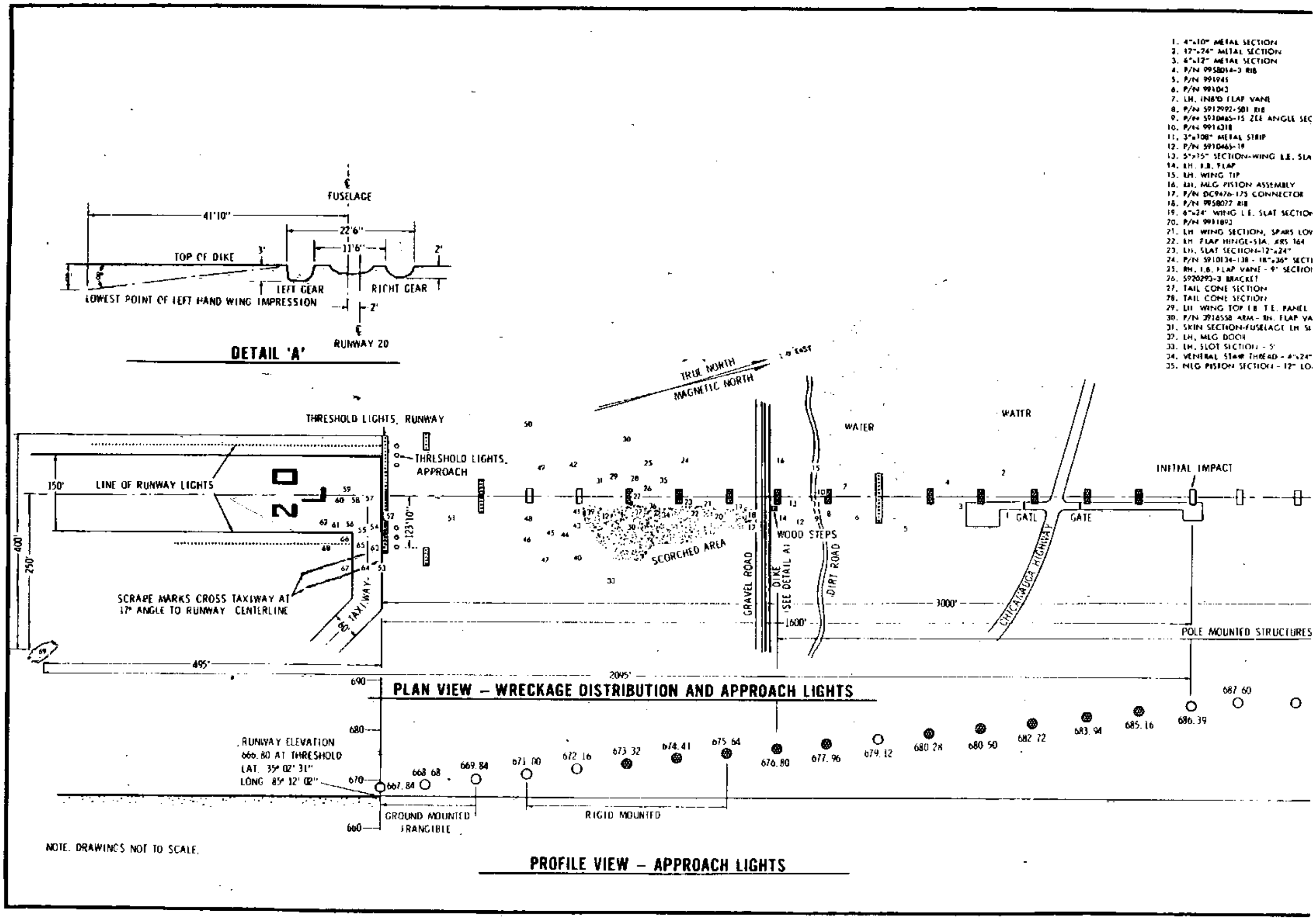


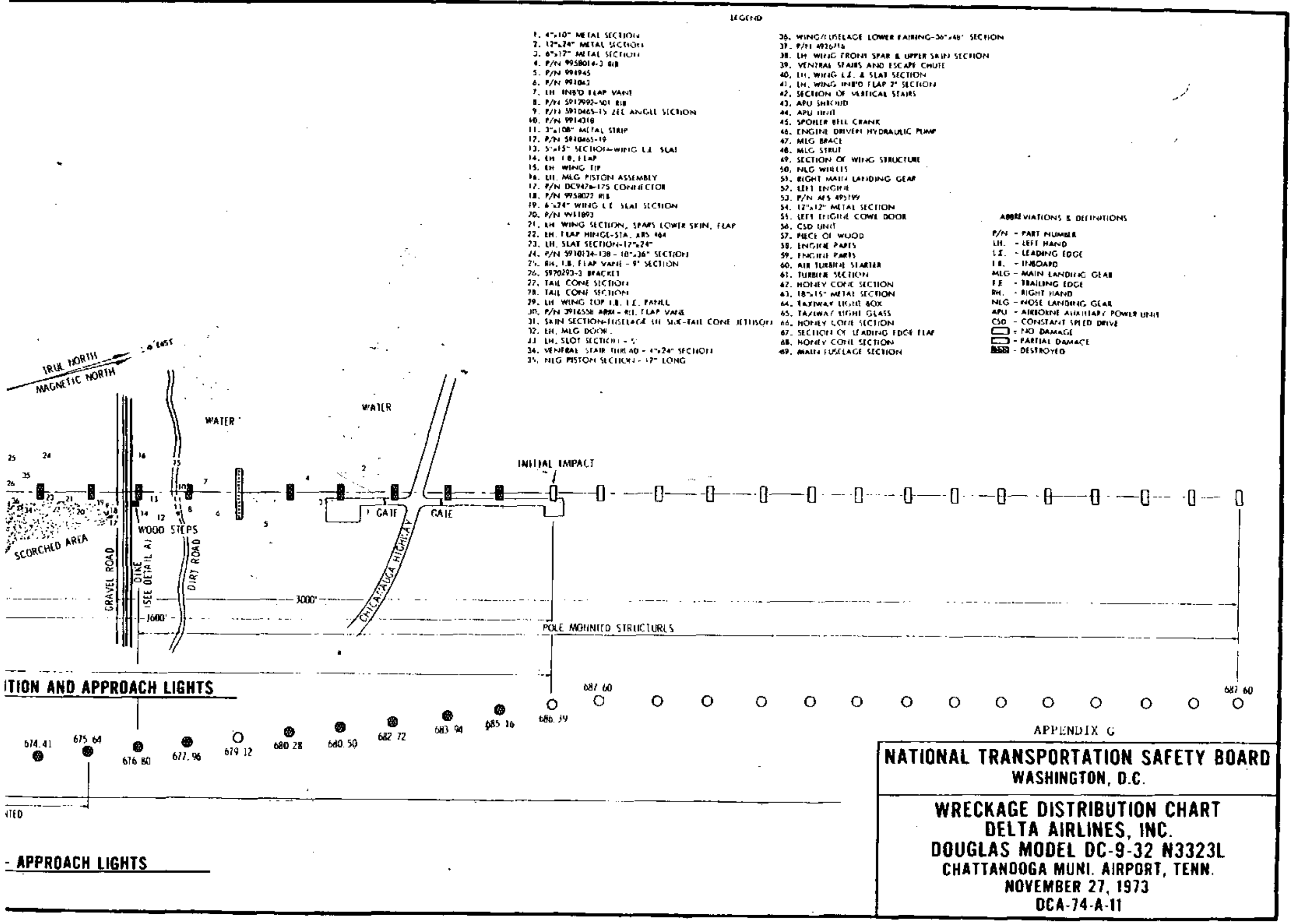
ALT
IAS
HDG
RADIO TRANSMISSIONS
0:00
0:30
1:00
1:30
2:00
2:30
3:00
3:30
TIME — MINUTES/SECONDS

Preceding page blank

APPENDIX F




DETAIL 'A'
FUSELAGE
RUNWAY 20
41'10"
22'6"
11'6"
TOP OF DIKE
LEFT GEAR
RIGHT GEAR
LOWEST POINT OF LEFT HAND WING IMPRESSION
TRUE NORTH
MAGNETIC NORTH
THRESHOLD LIGHTS, RUNWAY
THRESHOLD LIGHTS, APPROACH
LINE OF RUNWAY LIGHTS
150'
123'10"
SCRAPE MARKS CROSS TAXIWAY AT 17° ANGLE TO RUNWAY CENTERLINE
TAXIWAY
400'
250'
495'
2095'
1600'
3000'
SCORCHED AREA
GRAVEL ROAD
DIKE
(SEE DETAIL A)
WOOD STEPS
DIRT ROAD
WATER
WATER
GATE
GATE
CHICKAMAUGA HIGHWAY
INITIAL IMPACT
POLE MOUNTED STRUCTURES
PLAN VIEW – WRECKAGE DISTRIBUTION AND APPROACH LIGHTS
RUNWAY ELEVATION
666.80 AT THRESHOLD
LAT. 35° 02' 31"
LONG 85° 12' 02"
690
680
670
660
667.84
668.68
669.84
671.00
672.16
673.32
674.41
675.64
676.80
677.96
679.12
680.28
680.50
682.72
683.94
685.16
686.39
687.60
GROUND MOUNTED FRANGIBLE
RIGID MOUNTED
NOTE. DRAWINGS NOT TO SCALE.
PROFILE VIEW – APPROACH LIGHTS
1. 4"x10" METAL SECTION
2. 12"x24" METAL SECTION
3. 6"x12" METAL SECTION
7. LH. INB'D FLAP VANE
11. 3"x108" METAL STRIP
14. LH. I.B. FLAP
15. LH. WING TIP
16. LH. MLG PISTON ASSEMBLY
27. TAIL CONE SECTION
28. TAIL CONE SECTION
32. LH. MLG DOOR


LEGEND
1. 4"x10" METAL SECTION
2. 12"x24" METAL SECTION
3. 6"x17" METAL SECTION
4. P/N 9958014-3 RIB
5. P/N 994945
6. P/N 991043
7. LH INB'D FLAP VANE
8. P/N 5917992-501 RIB
9. P/N 5910465-15 ZEE ANGLE SECTION
10. P/N 9914318
11. 3"x108" METAL STRIP
12. P/N 5910465-19
13. 5"x15" SECTION-WING L.E. SLAT
14. LH I.B. FLAP
15. LH WING TIP
16. LH. MLG PISTON ASSEMBLY
17. P/N DC9476-175 CONNECTOR
18. P/N 9958072 RIB
19. 6"x24" WING L.E. SLAT SECTION
20. P/N WF1893
21. LH WING SECTION, SPARS LOWER SKIN, FLAP
22. LH. FLAP HINGE-STA. XRS 464
23. LH. SLAT SECTION-17"x24"
24. P/N 5910134-138 - 18"x36" SECTION
25. RH. I.B. FLAP VANE - 9" SECTION
26. 5970293-3 BRACKET
27. TAIL CONE SECTION
28. TAIL CONE SECTION
29. LH WING TOP I.B. T.E. PANEL
30. P/N 3914558 ARM - RH. FLAP VANE
31. SKIN SECTION-FUSELAGE LH SIDE-TAIL CONE JETTISON
32. LH. MLG DOOR
33. LH. SLOT SECTION - 5'
34. VENTRAL STAIR TREAD - 4"x24" SECTION
35. MLG PISTON SECTION - 17" LONG
36. WING/FUSELAGE LOWER FAIRING-36"x48" SECTION
37. P/N 4926716
38. LH WING FRONT SPAR & UPPER SKIN SECTION
39. VENTRAL STAIRS AND ESCAPE CHUTE
40. LH. WING L.E. & SLAT SECTION
41. LH. WING INB'D FLAP 2' SECTION
42. SECTION OF VERTICAL STAIRS
43. APU SHROUD
44. APU UNIT
45. SPOILER BELL CRANK
46. ENGINE DRIVEN HYDRAULIC PUMP
47. MLG BRACE
48. MLG STRUT
49. SECTION OF WING STRUCTURE
50. NLG WHEELS
51. RIGHT MAIN LANDING GEAR
52. LEFT ENGINE
53. P/N AES 495199
54. 12"x12" METAL SECTION
55. LEFT ENGINE COWL DOOR
56. CSD UNIT
57. PIECE OF WOOD
58. ENGINE PARTS
59. ENGINE PARTS
60. AIR TURBINE STARTER
61. TURBINE SECTION
62. HONEY COMB SECTION
63. 18"x15" METAL SECTION
64. TAXIWAY LIGHT BOX
65. TAXIWAY LIGHT GLASS
66. HONEY COMB SECTION
67. SECTION OF LEADING EDGE FLAP
68. HONEY COMB SECTION
69. MAIN FUSELAGE SECTION
ABBREVIATIONS & DEFINITIONS
P/N - PART NUMBER
LH. - LEFT HAND
L.E. - LEADING EDGE
I.B. - INBOARD
MLG - MAIN LANDING GEAR
T.E. - TRAILING EDGE
RH. - RIGHT HAND
NLG - NOSE LANDING GEAR
APU - AIRBORNE AUXILIARY POWER UNIT
CSD - CONSTANT SPEED DRIVE
- NO DAMAGE
- PARTIAL DAMAGE
- DESTROYED
TRUE NORTH
MAGNETIC NORTH
WATER
WATER
INITIAL IMPACT
GATE
GATE
CHICKAMAUGA HIGHWAY
SCORCHED AREA
GRAVEL ROAD
DIKE (SEE DETAIL A)
WOOD STEPS
DIRT ROAD
3000'
1600'
POLE MOUNTED STRUCTURES
ITION AND APPROACH LIGHTS
- APPROACH LIGHTS
674.41
675.64
676.80
677.96
679.12
680.28
680.50
682.72
683.94
685.16
686.39
687.60
687.60
APPENDIX G
NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C.
WRECKAGE DISTRIBUTION CHART
DELTA AIRLINES, INC.
DOUGLAS MODEL DC-9-32 N3323L
CHATTANOOGA MUNI. AIRPORT, TENN.
NOVEMBER 27, 1973
DCA-74-A-11

Preceding page blank

APPENDIX H

NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C.

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 H

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 DC-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.

By: John H. Reed
Chairman

APPENDIX H

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

WASHINGTON, D.C. 20591

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.

While 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 descent when conducting nonprecision approaches 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,

(signed) Alex Butterfield

Alexander P. Butterfield
Administrator