NATIONAL TRANSPORTATION SAFETY BOARD

AIRCRAFT ACCIDENT REPORT

SOUTHERN AIRWAYS, INC. DC-9, N97S

Tri-State Airport

Huntington, West Virginia

November 14, 1970

NATIONAL TRANSPORTATION SAFETY BOARD
Washington, D. C. 20591
REPORT NUMBER : NTSB-AAR-72-11

SA-422 File No. 1-0023

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16. Abstract

Southern Airways, Inc., DC-9, N97S, operating as charter Flight 932, crashed during a landing attempt at the Tri-State Airport, Huntington, West Virginia, at approximately 1936 e.s.t., on November 14, 1970. All 75 occupants, including 71 passengers and four crewmembers, were fatally injured. The aircraft was destroyed.

The flight, chartered to transport the Marshall University football team and boosters from Kinston, North Carolina, to Huntington, West Virginia, was attempting a nonprecision instrument landing approach to Runway 11 at the time of the accident. The crash occurred following impact with trees on a hill approximately 1 mile west of the runway threshold. The elevation of the broken trees at the initial impact site was approximately 922 feet m.s.l.

The National Transportation Safety Board determines that the probable cause of this accident was the descent below Minimum Descent Altitude during a nonprecision approach under adverse operating conditions, without visual contact with the runway environment. The Board has been unable to determine the reason for this descent although the two most likely explanations are (a) improper use of cockpit instrumentation data, or (b) an altimetry system error.

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TRI-STATE AIRPORT, HUNTINGTON, WEST VIRGINIA
NOVEMBER 14, 1970

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SOUTHERN AIRWAYS, INC., DC-9, N97S
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SYNOPSIS

Southern Airways, Inc., DC-9, N97S, operating as charter Flight 932, crashed during a landing attempt at the Tri-State Airport, Huntington, West Virginia, at approximately 1936 e.s.t., on November 14, 1970. All 75 occupants, including 71 passengers and four crewmembers, were fatally injured. The aircraft was destroyed.

The flight, chartered to transport the Marshall University football team and boosters from Kinston, North Carolina, to Huntington, West Virginia, was attempting a nonprecision instrument landing approach to Runway 11 at the time of the accident. The crash occurred following impact with trees on a hill approximately 1 mile west of the runway threshold. The elevation of the broken trees at the initial impact site was approximately 922 feet m.s.l.

The Minimum Descent Altitude, below which descent is not authorized until the runway environment is in sight, for this instrument approach was 1,240 feet m.s.l.

The weather at the time of the accident was: 300 feet scattered, estimated 500 feet variable broken, 1,100 feet overcast, visibility five miles, light rain, fog, smoke, wind 360° at 4 knots, altimeter setting 29.67, ceiling ragged and variable 400 to 600 feet.

Probable Cause

The National Transportation Safety Board determines that the probable cause of this accident was the descent below Minimum Descent Altitude during a nonprecision approach under adverse operating conditions, without visual contact with the runway environment. The Board has been unable to determine the reason for this descent, although the two most likely explanations are (a) improper use of cockpit instrumentation data, or (b) an altimetry system error.

Recommendations

The Board recommends that:

1. All segments of the aviation industry continue to focus attention on the unique demands for crew coordination and vigilance during nonprecision approaches. Particular emphasis should be placed on the accelerated development of area navigation systems with vertical guidance capability and on heads-up display systems.

2. The Administrator evaluate the need for the installation and use of ground proximity warning devices on air carrier aircraft.

3. The FAA continue to emphasize the importance of the provisions of Part 121.445 in its surveillance and inspection of flight operations under Part 121. Such emphasis is needed to assure that these operators are (1) using the best means available to enable pilots to qualify under 121.445, and (2) requiring pilots to show that they have acquired the requisite knowledge prior to completion of a flight release.

1. INVESTIGATION

1.1 History of the Flight

Southern Airways Charter Flight 932 (SOU 932) 1/ was scheduled as a ferry flight from Atlanta, Georgia, to Kinston, North Carolina, to return members of the Marshall University football team, the coaching staff, and other passengers to Huntington, West Virginia, from Kinston. The flight was then scheduled to continue to Hopkinsville, Kentucky, and Alexandria and Baton Rouge, Louisiana. The crew consisted of a captain, a first officer, and two stewardesses. In addition, an operations employee was assigned as a charter coordinator.

The flightcrew was given a standard briefing by company dispatch and a charter kit of appropriate documents, including: (1) Jeppesen Manuals for high and low altitude airways, and approach charts for all major civil and military airports in the U.S.; (2) the current Airman's Information Manual, Parts I, II, and III; (3) a complete set of Sectional Aeronautical Charts; and (4) all the necessary flight forms for cargo loading, weight and balance, flight planning, daily inspection and maintenance, and credit cards. In addition, a copy of the Southern DC-9 off-line airport restrictions was carried by the charter coordinator, and another copy was kept on each aircraft. The stewardesses and charter coordinator boarded the aircraft with the flightcrew at Atlanta and the aircraft was ferried to Kinston.

The flight departed Atlanta at 1548 2/ and arrived at Kinston at 1642. The aircraft was refueled, but no maintenance was requested or performed. Seventy passengers boarded the aircraft and the flight taxied from the ramp at 1828 with a total of 75 persons aboard.

The captain filed an Instrument Flight Rules (IFR) flight plan to Huntington, via direct Raleigh-Durham, North Carolina, direct Pulaski, Virginia, direct Huntington, at Flight Level 260 (FL 260). The true airspeed was 473 knots and the estimated time en route was 52 minutes. The flight departed Kinston at 1838 and proceeded in accordance with the flight plan. Subsequent air traffic control transfers were accomplished and, at 1923, SOU 932 established contact with Huntington Approach Control by advis-

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1/ The primary difference between this charter flight and a regularly scheduled flight conducted under Southern Airways' operating certificate is the applicable landing minima. The Federal Aviation Regulations impose higher landing minima on the pilot of a charter flight, unless he is qualified at the airport and lower minima have been established for the airport in the air carrier's operations specifications. In this instance the normal minima for Runway 11 were increased from 1,240 feet and 1/2-mile to 1,240 feet and 1 mile.

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

ing, ". . . we're descending to five thousand." 3/ The controller cleared them for a localizer approach to Runway 11 and added, ". . . the surface winds are favoring runway twenty-nine, three five zero degrees at six, altimeter two niner six seven. . . ." The crew acknowledged this information and then the controller advised, ". . . the Huntington weather three hundred scattered, measured ceiling five hundred, variable broken, one thousand one hundred overcast, visibility five, light rain, fog, smoke, ceiling ragged variable four to six hundred."

At approximately 1933, the captain said that he would fly at 130 knots, and the first officer responded that he was checking the time, and the approach should take 2 minutes. At 1934, the crew reported passing the outer marker inbound, and they were cleared to land. The wind was then reported as 340°, 7 knots. Following a discussion of the approach lighting during which the crew requested "step three," the tower controller stated, "Roger, that's where they are, with the rabbit (sequence flasher). Advise when you want them cut." The crew's response, "Very good," was the last transmission received. At approximately 1936, tower personnel observed a red glow west of the airport. When no response to subsequent radio calls was received, the tower controller initiated the emergency procedures.

Witnesses in the vicinity of the Runway 11 localizer course generally agreed that the aircraft was low, but otherwise appeared normal. The weather was described as varying between mist and light rain with low clouds. Some witnesses also indicated that visibility was restricted due to fog. However, one witness who was approximately two-thirds of a mile west of the initial impact site observed the aircraft pass approximately 300 feet above him and disappear from view beyond the hill. He saw the hill outlined in "good detail" by a glow from beyond the hill, and heard an increase in jet engine noise prior to the crash. Another witness, who was approximately 700 feet east of the initial impact, stated that the aircraft rolled to the right, almost inverted, and crashed in a steep, nosedown angle.

The tower controller stated that he maintained a continuous watch for SOU 932 once they reported passing the outer marker. Although he did not see the aircraft, he did observe the fire and explosion from the crash. He did not recall any differences between the reported and actual weather prior to the accident.

3/ A transcript of pertinent cockpit conversation is included in Appendix D.

The last flight to operate into Huntington prior to SOU 932 landed on Runway 11 at 1848 and departed at 1907. The captain of that flight stated that the weather was essentially as reported to him, 300 feet scattered, 500 feet variable broken. They broke out of the clouds at minimums, west of the refinery (located approximately 2 miles west of the airport). The forward visibility was good, and the runway was in sight from this point until they landed, although they did encounter some widely scattered scud clouds.

The accident occurred during hours of darkness at 38° 22' 27" N. latitude and 82° 34' 42" W. longitude.

1.2 Injuries to Persons

Injuries	Crew	Passengers	Others
Fatal	4	71	0
Nonfatal	0	0	0
None	0	0	

1.3 Damage to Aircraft

The aircraft was destroyed by impact and ground fire.

1.4 Other Damage

The aircraft destroyed many trees on a hill approximately 1,300 feet west of the main wreckage site.

1.5 Crew Information

The crew was qualified for the flight. (See Appendix B for details.)

1.6 Aircraft Information

The aircraft was certificated and maintained in accordance with existing regulations. It was fueled with Jet A-1 kerosene. (See Appendix C for details.)

1.7 Meteorological Information

At the time of the accident, a low-pressure area was centered near southwestern West Virginia. A frontal system extended southward from that area and the accident site was included in an extensive zone of low cloudiness and precipitation associated with these synoptic features.

The aviation area forecast for West Virginia, issued by the National Weather Service (NWS) office at Suitland, Maryland, valid for a 12-hour period, beginning at 1400, was, in part, as follows:

> Low pressure developing over the southeastern states and centered over northeastern Alabama, expected to move northeastward at 15 to 20 knots will lie over western North Carolina southwestern Virginia by 0200.
>
> Flight precaution recommended throughout forecast area because of lowering ceilings and visibilities and also because of occasional turbulence and possible icing.
>
> Over West Virginia . . . generally ceiling 1,000 to 2,000 feet overcast, 3 to 6 miles, haze, occasional ceiling 300 to 500 feet overcast, 1 to 2 miles, fog, scattered light rain. Conditions lowering more extensively after 1700, becoming more frequently ceiling 500 to 1,000 feet overcast, 1-1/2 to 3 miles, light rain, fog, and occasional ceiling 300 to 500 feet overcast, 3/4 to 1-1/2 miles, light rain, fog, with light rain to occasional moderate rain.
>
> Freezing level 6,000 to 8,000 feet over mountains . . . occasional moderate icing in clouds likely above the freezing level. . . .

The terminal forecast for Huntington, issued at 1145, and valid for a 12-hour period beginning at 1200 was in part as follows:

> 1200-2100, ceiling 500 feet overcast, 2 miles, light rain, fog, smoke, wind 030°, 12 knots, variable to ceiling 300 feet overcast, 1 mile, light rain, fog.

The next routine terminal forecast was issued at 1745, valid for a 12-hour period beginning at 1800 and was in part as follows:

1800-2300, 300 feet scattered, ceiling 500 feet broken, 1,000 feet overcast, 1-1/2 miles, light rain, fog, scattered clouds variable to broken.

The official surface weather observations for Huntington bracketing the time of the accident were as follows:

1855, 300 feet scattered, measured 500 feet variable broken, 1,100 feet overcast, 5 miles, light rain, fog, smoke, temperature 49°, dewpoint 47°, wind 360°, 4 knots, 29.67, ceiling ragged and variable 400 to 600 feet.

1945, 300 feet scattered, estimated 500 feet broken, 1,000 feet overcast, 5 miles, light rain, fog, smoke, temperature 49°, dewpoint 47°, wind 210°, 4 knots, 29.67, ceiling ragged, aircraft accident.

1956, record special, partial obscuration, estimated 500 overcast, 3/4-mile very light rain, fog, smoke, temperature 49°, dewpoint 47°, wind 290°, 5 knots, 29.67, fog obscuring 5/10 of the sky, ceiling ragged, intermittent very light rain.

The National Weather Service specialist who made the observations testified that ". . . I thought the visibility was remarkably good when I took my local (the 1945 observation), but about 10 or 15 minutes after that the fog formed very rapidly, and that's when the visibility came down. . . it was right over the field. It just seemed like it formed very rapidly and it just actually sank right over the whole field."

The Huntington 1900 radiosonde ascent showed saturated or virtually saturated conditions with stable air from about 2,000 to 5,000 feet and otherwise a moist adiabatic lapse rate. The freezing level was at 7,500 feet. The upper wind observation associated with this ascent was in part as follows:

Height (feet m.s.l.)	Direction (°true)	Velocity (knots)
Surface	360	7
2,000	075	12
3,000	130	18

A study of pressure patterns in the West Virginia area, at the time of the accident, was conducted for the Safety Board by the National Weather Service following the initial public hearing. The study showed that the dominant low-pressure area was elongated toward the northeast with surface pressures dropping at an average rate of 0.013 inch of mercury/hour. This would correspond to an indicated altitude increase of 13 feet/hour. The low-pressure area moved steadily northeastward with little change in intensity. Although there was an extensive area of light rain, no showery precipitation (possibly indicative of more rapid pressure variation) was reported within 250 miles of Huntington.

1.8 Aids to Navigation

The Tri-State Airport was equipped with an ILS localizer, but no glide slope. The localizer provided a nonprecision approach to Runway 11. The crew's Jeppesen Approach Chart depicting this procedure was dated December 27, 1968; however, the current approach chart at the time of the accident was dated November 6, 1970. (See Attachment 2.) The revised approach chart was incorporated in Southern's charter kits on November 13, 1970, by the chief pilot. Two kits were not available on that date because they were in use at the time, including the charter kit on N97S which had departed at approximately 0830 on the day the revisions were inserted. The basic differences in the two approach charts were: (1) an increase in the Minimum Sector Altitude 4/ from 2,500 feet to 2,600 feet m.s.l., for the sector west of the airport (180° clockwise through 360° inclusive); and (2) the addition of holding instructions to the missed-approach procedure text.

The Localizer-Runway 11 approach required a procedure turn south of the 114° localizer course within 10 miles of the outer marker, at 2,600 feet m.s.l. The outer marker minimum crossing altitude was 2,200 feet m.s.l., and further descent was then authorized to the Minimum Descent Altitude (MDA) 5/ of 1,240 feet m.s.l. The outer

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4/ Minimum Sector Altitude - provides 1,000-foot obstacle clearance within a 25-mile radius of a navigation facility (except localizers without a nondirectional beacon). A sector may not be less than 90° in spread, and the obstacle clearance must also apply in adjacent areas within 4 miles of the sector boundary. All altitudes are mean sea level (m.s.l.) unless otherwise indicated.

5/ Minimum Descent Altitude is the lowest altitude to which descent shall be authorized in procedures not using a glide slope. Aircraft are not authorized to descend below the MDA until the runway environment (runway threshold, or approved lighting aids or other markings identifiable with the runway) is in sight and the aircraft is in a position to descend for a normal landing.

marker and middle marker were located 4.6 and 0.6 miles, respectively, from the runway threshold. The localizer was offset approximately 0.7° to the south of the runway centerline. The offset was accomplished to place the antenna on stable ground where the electronic signal would remain within tolerances. A flight check of the facilities was accomplished by the Federal Aviation Administration (FAA) on November 15, 1970, and all were found satisfactory.

An instrument landing system was scheduled for installation and commissioning at the Tri-State Airport in June 1958. The localizer, middle marker, and outer marker installations were completed at that time, but there was insufficient terrain to provide adequate reflecting surface for the glide-slope antenna, within the existing criteria. Three applications for runway extension, which would also provide suitable terrain for the glide-slope antenna, were submitted to the FAA in Fiscal Years 1967, 1970 and 1971. The 1967 and 1970 requests were not approved because the necessary "matching funds" from the sponsoring agency were not available, and consequently the Federal funds were not committed. The 1971 request was still under consideration at the time of the accident.

Subsequent to the accident, concurrent negotiations involving the FAA, West Virginia State Aeronautics Commission, Wilcox Electric Company, Inc., and the Tri-State Airport Authority, resulted in the installation of a nonstandard glide slope for Runway 11, paid for by Federal funds only. Prior to installation, the FAA estimated that there was a 50 percent probability of success with the glide slope. A Wilcox Mark I, Series 8020 transmitter was placed 1,211 feet south of the runway centerline and 960 feet west of the Runway 29 threshold. The elevation of the site was 805.2 feet m.s.l. and the antenna was rotated 13.5° to align with the middle marker. This offset was required to place the site on suitable terrain, and resulted in an unuseable signal below 1,075 feet m.s.l. Consequently, there was no reduction in the minimum altitude authorized for the instrument approach. However, the signal generating capability of the facility to date has been as reliable as standard systems.

1.9 Communications

There were no known difficulties with radio communications.

1.10 Aerodrome and Ground Facilities

The Tri-State Airport was located on a hilltop approximately 2.5 miles southwest of Huntington, West Virginia, at an elevation of 828 feet

m. s. l. The only runway was Runway 11-29. It was 5,281 feet long and 150 feet wide, and was of concrete construction. Runway 11 was equipped with high-intensity runway lights, approach lights, and sequence flashers. All lighting was operating satisfactorily. There was no visual approach slope indicator (VASI) system installed.

There was very little level land extending beyond either end of the runway; however, there were other hills of similar size and elevation surrounding the airport. The highest obstacle in the area underlying the localizer course was a tree 6,700 feet east of the outer marker, at an elevation of 990 feet m. s. l. By contrast, the Ohio River and Big Sandy River passed within a few miles of the airport at elevations of approximately 500 feet m. s. l. in the north, west, and south quadrants. An area of bright lights surrounding a refinery was located on the west bank of the Big Sandy River just south of the localizer course, about 2 miles west of the runway threshold.

1.11 Flight Recorders

The aircraft was equipped with a Sundstrand flight data recorder, Model F-542, S/N 1047. The recorder unit had been exposed to extreme heat in the fire after impact, but the recording medium magazine was easily removed and the recorded foil surface was virtually undamaged. A readout of the last 10 minutes of normally recorded traces was prepared. The altitude trace was adjusted for an altimeter setting of 29.67 to indicate m. s. l. altitudes, but no other corrections were made to the data. Additional checks of the altitude trace were made as follows:

Location	Altimeter Setting	Recorded Difference	Tolerance
Atlanta Airport	29.71	- 18 feet	± 100 feet
Cruise FL 290	29.92	+ 200	± 450
Stallings Field (Kinston)	29.90	+ 88	± 100
Cruise FL 260	29.92	+ 235	± 400

The last 0.036-inch of foil travel contained sudden deviations in all recorded traces. This aberrant area, equivalent to 21.6 seconds of elapsed time during normal operation, included a 0.009-inch segment without the recording of any parameter trace. With the assistance of the manufacturer, various tests were conducted to duplicate the indications on the flight data recorder foil. Mechanical and electrical checks, g-loading on all three axes with indiscriminate interruptions of electrical power, and attempts mechanically to impede or accelerate foil travel all failed to provide a satisfactory explanation for the aberrations. It was determined that the 0.009-inch skip was caused by a shock of unknown magnitude or origin. Also, though some scribe marks during the 0.036-inch travel were normal in appearance, there was no correlation between the recorded parameters, except that the downward excursions appeared to have been caused by a heavy shock in excess of 30g's.

The flight data recorder static pressure source is the aircraft alternate static system. This system is completely separate from the captain's and first officer's normal static pressure systems, except that it is available as a backup source for their instruments, if selected by them. The alternate static ports are located on either side of the aircraft centerline approximately 10 feet forward, and slightly below, the normal static port panels.

The aircraft was also equipped with a Collins cockpit voice recorder (CVR), Model 642-C-1, S/N 508. The unit had sustained considerable impact damage to the electronics package, but there was no damage within the stainless steel case of the tape magazine. There was considerabl "wow and flutter" on the tape, indicating a mechanical distress condition within the recorder. There was also marked interference from background noise and the cockpit speakers. A partial transcript of the readout is attached as Appendix D.

1.12 Wreckage

The aircraft initially struck trees on a hill 5,543 feet west of the runway threshold, and cut a swath 95 feet wide and 279 feet long through the trees on a bearing of 110°, 122 feet right of the Runway 11 centerline extended. Several sections of wing leading edge, one trailing edge flap moveable vane, and a flap track, all from the right wing, and three large sections of radome were located near the swath cut.

The main wreckage site was located 4,219 feet from the threshold of Runway 11, and approximately 225 feet south of the middle marker. The aircraft cut a swath 39° below the horizontal through the trees at the wreckage site and came to rest in an inverted attitude.

The ground elevation at the initial tree impact was 860 feet m.s.l., and the elevation at the break in the tree at this location was 916 feet 2 inches m.s.l. The highest ground elevation adjacent to the swath cut was 894.5 feet m.s.l. Tree heights at this point measured 50 feet, which corresponded to a treetop elevation of 944.5 feet m.s.l. The ground elevation near the crest of the hill in the center of the swath cut was 880 feet m.s.l. The break in a poplar tree at this point was 42 feet above the ground (922 feet m.s.l.) However, the U. S. Department of Agriculture Forest Service estimated that the tree was 71 feet (± 1 foot) tall before breakage, based on a study of other trees in the area. The MDA was approximately 290 feet above the estimated maximum elevation of the tree top. The swath cut between the initial tree impact and the break in the poplar tree was $+2^{\circ}$, measured from the horizontal. The distance between these two trees was approximately 152 feet.

Most of the fuselage was melted or reduced to a powder-like substance; however, several large pieces were scattered throughout the burned area. Examination of the various components indicated that the landing gear and flaps were fully extended at impact. The horizontal stabilizer setting was 5.75 units noseup, which was in the normal range for the weight, and speed, in the approach configuration.

1.13 Fire

A severe ground fire at the main wreckage site followed impact. Firefighting activity at the crash site was limited to containing brush fires in the area. There was no evidence of in-flight fire.

1.14 Survival Aspects

This was a nonsurvivable accident.

1.15 Tests and Research

In reviewing the circumstances of this accident, the Safety Board again took notice of tests conducted by the Douglas Aircraft Company (DACO) in May 1967. The tests were designed to study the effect of possible water ingestion in the static ports of the aircraft. Several DACO field service reports had indicated that during final descent on ILS approaches, with full flaps and landing gear extended, the altimeter was alternately "pausing" and then "jumping." At each momentary pause and subsequent jump, the instantaneous vertical speed indicator tended toward zero. Most of the "jumps" were between 40 and 60 feet, but several were 80 to 100 feet in magnitude.

The initial tests were conducted in an altitude chamber. It was found that each port of a static plate entrained water by capillary action, and pressure differentials equivalent to about 35 feet in altitude, at sea level, were required to expel the water. A series of runs verified that any increase in the diameter of the orifice decreased the magnitude of the "jumps." Variations in the rate of descent affected the rate of "jumps," but not the magnitude.

Flow visualization tests were then conducted in the wind tunnel with 1/50-scale DC-9-10 and DC-8-55 models to identify any mechanism that might tend to concentrate water in the vicinity of the static ports. The testing covered both no-flap and 50°-flap configurations at angles of attack ranging from -8° to $+8^{\circ}$. The observed flow was orderly, and the only deviation was around a high velocity region on the nose of the DC-9. This was later found to be due to model asymmetry.

Actual flight tests were conducted in light-to-heavy rain with a DC-9-30 in the following flight conditions: descent in the landing configuration for both the DC-9-10 6/ and DC-9-30, and descent in the clean configuration that was representative of both aircraft. Nine simulated ILS approaches were flown in the DC-9-30 landing configuration. 7/ Both the normal and alternate static systems were monitored throughout, and no instances of sticky altimeter operation were observed. Additionally, five typical descents were made in the clean configuration, at 2,500 to 3,000 feet/minute, through light to sporadically heavy rain. No evidence of sticky altimeter operation was detected on any system.

At the request of the Safety Board and the FAA, the National Aeronautics and Space Administration has undertaken a long term Static Pressure Measurements Project at the Lewis Research Center. This exploratory research project includes flight and ground testing to determine the flight and weather conditions which may lead to altitude misinformation. A secondary objective is to compare the water ingestion resistance of existing static ports with static ports being considered for future aircraft. The flight test portion of this project has begun, and ground tests will be predicated on the results of the flight tests.

6/ The DC-9-30 aircraft was modified to incorporate a simulated DC-9-10 static system. It was flown at Series 10 VRef +5 knots, with the gear down, 50° flaps, and slats closed, to gather the DC-9-10 data.

7/ Landing gear down, slats and flaps extended, and VRef +5 knots.

The captain's altimeter (type E42459 10 113, S/N 115) and the first officer's altimeter (type A40179 10 020, S/N 430), both from N97S, were taken to the manufacturer's facility where a detailed teardown was made. The captain's barometric setting counter was determined to be reading approximately 29.67. The synchrotel reading on a servoed angle position indicator was 3.65°. This was calculated to represent an indication of approximately 568 feet; however, the rotor being measured was free to rotate. The outer and inner drums of the assembly, which were held in proper alignment by light spring tension, were displaced so as to indicate an offset of approximately 600 feet. A small area of paint was missing from the drum at an indicated altitude of approximately 1,250 feet. This mark was very similar in size and location to the drum index, but there was no paint adhering to the underside of the drum index.

The first officer's altimeter was determined to have been set at a barometric setting between 29.73 and 29.24. The displacement from normal alignment between the outer and inner drum was equivalent to approximately 3,000 feet. No impact marks could be found on the altimeter dial, but a portion of the dial next to the drum window revealed an area, similar in shape to the pointer tip, which had been protected from heat damage evident on the surrounding area. The orientation of the protected area indicated that the needle would have to have been either distorted or dislodged prior to the heat damage in order to mask this area of the dial. The masked area was near the outer dial hash mark indicating "3".

A test program was conducted by the Kollsman Instrument Corporation to determine the effect on an altimeter of (1) a 135° roll about the longitudinal axis of the aircraft and (2) sudden stoppage from impact during a roll. The altimeter, mounted on an aluminum bar, 24 inches from the point of rotation, in a standard instrument panel cutout, was set at 875 feet and 29.67. It was rotated about the offset axis at varying speeds from 18°/second to 90°/second. No significant pointer travel was noted due to rotation. Next, the altimeter was allowed to free fall from various heights to a sudden stop. The stop was adjusted to strike the altimeter housing at the rear, midpoint, and panel on successive drops.

The indicated altitude increased to approximately 1,000 feet on each occasion, and was as high as 1,230 feet on one drop from a height of 10 inches. The test was discontinued at this point to avoid damage to the instrument because the estimated shock valves were approximately 50 g's, and the indicated valve compared favorably with that found on the captain's altimeter drum.

1.16 Other

The Southern Airways DC-9 Operating Manual established the procedures to be followed in their operation of DC-9 aircraft. The nonprecision approach was presented graphically with annotations describing crew actions to be taken at the appropriate times, as follows:

1. Complete in-range checklist 10 minutes prior to estimated time of arrival.

2. Select 15° flaps, extend slats, and slow to appropriate maneuvering speed prior to commencing approach.

3. Commence procedure turn 30 seconds past outer marker (depending on wind).

4. Select 25° flaps, extend gear, complete landing checklist and slow to appropriate maneuvering speed.

5. Over radio fix start descent to MDA, maintain previous maneuvering speed.

6. Select 50° flaps, slow to VRef + 5 knots when runway is sighted.

7. Reduce thrust slowly over threshold to obtain VRef speed, touchdown target is 1,000 feet from threshold.

The Before Landing Final Checklist was described, in part, as follows:

GEAR (Both pilots)	DOWN/3 GREEN DOOR LIGHTS OUT PRESSURE AND QUANTITY NORMAL
500' FLAG SCAN SPEED RATE DESCENT	CHECKED

The Southern Airways DC-9 Flight Manual required the pilot not flying the airplane to make the following callouts during approaches:

a. Any deviation below published transition altitudes.

b. 500' above field elevation and state "No Flags" or "Flags On" as seen on instrument.

c. 100' above minimums.

d. At minimums, call out "Minimums-Runway in Sight" or "Minimums-No Runway."

e. Any sink rate of 1,000 feet/minute or more.

The manual also stated that descent rates in excess of 1,000 feet/minute and flat approaches were to be avoided. The procedure for either a missed-approach or a rejected landing was the same:

1. Set takeoff power.

2. Rotate immediately to stop descent (minimum 10^{o}) and simultaneously call flaps 15^{o}.

3. Continue as in normal takeoff.

4. Do not raise gear until climb is established.

The radio altimeter system was described in Southern Airways DC-9 Operating Manual in general terms, including the following, "Two separate radio altimeter systems on the (Dash 31) . . . are provided to obtain precise altitude information above the ground at the minimum decision (sic) altitude (MDA). This information is essential to the pilot in his decision to land or initiate a go-around maneuver." The chief pilot for Southern Airways testified that this statement was misleading that it was excerpted from the DACO DC-9 manual, and was more applicable to precision approaches over level terrain than to nonprecision approaches of this type. He emphasized that Southern's pilots were cautioned in training against using the radio altimeter as a primary reference. In amplifying their training procedure, he also indicated that the pilots were trained to call out altitudes in terms of m.s.l. except the "hundred above" and "minimums" which were obviously referenced to MDA. The 500-foot flag scan was required on all approaches, whether visual or instrument, and a comprehensive standardization program was conducted. He stated that he was not aware that any company pilots deviated from this practice. He estimated that more than half of the approaches made in their line operation were nonprecision.

On January 12, 1971, Southern Airways issued changes to their DC-9 Operating Manual as follows:

(1) A note was added to the Nonprecision Approach and Landing Diagram stating that, for a short approach where time expiration and MDA for the approach are expected to coincide, flaps may be extended to 50^{o} at the approach fix.

(2) An additional callout at 500 feet above minimum altitude was added.

(3) The discussion on use of the radio altimeter was modified to include a warning that the system was unreliable over hilly or rolling terrain, and should not be used for altitude information.

Southern Airways' authority for charter operations was contained in its Operation Specifications. This authority required that any "off-route" operation be accomplished as prescribed by Part 121 of the Federal Aviation Regulations applicable to supplemental air carriers and commercial operators, and by the exceptions which were contained in their Operations Specifications. The exception applicable to IFR takeoff and landing weather minima required that, when the pilot-in-command was not qualified for the airport, he must use the weather minima and instrument approach procedures prescribed in Part 97 of the Federal Aviation Regulations. The minima established for a localizer approach, by this part of the regulations, were 350 feet and 1 mile. However, the minima specifically established for supplemental air carriers or charter operations at the Tri-State Airport were 412 feet and 1 mile.

The airport and route qualifications applicable to the charter flight in this instance were stated in Part 121.445 as follows:

"(a) Each supplemental air carrier and commercial operator shall establish in its manual a procedure whereby each pilot who has not flown over a route and into an airport within the preceding 60 days will certify on a form provided by the operator that he has studied and knows the subjects listed in paragraph (b) of this section in regard to the routes and airports into which he is to operate.

"(b) Each qualifying pilot shall show that he has adequate knowledge of the following:

(1) Weather characteristics appropriate to the seasons.

(2) Navigation facilities.

(3) Communication procedures.

(4) Kinds of terrain and obstruction hazards.

(5) Minimum safe flight levels.

(6) Pertinent air traffic control procedures including terminal area, arrival, departure, and holding and all kinds of instrument approach procedures.

(7) Congested areas, obstruction, and physical layout of each airport in the terminal area in which the pilot will operate."

In accordance with the company's Operations Manual, when the captain signed the flight release, he certified that he had studied and knew the subjects listed above with regard to the route and airports into which he intended to operate. There was, however, no procedure in the manual to provide for a showing by the captain that he had the requisite knowledge.

The airport and route qualifications applicable to scheduled flights of Southern Airways are contained in Part 121.443. This part contains the above-listed requirements of Part 121.445 and also includes the following:

(1) He must show adequate knowledge of position reporting points and holding procedures. This may be demonstrated in a properly equipped synthetic trainer.

(2) He must make an entry, as a member of the flightcrew, at each regular, provisional, and refueling airport into which he is scheduled to fly. The entry must include a takeoff and a landing, and the qualifying pilot must occupy a seat in the pilot compartment, and must be accompanied by a pilot who is qualified for the airport.

(3) The entry requirements may be waived if the initial entry is made under VFR weather conditions; or if the air carrier shows that such qualification can be made using approved pictorial means; or if the Administrator is notified that the air carrier intends to operate into an airport near one into which the pilot concerned is currently qualified, and the Administrator finds that such qualification is adequate for the new airport, considering at least the pilot's familiarity with the layout, surrounding terrain, location of obstacles, and instrument approach and traffic control procedures at the new airport.

The original negotiations between Marshall University and Southern Airways resulted in initial rejection by Southern Airways because of the takeoff weight limitations of their aircraft. The subsequent negotiations resulted in a reduction in the weight of passengers and baggage to be carried from approximately 19,500 pounds to 17,500 pounds, and the charter flight was scheduled. The flight was then offered for bid to the pilots and assigned on the basis of seniority, the same as regularly scheduled flights.

The flight was dispatched initially from Atlanta for the entire charter sequence to Baton Rouge. At Kinston, the captain contacted the dispatcher in Atlanta and an update was accomplished by telephone. Both releases anticipated a landing on a wet runway at Huntington, and the 15 percent additional runway requirement was included in the landing distance computations.

The same aircraft, dispatchers, flight planning services, and supervising personnel were used in the charter operation as in the regularly scheduled service. In addition, a charter coordinator was assigned to assist the flightcrew in administrative matters generally involving ground operations. The coordinator's duties involved supervising and expediting ground operations, arranging for fueling, completing weight and balance forms, etc. In the performance of these duties, he normally communicated directly with the captain shortly before landing. Although he was permitted to enter the cockpit under these circumstances, he was not authorized to occupy the jumpseat. In this instance, the charter coordinator was in the cockpit during the instrument approach, and discussed the fueling at Huntington. He also commented, "Bet'll be a missed-approach" approximately 16 seconds before impact.

During the investigation, considerable attention was focused on the height of the trees on the hill where initial impact occurred. It was determined by an FAA Runway Obstruction Survey, dated December 1, 1970, that several trees on the hill penetrated the ILS approach surface 8/ and therefore constituted obstructions to air navigation as defined in Part 77, Subpart C, of the Federal Aviation Regulations. However, these standards are used in (1) administering the Federal-Aid Airport Program, (2) transferring property under Section 16 of the Federal Airport Act, (3) providing technical advice in airport design and development, and (4) imposing requirements for public notice of construction or alteration of structures where notice will promote air safety. The criteria used in the establishment of flight procedures and aircraft operational limitations are contained in Part 97 and the U. S. Standard for Terminal Instrument Approach Procedure (TERPS). Paragraph 954 of TERPS requires that the minimum obstacle clearance in the final approach area 9/ shall be 250 feet for a localizer approach. The trees did not violate this requirement.

A pen recording was made of the outer marker identifier signals as they were recorded in the CVR tape, to assist in locating the flightpath of SOU 932 through the radiation pattern. For the purpose of this evaluation, it was assumed that the receiver sensitivity of the DC-9 was the same as that of the FAA flight-check aircraft. It was also assumed that the identification tone had reached its maximum signal strength when the recorded signal stopped. Based on the calculations, it was determined that the aircraft was approximately 1,850 feet south of the outer marker transmitter when the signal stopped. Any variation in these assumptions would, of necessity, place the aircraft closer to the transmitting antenna than depicted on Attachment 1.

8/ Part 77.27(b) defines ILS approach surface as a surface longitudinally centered on the extended centerline of an ILS runway beginning at each end of the primary surface and extending outward and upward at a slope of 50 to 1 for a horizontal distance of 10,000 feet and at a slope of 40 to 1 for an additional 40,000 feet. This surface is the width of the primary surface at the beginning and expands uniformly to a width of 16,000 feet at a distance of 50,000 feet from the end of the primary surface. The primary surface of Runway 11 was 1,000 feet wide and extended 200 feet beyond the threshold at each end of the runway.

9/ Paragraph 930(1) gives the dimensions for the final approach area as 50,000 feet long measured outward along the final approach course from a point 200 feet outward from the runway threshold, and 1,000 feet wide at that point expanding uniformly along the localizer course to a width of 16,000 feet at a point 50,000 feet from the beginning point.

2. ANALYSIS AND CONCLUSIONS

2.1 Analysis

The aircraft center of gravity was within allowable limits. Based on the aircraft performance capability, there was sufficient runway available for N97S to have landed under the conditions existing at Huntington at the time of the accident.

The crew was properly certificated and qualified for the flight. The aircraft had been maintained in accordance with existing company procedures and the Federal Aviation Regulations. The investigation disclosed no malfunction or failure in the aircraft structure, primary flight controls, or powerplants.

The Board reviewed the charter arrangements, operations specifications, and regulations governing the dispatch and conduct of this flight. Although the flight was conducted in accordance with the prescribed procedures, there is one area which is of concern to the Board. An equivalent level of safety for "off route" operations, of the type involved in this accident, is theoretically achieved by the increased landing minima applicable to such operations. However, the crew requirements for "off route" airport qualification do not require the same degree of qualification as that required for scheduled operations. The reason for this is that it would not be practical to require an actual entry into every possible "off route" airport, nor would it be practical to have on hand the approved pictorial display for every possible "off route" airport. Nevertheless, the Board believes that a more positive means for determining that a pilot is qualified to make an initial entry into an "off route" airport should be established by the FAA and the air carriers. The company's operations manual provides that all a pilot is required to do for qualification is to sign a flight release form indicating that he has studied and knows the items enumerated in FAR 121.445. By comparison, FAR 121.443, which applies to scheduled operations, requires that the pilot-in-command, before making his initial entry into an airport under IFR conditions, must demonstrate that he has adequate knowledge, by actual entry into that airport, by entry into a nearby airport, by synthetic trainer, or by use of approved pictorial displays.

There is no evidence in this case to indicate that the crew had not sufficiently familiarized itself with the Huntington airport, surrounding terrain, and the approach and landing procedures. At the same time, there is no way to assure that the crew had actual knowledge of the foregoing prior to departure, since they were not required to demonstrate positively such knowledge. Accordingly, the Board believes that the procedures should be revised to require that pilots demonstrate by some means (e.g., an oral or written test or examination other than signing the flight release) that they are familiar with the "off route" airport into which they will operate. 10/

The flightpath and profile (Attachment 1) show that the aircraft descended through the MDA approximately 2 miles from the end of the runway and that such descent was not corrected in time to avoid impact with the trees. The major thrust of the investigation was focused on uncovering the reason or reasons which might explain this descent.

The relatively stable descent depicted by the flight recorder altitude trace does not suggest that a loss of control or autopilot "runaway" was experienced during the approach. However, conversation between the pilots at approximately 1931 and 1934 expressed concern with the performance of the autopilot. The captain's comment at 1931, ("that thing captured! How did it capture?") expressed surprise that the autopilot had apparently captured a glide slope signal when there was no signal. The glide slope capture probably resulted because the captain turned the autopilot NAV SELECT switch to ILS rather than to either MAN G/P or NAV LOC, which should be used on a localizer approach. Since the autopilot controls the aircraft on the glide slope by maintaining a null signal, the total absence of a glide slope signal, as in this case, would have resulted in an automatic 700 to 800 feet/minute descent. Subsequent increases in the rate of descent indicate that the NAV SELECT switch was turned to a proper position. The later comment at approximately 1934, ("This autopilot ain't responding just right - - - - sluggish") indicates dissatisfaction with the performance of that component, but the captain did not specify in which axis, or in what manner, it was "sluggish." An analysis of heading and altitude traces of the flight recorder indicates that the autopilot was used to maintain a course inbound on the localizer and to descend the aircraft during at least two periods of the instrument approach. Notwithstanding the captain's comments, both of which were made while the flight was in the vicinity of the outer marker, there is no indication of any hazardous situation. Although the captain's attention to the operation of the autopilot to the extent reflected by these remarks could have detracted from his normal instrument scan, there is no evidence to suggest that the autopilot was misused or that it had any direct bearing on the accident.

10/ A recommendation to the above effect is set forth hereinafter, in the Recommendations section.

One area which the Board carefully considered is the extent to which the final stages of the descent were influenced by visual reference to lights on the surface. Conversation between the captain and first officer during the 10-second period preceding MDA passage indicates that they were beginning to see the lights on the ground, or at least the glow of the lights. It is possible that the sighting of these lights, in combination with the knowledge that they were approaching the bottom of the lowest cloud layer, could have induced the captain to continue the descent below MDA in order to see the runway environment at the earliest moment. The descent, in fact, did continue through this period, and ground witnesses observed the aircraft clear of clouds in this area.

It is also possible that the conduct of the approach could have been affected by a visual illusion produced by the difference in the elevation of the refinery and the airport. Approximately 2 miles from the runway, the flight was approaching the bright lights surrounding the refinery and, as noted above, the crew was discussing at least the glow, and probably fleeting glimpses, of ground lights through the broken clouds. As the descent continued, the opportunity for ground reference through scattered clouds would have increased. Below approximately 1,100 feet m.s.l., the reported cloud base, the only restriction to visibility should have been the fog, smoke, and light rain.

If the approach lights or sequence flasher lights were sighted while the refinery lights were still in the field of vision, with no appreciable lights between, the pilots would have mentally visualized both light sources at the same elevation as the nearer lights. Therefore, the height above both lights would appear to be about 700 feet, whereas the actual height above the approach lights would have been only 400 feet, due to the 300-foot difference in elevation between the refinery and the approach lights. After the aircraft passed the refinery, the preconceived image would have been retained and the visual cues would have told the crew that they were approximately 300 feet higher than desired.

The remaining evidence, however, strongly suggests that the crew never obtained visual contact with the approach lights or with any part of the runway environment. The visual illusion discussed above, for example, would have prompted an increase in the rate of descent, which significantly is not reflected on the flight data recorder. Even more important, there were no comments on the cockpit voice recorder pertaining to ground lights other than those mentioned as the aircraft passed over the refinery. If any lights associated with the runway environment had been sighted, it can be presumed that some mention of the sighting would have been made. Certainly, such a presumption is far more likely than the explanation that the runway environment was sighted, but that such sighting was either sufficiently obvious to negate the need for a callout or was indicated and acknowledged by nonverbal signals.

The recorded conversation also indicates that the crew was not aware that the aircraft had descended below MDA. The first officer's comment at 1935:06.8 ("We're two hundred above") is most logically construed as a reference to MDA. The following comment by the charter coordinator (Bet'll be a missed approach") can be taken to mean that the flight was approaching MDA, yet the runway environment was still not in sight. 11/ The next statement on the recorder ("Four hundred") most probably means that the aircraft had reached MDA, which is 400 feet above the airport elevation. Such an interpretation is consistent with the following remark of the captain ("that the approach?"), which indicates that he was asking, perhaps rhetorically, whether they had reached the farthest point to which the flight could legally descend. The first officer responded "Yeah," which again implies that the MDA had been reached and the runway environment was not in sight. The available evidence also indicates that a level off or missed-approach was then initiated. The swath cut through the trees, ground witness statements, and the flight recorder altitude trace all show that the descent was stopped, power was added, and a gradual climb was commenced. Furthermore, the first officer called out airspeed in terms of a number ("Hundred and twenty-six") instead of a reference speed ("bug plus---"), which is indicative of a go-around rather than a continuing approach.

In view of the foregoing, the Board concludes that the crew never sighted the runway environment and was not aware that the flight had descended through actual MDA.

From a study of the conversation and activities reflected by the voice recorder, it is apparent that, while the approach was conducted in a systematic manner, the crew deviated from some of the required procedures. With respect to required callouts, there was no mention that the gear was down and locked by either pilot. The first officer did not call 500 feet above the field elevation with a check of instrument flags, speed, and rate of descent as required on the Before Landing Final Checklist. There was a call, "We're two hundred above," but this did not preclude the required

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11/ Although the charter coordinator was not a pilot, it is likely that he would be familiar with the MDA altitude, due to previous conversations in the cockpit, and would also be able to read altitude from the cockpit instruments.

calls at 100 feet above minimums and at minimums, with a positive statement at the latter point as to whether or not the runway was in sight. Finally, there was no report that the rate of descent exceeded 1,000 feet/minute, although the rate of descent for the 10-second period prior to the level off was 1,350 feet/minute. 12/

Apart from the first officer's deviations with respect to callouts, the captain also deviated from prescribed procedures by failing to level off the aircraft at or above what he believed to be MDA. Thus, when the first officer called out "Two hundred above," the captain should have anticipated reaching MDA, and should have taken action to assure that the aircraft would be levelled off by the time the aircraft reached MDA. Instead, the captain did not start to rotate the aircraft until several seconds after the "Four hundred feet" callout, with the consequence that the aircraft sank an additional 90 feet before the descent was finally arrested. 13/

It is difficult to assess the impact of the above deviations on the descent of the flight below MDA. Although strict adherence to optimal approach procedures is of critical importance in executing a nonprecision approach under actual instrument conditions and might have made a difference in this instance, it nevertheless appears that the crew was aware of altitude, as reflected by the cockpit conversation, and in fact initiated a go-around when they believed they had reached MDA.

The remaining and critical question is why the descent through MDA was not recognized by the crew. After carefully studying the evidence bearing on this question, the Board is of the view that there are only two reasonably possible explanations.

The first of these possibilities is that the crew was using the barometric altimeters to determine their height above MDA and the vertical speed indicators to monitor the rate of descent during the approach, but that these instruments were providing erroneous information. It is

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12/ The standard procedure of selecting 25° flaps until the runway was in sight also was not followed, since the flaps were apparently lowered to 50° at the outer marker. However, this decision by the captain was basically sound, as demonstrated by the subsequent change in Southern's procedures.

13/ The flight recorder altitude trace reflected an altitude of 1,005 feet m.s.l. when the "Four hundred" callout was made, whereas, the initial impact with the trees occurred at 916 feet m.s.l.

possible that a static system error caused the barometric altimeter to read higher than the actual altitude of the aircraft and produced a decrease in the indicated rate of descent on the vertical speed indicator. In these circumstances, the pilot would reduce power and possibly lower the nose of the aircraft in order to regain the desired rate of descent. This in turn would result in the aircraft's being lower than indicated on the altimeter, and descending at a rate greater than that displayed on the vertical speed indicator.

The existence of an error such as that described above is consistent with certain indications on the flight data recorder. For example, there are several increases in the rate of descent recorded by the flight recorder during the final approach indicating that the captain may have been attempting to compensate for the lower-than-actual rate of descent. Since these descent rates were all in excess of 1,000 feet/minute, the absence of any required callout would support the premise that the vertical speed indicator was reflecting a rate of descent lower than the actual descent rate. Moreover, during the last 10 minutes of flight, there were two instances in which the flight recorder reflected descents which resulted in overshoots followed by gradual returns to the desired altitude. We recognize that these overshoots may have resulted from either the pilot's technique in the manual operation of his flight controls or the use of the aircraft autopilot. It is possible, however, that these overshoots could be symptomatic of a lagging of the aircraft instruments due to an error within the static systems. It is also conceivable that there could be an error in one or all static systems such that it would manifest itself while the aircraft was descending but not after levelling off. The first of these descents was 175 feet and resulted in an overshoot of 50 feet. The second descent, which occurred at 6 minutes 7 seconds before impact, was 575 feet with a resultant overshoot of 150 feet. Both of these overshoots were corrected by a gradual climb back to the desired altitude. The ratio of the amount of overshoot to the total descent is 0.286 and 0.261, respectively, or 26 to 29 feet for each 100 feet of descent. The final descent of 1,200 feet with an apparent overshoot of 318 feet results in an error ratio of 0.265 or 27 feet per 100 feet of descent, which closely parallels the error ratios of the two earlier overshoots.

With respect to physical evidence pertaining directly to the barometric altimeters, it appears that both were correctly set at 29.67, thereby eliminating any indicated error from that source. The displacement of the outer and inner drums, 600 feet and 3,000 feet for the captain's and copilot's barometric altimeters, respectively, was the result of impact forces' overcoming the light spring tension holding them in place. Since the drum assemblies of both altimeters were essentially identical, the variation in displacement is attributed to the difference in impact forces encountered.

Other damage to the internal mechanism of each barometric altimeter precluded positive determination of their operating capability prior to impact. Nevertheless, if the mark at the 1,250-foot point on the captain's altimeter drum was made at initial impact, the altimeter was reading 300 feet high. Similarly, the marking on the first officer's altimeter could be construed to indicate an error of approximately 300 feet. To place the significance of these markings in proper perspective, however, it should be noted that tests conducted subsequent to the accident demonstrated that the 300-foot difference could have been caused by impact forces.

Finally, evidence supportive of an altimeter error can be derived from the cockpit voice recorder. During the final stages of the descent, the first officer made four altitude callouts. All of these callouts except the first, which was made by reference to the ground, were approximately 200 feet higher than the actual altitude of the aircraft as reflected by the flight data recorder. 14/ Since the barometric altimeter is the primary source of altitude information, it would be reasonable to assume that these callouts were made by reference to that instrument.

The foregoing discussion constitutes one possible explanation for the unrecognized descent through MDA by demonstrating how an error in the static system could mislead the pilots by causing erroneous indications on the barometric altimeters and the vertical speed indicators. If such an error did, in fact, occur, then the altimeter would have read 200-300 feet high, which in turn would account for the fact that the crew did not arrest the descent until the aircraft reached an altitude of approximately 916 m.s.l. or over 300 feet below MDA.

There is one remaining factor which must be considered in evaluating the likelihood of an error in the static system instruments. Since an error in the static system would also affect the indicated airspeed, the Board calculated the effect of a static system error sufficient to cause an indicated altitude error of approximately 300 feet. The calculation assumed that a static pressure difference existed between ambient and that sensed by the altimeter so that when the altimeter indicated 1,240 feet, the actual altitude was 916 feet. By use of a calibrated airspeed of 130 knots 15/ and the

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14/ For a comparison of these altitudes, see the chart set forth below on page 29.

15/ The figure of 130 knots was selected since the evidence confirms that the airspeed instruments were indicating speeds of that magnitude. The captain stated that he was going to fly the [Footnote continued]

United States Standard Atmosphere Table, pressure ratios were determined and applied to the existing QNH 16/ for the altitudes 1,240 and 916 feet. The pressure required at the Pitot head to generate an indicated airspeed of 130 knots at 1,240 feet was also calculated.

It was then assumed that the aircraft descended to 916 feet and that the static system continued to sense a static pressure equivalent to 1,240 feet, and the pilot controlled his aircraft so as to maintain an indicated airspeed of 130 knots. This would require a constant Pitot system pressure. With these conditions, it was found that at 916 feet, when the indicated airspeed was maintained at 130 knots, the actual airspeed would have been 100 knots. 17/

Inasmuch as an actual speed of 100 knots is very close to the stalling speed of the aircraft in the landing configuration, it is highly unlikely that such a condition would escape the notice of the pilots. It is therefore significant that no mention of any such problem was made during the approach. The accuracy of the airspeed instruments is further verified by the time taken to fly from the outer marker to the point of impact. In view of the above, the Board concludes that both the indicated and actual airspeeds were in the area of 130 knots during the approach.

The only explanation which would reconcile an inaccurate barometric altimeter with an accurate airspeed indicator is that there was an error in the Pitot system which roughly offset the error in the static system. The Board, however, is not aware of any phenomenon, atmospheric or otherwise, which could produce such an offsetting error, nor was there any evidence thereof uncovered during this investigation. In this connection, it should be noted that long-term research is underway to determine whether flight and weather conditions can lead to misinformation from instruments connected

[Footnote continued] approach at 130 knots, and the first officer's callouts were within ± 7 knots of that figure. This approximate value was also recorded by the airspeed trace on the flight data recorder.

16/ QNH is the altitude above sea level based on station barometric pressure.

17/ The above calculations are set forth in detail in Appendix E. As further calculated in that appendix, a static system error which would cause a 200-foot altimeter error would produce a corresponding airspeed error of -17.5 knots (i.e., when the airspeed indicator read 130 knots, the actual airspeed would be 112.5 knots).

to the static system. But until this or other efforts produce positive evidence of a phenomenon which could cause offsetting errors of the type discussed above, the Board cannot conclude that a static system error is supported by sufficient evidence to be termed a causal factor in this accident.

The second reasonably possible explanation for the unrecognized descent below MDA is that the first officer was using the radio altimeter as the primary source of altitude reference, and the crew was thereby misled into believing the aircraft was higher than it actually was because the ground surface in the approach area is at some points substantially lower than the field elevation. 18/ Support for this theory can be derived from an analysis of the altitude callouts on the cockpit voice recorder. There were at least four references to altitude after the flight passed the outer marker inbound. Since the crew had no way of determining the elevation of the terrain below them, the values could have been either read directly from the radio altimeter or calculated mentally by subtracting the field elevation from the barometric altimeter reading. The following tabulation shows (1) the first officer's callout, (2) the flight recorder indication, (3) the terrain elevation at that point, (4) the calculated radio altimeter reading, based on the flight recorder altitude minus the terrain elevation, and (5) the flight recorder altitude reading minus the field elevation (828 feet).

Callout (a.g.l.)	Flight Recorder (m.s.l.)	Terrain (m.s.l.)	Calculated Radio Altimeter (m.s.l.)	Calculated Barometric minus Field Elevation (a.g.l.)
1,000 feet	1,842 feet	600 feet	1,242 feet	1,014 feet
ay, ah, 700	1,330	500	780	502
200 above (612 feet)	1,224	530	694	396
400 feet	1,005	690	315	177

Any reliance on these figures must include recognition of their limitations. The computed flightpath of the aircraft may be affected by such

18/ The radio altimeter, unlike the barometric altimeter, indicates the height of the aircraft above the terrain over which the plane is flying.

variables as winds aloft and flight recorder accuracy. Any lateral adjustment to the flightpath may change the height of the aircraft above the hilly terrain. The time correlation between the flight recorder and cockpit voice recorder may not be exact and could alter the analysis. The individual delay, anticipation, or approximation in each of the callouts could have some bearing on the tabulation. Finally, there is no way of determining whether those variables which could be involved would offset each other or would be cumulative. However, with respect to the tolerances, the aircraft was apparently flying parallel to a 600-foot contour line at the time of the 1,000-foot callout, and the flightpath would have to be shifted approximately 350 feet horizontally before a difference of 100 feet in the terrain clearance would be indicated on a radio altimeter. The second and third callouts occurred when the flight was near the flat terrain of the riverbed and the flightpath would have to be shifted approximately 700 feet horizontally before the terrain clearance would appear to change 100 feet. When the final callout was made, the flight was crossing perpendicularly to a steep ridge which rises sharply to an elevation of approximately 700 feet on the east bank of the river. The flightpath must be shifted at least 400 feet horizontally before a change of 100 feet would be indicated in the terrain clearance. 19/

Analysis of the tabulation suggests that all but the initial callout of "A thousand feet above the ground . . ." could have been made with reference to the radio altimeter, but even it was couched in terms generally associated with the radio altimeter. The readings that would derive from subtracting the field elevation from the barometric altimeter reading are consistently about 200 feet low, and assuming that the barometric altimeter was accurate, the first officer would have been reporting different values if he had been using that method. On the other hand, the altitude values derived by reference to the radio altimeter are all within 100 feet of the altitudes reported by the first officer. Moreover, the final exclamation recorded prior to the commencement of the sound of impact ("HUNDRED") accords with the altitude which would have been reflected by the radio altimeter at that time and therefore is further evidence that the first officer may have been using that instrument during the approach. 20/

Southern's training program distinguished between the use of radio

19/ It is not possible to determine accurately the aircraft position longitudinally on the flightpath when a radio altimeter reading might have been made that resulted in an altitude call.

20/ It is also possible that the word "HUNDRED" was not a reference to altitude, but rather was the first part of an airspeed callout.

altimeters in instrument approaches over level and irregular terrain. However, the Southern Airways DC-9 Operating Manual did not make such a distinction, but rather accentuated its use for all instrument approaches by stating that, "Two separate radio altimeter systems . . . are provided to obtain precise altitude information above the ground at the minimum decision [sic] altitude (MDA). This information is essential to the pilot in his decision to land or initiate a go-around maneuver." Notwithstanding the fact that the crew may have been formally trained to use the radio altimeter as a secondary reference, the tabulation comparing the available altitude references indicated that the first officer may have relied on the written material and was using the radio altimeter for altitude information.

If the first officer was making altitude callouts by reference to the radio altimeter, as hypothesized above, the remaining question concerns the extent to which the captain relied upon, and was misled by, such callouts. Sound operating procedures dictate that the captain should have been using his barometric altimeter during the approach, and therefore should have been aware of the disparities between altitudes reflected by that instrument and the first officer's callouts. Why these disparities were apparently not detected by the captain is difficult to explain. It is possible that he, like the first officer, was relying on his radio altimeter. A second possibility is that he was not using his barometric or radio altimeter, but rather was relying solely on the first officer for altitude information. Finally, he may have been including his barometric altimeter in his instrument scan, but was concerned with other items during the final stages of the approach to such an extent that he did not notice any variations.

On the other hand, there are several weaknesses to the theory that the radio altimeter was being used for altitude information. First, and perhaps most important, the radio altimeter is not intended for use during an approach over unknown or uneven terrain, and it is therefore difficult to accept that qualified, experienced pilots would resort to that instrument in conducting the approach at Huntington. The theory also assumes an unlikely dual human failure in that the captain was either also using his radio altimeter or did not recognize the differences between the barometric altimeter and the altitude information called by the first officer and was relying on the latter. Finally, the rates of descent between the calls of "Seven hundred feet," "Two hundred above," "Four hundred," and rotation, if made from reference to the radio altimeter, do not correspond to the rates of descent recorded by the flight data recorder for the same periods.

This variation is demonstrated in the following calculations. By using the terrain elevation established by the flightpath analysis for the position of the aircraft at the time the reference calls were made, and adding these calls to that elevation, the following tabulation shows (1) the first officer's callout, (2) the flight recorder indication, (3) terrain elevation, and (4) the altitude, if a radio altimeter was being used (terrain plus the callout).

Callout	Flight Recorder	Terrain Elevation	Terrain Plus Callout
700 feet	1,330	550	1,250
200 above	1,224	530	1,130
400	1,005	690	1,090
Rotation prior to tree impact	925	891	

Based on the above points, the following rates of descent would be required:

Between Calls		Rates of Descent (feet/minute) Flight Data Recorder	Rates of Descent (feet/minute) Terrain Plus Callouts
"700 feet" to "200 Above"	(5.2 seconds)	1,155	1,386
"200 Above" to "400"	(9.4 seconds)	1,184	1,053
"400" to point of rotation	(2 seconds)21/	1,286	2,789

It is noted that the rates of descent calculated for the flight recorder data are in an increasing pattern and relatively close to the overall rate described by the flight recorder. The rates of descent based on the calculated radio altimeter callouts show close correlation for the initial two callouts, but in the final segment the descent rate is approximately double the overall rate.

After carefully weighing the conflicting points set forth above, the Board concludes that the theory under consideration -- namely, that the unrecognized descent through MDA was the result of using the radio altimeter

21/ Analysis of aircraft performance data, the flight data recorder, and the cockpit conversation leads to the conclusion that the aircraft was rotated approximately 2 seconds after the callout of 400 feet.

for altitude reference -- is not supported by sufficient evidence to be termed a causal factor in this accident.

One final matter, airport facilities, warrants comment. Many of the circumstances of this accident are typical of the approach/landing accidents that occur during nonprecision approaches. As a result, the Board examined the environmental conditions that existed in this case to determine what aids would have assisted the pilot in making a nonprecision approach.

The terrain under the approach path was irregular with numerous hills of varying heights. There were few lights along the approach path excepting those of the refinery which were to the right of the inbound track. The lower clouds were ragged and the restrictions to visibility included darkness, rain, fog, and smoke. The pilot had his barometric altimeter, vertical speed indicator, airspeed indicator, and radio altimeter to aid him in establishing the desired descent profile. However, the pilot had little, if any, information instantly available to him regarding the elevation and character of the terrain below the aircraft or the flightpath related thereto.

External navigational aids used to provide vertical guidance to a pilot during an instrument approach include Precision Approach Radar (PAR), ILS glide slope, and VASI system. There was no PAR installed at Huntington nor was the installation of one under consideration. The FAA policy was to provide VASI systems primarily where no other electronic guidance was either planned or available. Since Huntington had been actively negotiating for a glide slope since 1957 no VASI system was installed. In this case, the VASI system would have been useful if the pilot had been able to see the first 1, 500 feet of the runway. However, if the pilot had not visually acquired contact with that much of the runway he would not have been able to use the VASI system for vertical guidance.

It is also possible that the nonstandard glide slope which was installed subsequent to the accident might have prevented this accident in that the pilot would have been provided with a primary electronic indication of his position relative to the desired glide path. This cross-check against the altimeter information available would have alerted the crew to any discrepancy between the intended and actual descent. Additionally, if the aircraft remained on the glide slope, it would have arrived at the MDA approximately 2, 500 feet closer to the hill where initial impact occurred, and it would have had to descend at an unusually steep angle of about 10° to strike the trees from that point.

In view of the apparent success of the nonstandard glide slope at Huntington, it is unfortunate that such an installation was not made sooner. However, the experience gained with this installation should provide a basis for possible application to other airports where standard installation criteria cannot be met without major construction.

2.2 Conclusions

(a) Findings

(1) The pilots were properly certificated and qualified to conduct this flight.

(2) The aircraft was certificated and maintained in accordance with the existing FAA rules and company procedures, and was properly equipped for the intended flight.

(3) The flight was conducted in accordance with the provisions of FAR 121.445 and with company procedures applicable to "off route" charter flights.

(4) The charter arrangements between Southern Airways, Inc. and Marshall University were adjusted and the aircraft was loaded within the operational capability of the aircraft.

(5) The carrier used the same aircraft, pilots, dispatches, flight planning services, and supervising personnel in this operation as they used in their regularly scheduled service.

(6) The flight release to the Huntington airport anticipated that the runway would be wet, and was predicated on the availability of sufficient runway as required by FAR 121.195(b).

(7) The aircraft weight and center of gravity were within limits for the intended landing at Huntington.

(8) The runway length at the Huntington airport was adequate for the intended landing, under the existing circumstances.

(9) The instrument approach aids at Huntington, which provided lateral but not vertical guidance to the runway, were operating properly at the time of the accident.

(10) The airport lighting system, which included high intensity approach lights, sequence flashers, and high intensity runway lights, was in operation and properly set at the time of the accident.

(11) The minima for this approach (minimum descent altitude of 1,240 feet m.s.l. and minimum visibility of 1 mile) were the same as those prescribed for any nonscheduled flight into Huntington. These minima were adequate for the intended operation.

(12) The weather reported at the field at the time of the accident was 300 feet scattered, measured 500 feet variable broken ceiling, 1100 feet overcast, visibility 5 miles in light rain, fog, and smoke; however, the weather in the approach area was worse.

(13) The investigation disclosed no malfunction or failure in the aircraft structure, primary flight controls, or powerplants.

(14) There was no physical evidence of a defect or contamination in the static system tubing or ports; a static system error is extremely unlikely unless there was an offsetting error in the pitot system.

(15) The captain was using the autopilot throughout the approach and there was no evidence of a significant autopilot malfunction.

(16) Based on the recorded cockpit conversation, the crew was familiar with the approach procedures at Huntington and with the MDA on the approach being flown.

(17) The crew deviated from the optimal approach procedures in several respects; however, the effect of this deviation on the accident cannot be assessed inasmuch as the cockpit conversation indicated the crew had altitude awareness.

(18) The flight descended through the MDA of 1,240 feet m.s.l. approximately 2 miles from the end of the runway and the descent continued for over 300 feet before the crew initiated a missed approach or go-around.

(19) The copilot's call of "Four hundred" is construed to mean that an altimeter indicated that the aircraft was at the MDA.

(20) The crew was unaware that the aircraft had descended through the actual MDA.

(21) The crew sighted the glow from the refinery lights during the approach, but never obtained visual contact with any part of the runway environment.

(22) The probable reason for the unrecognized descent through MDA cannot be determined; the two most likely explanations are (a) an error in the static system which caused the barometric altimeters to indicate a figure higher than the actual altitude, or (b) reliance by the crew on the radio altimeter as a primary altitude reference while executing an approach over uneven terrain.

(23) The accident might have been prevented if there had been available the nonstandard glide slope which was installed at a later date.

(b) Probable Cause

The National Transportation Safety Board determines that the probable cause of this accident was the descent below Minimum Descent Altitude during a nonprecision approach under adverse operating conditions, without visual contact with the runway environment. The Board has been unable to determine the reason for this descent, although the two most likely explanations are (a) improper use of cockpit instrumentation data, or (b) an altimetry system error.

3. RECOMMENDATIONS

Although the Safety Board has been unable to determine the probable reason for the unrecognized descent below MDA in this instance, the Board wishes to reiterate its concern with the general problem of landing and approach accidents and to reemphasize its interest in the various preventive measures which might prove useful in reducing the rate of these kinds of accidents. There is a need for all segments of the aviation industry to continue to focus attention on the unique demands for crew coordination and vigilance during nonprecision approaches. Area navigation systems, now in the final proving stages of development, will apparently provide descent guidance capability within the aircraft and should be standard equipment on all future transport category aircraft. The retrofitting of aircraft in the inventory should be expedited as much as possible.

The Safety Board also notes and supports the FAA in its issuance of Air Carrier Operations Bulletin No. 71-9 which emphasizes the common faults noted in nonprecision approaches and proposes several recommendations to eliminate these faults. (See Appendix F.)

In view of the foregoing, the Safety Board recommends that:

1. All segments of the aviation industry continue to focus attention on the unique demands for crew coordination and vigilance during nonprecision approaches. Particular emphasis should be placed on the accelerated development of area navigation systems with vertical guidance capability and on heads-up display systems.

The Board, on February 13, 1968, supported a Notice of Proposed Rule Making which would require the installation of an altitude warning device for turbojet powered civil airplanes. The basis for this support, cited in the letter, was a series of aircraft accidents involving air carrier aircraft that had been involved in controlled crashes into the ground or water. Of the five accidents cited, three occurred during the final approach to landing. In the other two cases, the aircraft were descending in preparation for an approach and landing.

On January 17, 1969, writing with reference to accidents which occur during the approach and landing phase of flight, the Board recommended, among other things, the development and installation of audible and visual altitude warning devices and the implementation of procedures for the use of such devices. The FAA response to this recommendation was to cite its rule making dated September 1968, which required the installation of altitude alerting devices in all turbo powered civil aircraft. This device would provide both aural and visual indications to warn pilots when they approach selected altitudes during climbs, descents, and instrument approaches. However, the Board has found that this device as installed and operated does not provide any information regarding the aircraft proximity to the ground during the final approach phase of a landing approach.

On November 10, 1971, in an aircraft accident report, NTSB-AAR-71-14, the Board recommended that a ground proximity warning device be developed for use during the approach and landing phase of flight. The Board further recommended that appropriate operating procedures be developed and implemented.

The Administrator's response to this recommendation stated in part: ". . . With respect to the recommendation to develop a ground proximity warning system for use during approach and landing, we believe the present instruments and procedures are safe and adequate. This presupposes that proper cockpit disciplines are maintained . . . We are, however, reassessing our system requirements for nonprecision straight-in approach systems with a view to providing additional assistance to the pilot in the form of accurate position information which will make his evaluation of the visual approach segment less susceptible to human error . . ." (See Appendix G.)

Finally, on February 25, 1972, Board Report NTSB-AAR-72-4 contained a recommendation that the Administrator require all air carrier aircraft to be equipped with a functional ground proximity warning device in addition to the barometric altimeters. The Administrator's response continued to support the earlier position quoted above. (See Appendix G.) In addition, the FAA advised the Board that they were developing new criteria which they proposed to apply to nonprecision approaches. One criterion involves establishing a final approach descent fix. This fix would be located at a point on the final approach from which a normal descent path of approximately 3° from MDA to touchdown could be commenced, provided the required visual reference was established. Pilots would be required to maintain an altitude at or above the MDA until passing this descent fix. Another criterion the FAA proposed will be to provide VASI for each runway served by a nonprecision approach. The VASI will provide vertical guidance at normal descent rates for the visual segment of the approach.

The Board believes that these two items will aid in preventing accidents that occur during nonprecision approaches and believes that these proposals are timely and appropriate. The Board also urges the FAA, wherever physically possible and within the limits of available resources, to convert approaches from nonprecision to precision at qualified airports through the installation of an ILS. In this connection, even the installation of a nonstandard glide slope, such as the one currently in use at Huntington, is a substantial improvement in the aids available to a pilot in making his approach descent.

With regard to the Administrator's response to our recommendation that he reevaluate his position regarding the installation and use of ground proximity warning devices, the Board notes that the decision is based on the assumption that "proper cockpit disciplines are maintained." We have found in several cases of this type that cockpit disciplines were disrupted by unusual actions or events and the crew was distracted from its task of monitoring the aircraft altitude. We believe that a ground proximity warning device would serve to bring the crew's attention back to the altimeters as the aircraft approached preselected altitudes during an instrument approach. Therefore, the Board again recommends that:

2. The Administrator evaluate the need for the installation and use of ground proximity warning devices on air carrier aircraft.

After consideration of the airport qualifications established by FAR 121.443 and 121.445, the Board concludes that the requirements of 12.445 are less specific than those in 121.443. The Board believes that Part 121.445, or the carrier procedures promulgated thereunder, could be more specific, particularly in the manner by which the pilot is required to show that he has the requisite knowledge. Therefore, the Board recommends that:

3. The FAA continue to emphasize the importance of the provisions of Part 121.445 in its surveillance and inspection of flight operations under Part 121. Such emphasis is needed to assure that these operators are (1) using the best means available to enable pilots to qualify under 121.445, and (2) requiring pilots to show that they have acquired the requisite knowledge prior to completion of a flight release.

Finally, the Board wishes to acknowledge and express continuing support for the long term Static Pressure Measurements Project undertaken by the National Aeronautics and Space Administration at the Lewis Research Center. The Board believes that these tests and similar efforts by other organizations will provide significant data on the flight and weather conditions which might lead to static system contamination and altitude misinformation, a subject which is invariably raised in connection with landing and approach accidents. The Board therefore urges that such testing be expedited and will await with anticipation the results thereof, which hopefully will shed some light on an area that has too many unknowns.

BY THE NATIONAL TRANSPORTATION SAFETY BOARD:

/s/ JOHN H. REED
Chairman

/s/ OSCAR M. LAUREL
Member

/s/ FRANCIS H. McADAMS
Member

/s/ LOUIS M. THAYER
Member

/s/ ISABEL A. BURGESS
Member

April 14, 1972

INVESTIGATION AND HEARING

1. Investigation

The Board received notification of the accident at approximately 2025 on November 14, 1970, from the Federal Aviation Administration. An investigating team was immediately dispatched to the scene of the accident. Working groups were established for Operations, Air Traffic Control, Weather, Witnesses, Human Factors, Structures, Systems, Powerplants, Maintenance Records, and Flight and Voice Recorders. Interested parties included the Federal Aviation Administration; Southern Airways, Inc.; Douglas Aircraft Division; McDonnell-Douglas Corporation; Air Line Pilots Association; and Pratt & Whitney Division, United Aircraft Corporation. The on-scene investigation was completed on November 23, 1970.

2. Hearing

A public hearing was held at Huntington, West Virginia, on December 14 - 16, 1970. Parties to the Investigation included the Federal Aviation Administration; Southern Airways, Inc.; Douglas Aircraft Division, McDonnell-Douglas Corporation; and Air Line Pilots Association. The hearing was reconvened June 23 - 25, 1971, in Washington, D. C.

3. Preliminary Reports

A summary of the testimony which was taken at the first public hearing was published by the Board on January 25, 1971. An additional summary was released on July 28, 1971.

Crew Information

Captain Frank H. Abbott, Jr., aged 47, was employed by Southern Airways, Inc., on July 21, 1949. He held airline transport pilot certificate No. 507765 with ratings in DC-3, DC-4, DC-9 and M-202/404, and commercial privileges in single-engine land airplane. He also held a flight instructor certificate with airplane and instrument ratings. He had accumulated approximately 18,557 total flying hours, including 2,194 hours in the DC-9. He completed his last proficiency check on October 14, 1970, and his FAA first-class medical certificate was issued on October 22, 1970, with the limitation that the holder shall wear correcting lenses while exercising the privileges of the certificate.

First Officer Jerry R. Smith, aged 28, was employed by Southern Airways, Inc., on April 12, 1965. He held commercial pilot certificate No. 1581568 with airplane single-engine land and instrument ratings. He had accumulated approximately 5,872 total flying hours, including 1,196 hours in the DC-9. He completed his last proficiency check on July 14, 1970, and his FAA first-class medical certificate was issued on November 5, 1969, without limitations. It was still valid as a second-class medical certificate at the time of the accident.

Captain Abbott and First Officer Smith had rest periods of approximately 20 and 18 hours, respectively, prior to reporting for duty for this operation. At the time of the accident, both had been on duty five hours, of which two hours, 21 minutes, were flight time.

Stewardess Pat Vaught was employed by Southern Airways, Inc., on June 11, 1962. Her last recurrent training was completed on October 21, 1970.

Stewardess Charlene Poat was employed by Southern Airways, Inc., on March 28, 1964. Her last recurrent training was completed on October 22, 1970.

Aircraft Information

N97S, a McDonnell-Douglas DC-9-31, was delivered to Southern Airways on June 20, 1969. It had been flown a total of approximately 3,667 hours prior to the accident. Pratt & Whitney JT8D-7 engines were installed as follows:

Position	Serial No.	Total Time	Total No. Cycles
1	P-657140D	5,030.8	8,473
2	P-657297D	4,533.9	8,120

The aircraft weighed 95,795 pounds 8/ at takeoff and the center of gravity (c.g.) was 18.4 percent MAC. The maximum allowable weight limits were 97,344 pounds for takeoff (based on runway length) and 93,254 pounds for landing on a wet runway at Hungtington. The c.g. limits were 6 percent MAC and 32 percent MAC. The computed landing weight was 89,235 pounds with a c.g. of 17.12 percent MAC. In accordance with company procedures, the actual weights of the passengers were used in the computation of total passenger weight.

The actual stopping performance for the DC-9-30 was computed by DACO for the following conditions: (1) landing weight 89,235 pounds, (2) field elevation 828 feet, (3) runway wet and gradient zero, (4) threshold speed 126 knots and contact speed 1.25/1.30 times threshold speed, (5) temperature 49°, (6) 80 percent worn tires, and (7) both engines at maximum continuous reverse thrust until 60 knots and then 1.2 EPR reverse thrust. Corresponding landing distances were also computed, assuming touchdown 1,000 feet from the start of the runway.

Tailwind (knots)	0	3	5
Stopping Distance	2,634	2,686	2,712
Landing Distance	3,634	3,686	3,712

8/ This weight is based on the actual operating weight of the aircraft, rather than the published aircraft operating weight. Consequently, it is slightly higher than the 95,263 pounds computed by the crew.

TRANSCRIPTION OF COCKPIT VOICE RECORDER TAPE -- DOUGLAS DC-9, N97S, HUNTINGTON, WEST VIRGINIA, NOVEMBER 14, 1970, DCA 71-A-5

LEGEND

%	-	Break in continuity
CAM	-	Cockpit area microphone sound source
RDO	-	Radio transmission from N97S
-1	-	Voice identified as captain
-2	-	Voice identified as first officer
-3	-	Voice identified as additional crewmember
-?	-	Voice unidentified
HTS	-	Huntington Approach Control
IND	-	Indianapolis Center
*	-	Unintelligible word or phrase
( )	-	Words within parentheses are subject to further interpretation
CRW	-	Charleston Tower

TIME	SOURCE	CONTENT
1916:59.9	RDO-1	Charleston Tower, this is Southern nine thirty-two.
	CRW	Southern nine thirty-two, Charleston Tower.
	RDO-1	We're going over to Huntington, we passed just south of Charleston. What kind of weather you got down there now?
	CRW	Charleston weather estimated ceiling six thousand broken, visibility four, ground fog and smoke.
	RDO-1	What's your spread?
	CRW	Temperature five zero, dew point four nine.
	RDO-1	Thank you.
	RDO-1	Look like it's going to hold up a while?
	CRW	Sure thing.
	CAM-2	Sounds like a gal.
	CAM-1	It is.
	CAM-1	Broken up here at Charleston.

TIME	SOURCE	CONTENTS
	CAM-2	Yeah, it's gotten a lot better. Maybe it's gotten better over here, it's not too far away.
		% % %
	CAM-1	You might try it again.
	RDO	Sound of tuning of ADF.
		% % %
1919:00.2	RDO-2	Southern nine thirty two out of eleven thousand five hundred.
		% % %
	CAM-1	Approach plate's two years old.
	CAM-2	Yeah * * * *
	CAM-2	On these charter kits they don't keep those things up like they're supposed to.
	CAM	Sound of laughter.
	CAM-1	How many miles you got to Pulaski?
	CAM-2	About to run out * * *
	CAM-2	It's pointing that way, Frank. Can't get a code on it, though.
	CAM-1	Let's run the rest of the in-range check.
	CAM-1	How many miles you got on it? I can't * * * it's gone off.
	CAM-2	Yeah, it's gone off.
	CAM-2	(Bugs) one two three.
	CAM-1	Put Charleston on yours * * *
	RDO-1	Center, Southern nine thirty two.
1921:57.3	IND	Southern nine thirty two, descend and maintain five thousand, say again.

TIME	SOURCE	CONTENTS
1922:02.7	RDO-2	Okay, Southern nine thirty-two, we're out of eight now, we're going to five, and approximately how far do you show us from the Huntington Airport?
1922:09.7	IND	Nine thirty-two approximately twenty miles southeast of Huntington Airport.
	RDO-2	Roger.
	IND	Southern nine thirty two squawk zero four zero zero, contact Huntington Approach Control one two zero point niner, radar service terminated.
	RDO-2	One two zero point nine, good day sir.
	CAM-1	Here we go.
	RDO-2	Huntington Approach, Southern nine thirty-two, we're descending to five thousand.
	HTS	Southern nine thirty two, Huntington Approach Control, you're cleared for an approach, correction, you're cleared for a localizer one one approach, the surface wind's favoring runway two nine, wind three five zero degrees at six, altimeter two nine six seven, report leaving five thousand. I'll give you the weather shortly.
	RDO-2	Okay, we got the altimeter and we'll check with you leaving five thousand, we plan on approach to one one.
	HTS	Roger.
	RDO	Sound of ILS localizer identification.
	HTS	Southern nine thirty-two, the Huntington weather three hundred scattered, measured ceiling five hundred variable broken, one thousand one hundred overcast, visibility five, light rain, fog, smoke. Ceiling ragged, variable four to six hundred.
	CAM-?	Phew!
	RDO-2	Very well, thank you sir.
	CAM-1	Very well!

TIME	SOURCE	CONTENT
	CAM	Sound of laughter.
	CAM-1	Very well?
	CAM-2	Four hundred and twelve.
	CAM-1	Yeah, and a mile visibility.
	CAM-2	He said the visibility was * *
	CAM-2	I'll ask him again.
	RDO-2	What's your visibility again?
	CAM-1	* * * and twenty-six hundred from all directions.
	HTS	Visibility five, light rain, fog, smoke.
	RDO-2	Right.
	CAM-1	Right on the --------- right on the minimums * * *
	CAM-1	See if you can get that thing tuned in a little bit better, sort of wavering.
	CAM-2	All right.
1924:15.7	RDO-2	Southern nine thirty two is out of five.
	HTS	Out of five, report outer marker outbound.
	RDO	Sound of ILS outer compass locator identification.
	CAM-2	Localizer is one oh nine nine, ---- one fourteen inbound.
	CAM-1	Wonder how many miles it is to Kanawha?
	CAM-2	Stand by.
	CAM-2	Charleston's not but about fifty miles.
	CAM-1	You got Charleston set on yours?
	CAM-2	Charleston's set on * * * about thirty * * *
	CAM-1	Damn close.

TIME	SOURCE	CONTENT
	CAM-2	Ought to be getting pretty damn close 'cause he gave us twenty miles right back there. That's been four or five minutes.
	CAM-2	You're getting slant ---- slant range on it.
	CAM-2	* * *
	CAM-2	Marker's identified.
		% % %
1926:24.5	CAM-2	Forty-two DME. How many you got?
	CAM-1	Thirty-seven.
	CAM-1	Coming over middle marker.
1926:43.1	CAM-2	Middle marker there.
	CAM-3	Frank, you want full fuel load out of here?
	CAM-1	Might as well.
	CAM-2	Minimum is nineteen ---- wonder how much they'll charge us?
	CAM-3	Well, we get contract price, whatever that is, whatever we pay for it.
	CAM-2	We got a mile or two to go, Frank, 's all.
	CAM-?	Yeah.
	CAM-1	We're showing on the localizer.
	CAM-3	Hope we don't have this all the way in. It's rough.
1927:58.9	CAM-2	There she is.
	RDO-2	Southern nine thirty two, we're over the marker now, proceeding outbound.
	HTS	Southern nine thirty-two, roger, report the marker inbound.
		(Note: Underlined words above and below spoken simultaneously)
	CAM-1	Slats and five.

TIME	SOURCE	CONTENT
	RDO-2	Very well.
1928:11.0	CAM-1	Slats and five.
1928:35.6	CAM-1	(From the) lights on the ground (it looks like) fog.
	CAM-2	Makes it sorry, doesn't it?
	CAM-1	You checked the missed approach?
	CAM-2	All right, you pull up to twenty-seven hundred feet by the east course of the ILS to Shoals, Shoals Fan Marker, report Shoals then straight out * * *
	CAM-?	*
	CAM-1	*
	CAM-2	Sound of laughter.
	CAM-2	Well, I don't know.
1930:03.0	CAM-2	(I believe) half those lights should be off to our left. Kinda hard to say, though.
1930:43.6	CAM-1	We're in a rainshower, all right.
	CAM-2	Yeah, I know it.
1930:49.6	CAM-1	We sure are. The temp (is dropping).
	CAM-2	Yeah, ah, that rain is (mixed) in with fog.
	CAM	Sound of windshield wipers commences.
	CAM	Sound of landing gear in transit commences
	CAM-2	Okay, you got the no smoking, ignition, radar standby, auto shutoff armed, waiting on the gear ----- got the spoilers?
	CAM-1	Armed.
	CAM	Sound of click similar to that of arming spoilers.
	CAM-2	Checked, out.
1931:26.2	CAM-1	That thing captured! How did it capture?

TIME	SOURCE	CONTENT
	CAM-2	Yeah, it ought to.
	CAM-1	You getting a glide slope capture and you ain't got a glide slope.
	CAM-?	*
	CAM-2	I might capture on the, ah, on ILS, ah, Frank, regardless of glide slope. I don't have no capture, though.
1931:49.8	CAM-1	Okay, give me, ah, twenty-five *
	CAM-2	Yeah, it's good, it's got the capture.
	CAM-?	*
	CAM-1	I got it cut off there now.
	CAM-2	Got twenty-five flaps, all is squared.
	CAM-1	We ought to be over the outer marker at twenty --- two hundred feet *
	CAM-2	Yeah.
	CAM-3	I'm sorry, Frank.
	CAM-1	You going to call out minimums?
	CAM-2	Yeah, I sure will. I'll sing 'em out to you.
	CAM-2	As you get on down it, ah, this rough air ought to give us a little break.
	CAM-1	Well, if it's like he said, it's not blowing any harder than he says it is, why ----
	CAM-2	Down draft.
	CAM-1	It took us down to the marker level.
	CAM-?	Yeah, that's enough.
	CAM-?	Yeah.
1933:17.9	CAM-1	Must be a little rainshower.
1933:19.9	CAM-2	Back in the soup.

TIME	SOURCE	CONTENT
	CAM-1	Jerry, I'm going to be flying about one thirty.
	CAM-2	I'm going to check the time for you. It'll be about two minutes from the, ah, outer marker *
1933:43.4	RDO	Sound of outer marker begins.
1933:47.9	RDO	Sound of outer marker ceases abruptly.
	RDO-2	Southern nine thirty-two the marker inbound.
	CAM-?	*
	HTS	Southern nine thirty-two is cleared to land. You can advise on the lights, the wind is now three four zero degrees seven.
1933:59.1	CAM	Sound similar to click of flap selector.
	RDO-2	Okay, the lights be good about step three, I guess.
	HTS	Roger, that's where they are, with the rabbit. Advise when you want them cut.
	RDO-2	Very good.
1934:09.2	CAM-2	On the bug.
	CAM-3	* rough.
	CAM-1	This autopilot ain't responding just right ---- sluggish.
	CAM-2	Yeah.
	CAM-1	Might catch up.
	CAM-2	Okay, I got the time for you.
1934:32.4	CAM-2	A thousand feet above the ground, rate and speed good.
	CAM-2	Speed a little fast, looks good, (1934:45.2) got bug and twelve.
1934:55.4	CAM-1	See something?

TIME	SOURCE	CONTENT
	CAM-2	No, not yet. It's beginning to lighten up a little bit on the ground here at, ay, ah, (1935:01.6) seven hundred feet.
1935:03.2	CAM-2	Bug and five.
1935:06.8	CAM-2	We're two hundred above.
1935:10.6	CAM-3	Bet 'll be a missed approach.
1935:18.2	CAM-2	Four hundred.
1935:19.3	CAM-1	That the approach?
	CAM-2	Yeah.
1935:21.3	CAM-2	Hundred and twenty-six.
1935:25.7	CAM-2	HUNDRED
1935:26.5	CAM	Sounds of impact begin.
1935:32.5		End of recording.

EFFECT OF STATIC SYSTEM RESTRICTION OR BLOCKAGE ON AIRSPEED INDICATION

The magnitude of the error in indicated airspeed which will exist as a result of a static system pressure error is calculated for two assumed values of indicated altitude error.

Condition 1:

The nonstandard day QNH altimeter setting is 29.67 inches Hg. The altitude of the aircraft is 916 feet m.s.l. (which corresponds to altitude of initial impact). The indicated altitude is 1,240 feet m.s.l. (which corresponds to the published minimum descent altitude).

If this error is a result of a pressure difference between ambient and that measured within the aircraft static system, the corresponding indicated airspeed error is found as follows:

The airspeed indication is based upon the following equation:

$$q_c = P_t - P_a = P_{asl} \left[1 + 0.2 \, (V_c/a_{sl})^2 \right]^{3.5} - P_{asl} \qquad (1)$$

Where: q_c = differential pressure, inches Hg.

P_t = free stream total (Pitot) pressure, inches Hg.

P_a = ambient (static) pressure, inches Hg.

P_{asl} = standard day sea level pressure, 29.921 in. Hg.

V_c = calibrated airspeed, knots

a_{sl} = sea level speed of sound, 661.48 knots

Substituting V_c = 130 knots into equation (1) yields

q_c = .8168 in. Hg.

or $P_t = P_a + .8168$ in. Hg. (2)

From the United States Standard Atmosphere Table:

P_a/P_{asl} for 1,240 feet m.s.l. equals .9560

For a nonstandard day when QNH = 29.67 in. Hg.

P_a for 1,240 feet m.s.l. = .9560 x 29.67 = 28.364 in. Hg.

Also P_a/P_{asl} for 916 feet m.s.l. equals .9673

For the same nonstandard day:

P_a for 916 feet = .9673 x 29.67 = 28.700 in. Hg.

Thus for the airspeed indicator to read 130 knots when the static system senses a pressure of 28.364 in. Hg. (1,240 feet), the Pitot system pressure must be (from eq. 2)

$$P_t = P_{a_{1,240}} \div .8168 = 28.364 \div .8168$$

$$P_t = 29.1813 \text{ in. Hg.}$$

Assuming that the aircraft now descends to 916 feet m.s.l. and the static system continues to sense a pressure equivalent to 1,240 feet m.s.l. (28.364 in. Hg.), if the pilot controls the aircraft so that his airspeed indicator continues to read 130 knots, the Pitot system pressure P_t must also remain constant (29.1813 in. Hg.).

To determine the actual aircraft velocity, i.e., the airspeed that would be indicated if the static system was sensing the correct pressure corresponding to 916 feet (28.700 in. Hg.), find q_c:

$$P_t = 29.1813 \text{ in. Hg.}$$

$$P_{a_{916}} = 28.700 \text{ in. Hg.}$$

or $$q_c = P_t - P_{a_{916}} = 29.1813 - 28.700$$

$$q_c = .4813 \text{ in. Hg.}$$

Substituting into eq. (1) and solving for V_c yields:

V_c = 100 knots

Thus for conditions stated, the actual velocity of the aircraft would be 100 knots, an error of -30 knots.

Condition 2:

For the same nonstandard day, QNH altimeter setting equal 29.67 inches Hg., the actual velocity of the aircraft is calculated for a corresponding altitude error of 200 feet.

From equation (1) above, for V_c = 130 knots

q_c = .8168 in. Hg.

P_a/P_{asl} for 1,240 feet m.s.l. equals .9560

$P_{a_{1,240}}$ = 28.364 in. Hg.

From the United States Standard Atmosphere Table:

P_a/P_{asl} for 1,040 feet m.s.l. equals .9629

For the QNH = 29.67 in. Hg. condition:

P_a for 1,040 feet = .9629 x 29.67

$P_{a_{1,040}}$ = 28.570 in. Hg.

From condition (1) above:

$P_t = P_{a_{1,240}} + .8168 = 28.364 + .8168$

P_t = 29.1813 in. Hg.

Assuming that the aircraft descends to 1,040 feet m.s.l. and the static system continues to sense a pressure equivalent to 1,240 feet m.s.l. (28.364 in. Hg.), if the pilot controls the aircraft so that his airspeed indicator continues to read 130 knots, the actual aircraft velocity is found as follows:

$$P_t = 29.1813 \text{ in. Hg.}$$

$$P_{a_{1,040}} = 28.570 \text{ in. Hg.}$$

or $$q_c = P_t - P_{a_{1040}} = 29.1813 - 28.570$$

$$q_c = .6113 \text{ in Hg.}$$

Substituting into eq. (1) and solving for V_c yields:

$$V_c = 112.5 \text{ knots}$$

Thus for conditions stated, the actual velocity of the aircraft would be 112.5 knots, an error of -17.5 knots.

AIR CARRIER OPERATIONS BULLETIN NO. 71-9

SUBJECT: Training Emphasis on Non-Precision Approach Procedures and Interpretation of Low Visibility Weather Reports.

Recent air carrier accidents which occurred during non-precision approaches pin point the need for action to improve this type of operation. A study was initiated sometime back with a goal to examine existing criteria and make recommendations for changes to criteria. The study group must determine if improvements can be made which will aid the pilot in making a decision to descend below MDA during a non-precision approach. Meanwhile, there is a need to reemphasize training in non-precision approaches as well as improving the knowledge and understanding of the implications of reported low visibility weather.

Accident investigators from the NTSB and inspectors from the Washington Office have questioned air carrier pilots about the meaning and implication of reported obscuration in weather sequences. The pilot response reflected inadequate knowledge of the subject. Of particular interest is the fact that partial obscuration is described in the remark section and can be anything from 1/10 to 9/10 coverage and still be considered partial. The implication of a 7/10 or 8/10 obscuration is that a pilot could reasonably expect to encounter restrictions to visibility as he descends from a position below cloud level toward the runway environment. However, pilots questioned were not aware of this because they did not relate the remarks information to the obscuration.

In view of the lack of knowledge on the part of the pilots interviewed, operations inspectors should assure that training programs adequately cover weather sequences and interpretations that may be made from the low visibility data supplied on the weather sequence.

The FAA Academy has prepared a paper on non-precision approaches which contains excellent material to assist in upgrading the professionalism required during a non-precision approach. The material is reproduced in part as follows:

THE NON-PRECISION INSTRUMENT APPROACH
—— MORE PRECISION IS NEEDED ——

The ability to conduct the non-precision approach in a professional manner has given way in large part to the computed and automated approaches; i.e., flight director and autocoupled approaches. The instrument pilot of today is being trained in a manner which emphasizes the philosophy of the precision

ILS approach to Category I, II and III procedures and weather minima, but de-emphasizes the basic non-precision instrument approach procedures. His training no longer stresses the need for precise timing, closely controlled rates of descent, thorough knowledge of the procedure, and the basic skills and techniques of using the raw data information displayed in the cockpit. As a result, he has become in far too many cases, something less than a professional in conducting the non-precision approach.

What can be done to reverse this trend? One way would be to re-emphasize the need to know and practice the basic skills and techniques associated with the non-precision approach. Another could be to recognize the need for more precision during the so-called non-precision approach. Even a name change for this type procedure(s) may be in order. Perhaps we should stop using the philosophy of non-precision and face up to the need for standards that all phases of flight should be based upon precision and professionalism. Still another area in the conduct of non-precision approach has to do with the attitude, cockpit discipline and crew coordination of the flight crew. Recent events strongly indicate a widespread lack of appreciation for the importance of these factors. Substandard attitude, discipline and coordination are apparent to the degree that many approaches are being flown in a hit-or-miss fashion rather than in a disciplined by-the-book procedure. The results in far too many instances have been making newspaper headlines. This area in particular is in great need of added emphasis.

In addition to the preceding points, more operational knowledge of the construction of the non-precision approach as spelled out in the TERPS Handbook 8260.3A, is needed. Such things as obstruction clearances, descent gradients, final course alignment criteria, and the primary boundaries of the approach segments are need-to-know factors for the professional airman.

What are some of the shortcomings and common faults frequently noted in the execution of non-precision approaches?

1. Failure to conduct comprehensive briefing on the approach procedure and techniques to be used.

2. Failure to execute the procedures as published; i.e., cutting the procedure short, especially when the initial phase is on top of the restriction to visibility. This corner cutting carries over into the final approach phase where all at once everything piles up and the crew is not always equal to the task.

3. Failure to cross-check altimeters and other flight instruments during the initial and final approaches.

4. Using procedures and techniques which give the pilot too much to do at the start of the final approach segment; i.e., checking the final approach fix passage; calling for gear down and before landing

checklist; calling for approach or landing flaps as appropriate; commencement of timing if required; commencement of the required descent rate; establishment of correct airspeed; etc., - at least six things which must be accomplished in short order. Experience has shown that one or more of these items are often unintentionally delayed or forgotten, usually to the degradation of the overall quality of the approach.

5. Failure to tune and properly identify the approach facility(s).

6. Failure to precisely note FAF passage.

7. Failure to commence timing at the FAF.

8. Failure to promptly commence a properly controlled and correct rate of descent so as to arrive at MDA in a position to sight the runway environment and continue a <u>normal</u> approach to a landing so as to avoid excessively high rates of descent at any point during the final approach segment.

9. Inattention to the details of the task at hand; e.g., conversation and actions concerning unrelated and irrelevant things.

10. Opposite corrections to tail ADF bearings.

11. Poor quality of ADF maintenance and upkeep; e.g., the oft-heard remark that, "the ADF is no good in the modern jets," when all it likely needs is to be written up and carefully repaired.

12. Lack of appreciation or knowledge for the different scale values of the localizer and VOR as displayed on the Course Indicator.

13. Failure to carry out proper crew coordination procedures. Especially, when the copilot is flying the Captain often fails to execute the normal copilot functions and duties.

14. Not staying on instruments; i.e., both pilots looking out for the runway threshold rather than one staying on instruments and the other cross-checking and looking out for the runway environment.

15. Inattention to precise course interception, and cross-checking on secondary instruments.

16. Failure to level off <u>at</u> or slightly <u>above</u> MDA.

17. Persistence in continuing a substandard approach rather than promptly executing the missed approach. There seems to be a strong-feeling false pride against executing a missed approach.

18. Not using a stabilized approach concept.

19. Not preplanning how to conduct the approach so as to fly the airplane through the window (key point) at MDA approximately one mile from the runway threshold.

20. Not striving for a high degree of accuracy and precision in the conduct of the non-precision approach.

21. Not giving due consideration to the possible adverse effect of remote-source weather and altimeter setting information.

RECOMMENDATIONS.

1. Emphasize the need for more discipline, crew coordination and precision in the various non-precision approaches.

2. Develop new and more specific crew-concept procedures for all non-precision approaches similar to the procedures being used on the full ILS approaches. Following are some examples which apparently are appropriate.

   a. Complete in-range checklists and comprehensive instrument approach briefing prior to initiating the approach. Careful calculation of final approach ground speed.

   b. Extend landing gear and approach flaps and complete before-landing checklist after intercepting inbound course and prior to FAF passage. Establish altitude at the minimum recommended value so as to avoid subsequent high rates of descent.

   c. Use established altimeter, flight instrument and warning flag cross-check procedures just prior to the FAF.

   d. Note FAF passage, start timing and promptly commence pre-determined rate of descent. Set landing flaps if appropriate.

   e. Make altitude and course deviation callouts during final descent.

   f. Carefully monitor timing and descent so as to arrive at or slightly above MDA prior to the KEY POINT (Normally one mile from the runway threshold). The KEY POINT may be determined by timing (usually 30 seconds prior to MAP), by DME, by cross bearing, or other type fix.

   g. POSITIVELY monitor MDA limits and do not descend below until the runway environment is in sight and the airplane is in position for a NORMAL approach to a landing. Assuming a HAT of 300' to 400', this should occur at the KEY POINT and approximately one mile from the threshold.

Abandon the approach and execute the missed approach procedure if the approach is substandard or if g. above is not possible. It is NOT necessary to carry out the timing to the final MAP.

3. Consider revising the instrument procedures and approach plate display by establishing a KEY POINT FIX (KPF), approximately one mile from the threshold or farther out where MDA and visibility minima are above standard. The fix may be determined by DME, MM, NDB, intersection, or by timing.

4. Calculate and display on approach plates the timing from FAF to the Key Point Fix (KPF).

5. Calculate and display on approach plates the recommended rate of descent required on final approach to reach MDA at or before the KPF.

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NATIONAL TRANSPORTATION SAFETY BOARD
DEPARTMENT OF TRANSPORTATION
WASHINGTON, D.C. 20591

January 17, 1969

Mr. David D. Thomas
Acting Administrator
Federal Aviation Administration
Department of Transportation
Washington, D. C. 20590

Dear Mr. Thomas:

Accidents which occur during the approach and landing phase of flight continue to be among the most numerous. They are again highlighted by some of the events of the past month that have aroused nationwide interest in air safety. Most approach and landing accidents have been attributed to improper operational procedures, techniques, distractions, and flight management. In many cases vertical/horizontal wind shear, forms of turbulence, and altimetry difficulties were, or could have been contributing factors. The phenomenon of breaking out into visual flight conditions and subsequently becoming involved in patches of fog, haze, rain, blowing snow and snow showers and other visibility obscuring forms of precipitation seems to be fairly common occurrence. The sensory illusion problem associated with night approaches over unlighted terrain or water is another likely factor about which more is being learned daily.

Other related factors are the handling characteristics of our transport type aircraft in day-to-day operations, the absence or outage of glide slope facilities, cockpit procedures, possible effects of snow or rain on dual static port systems as they could affect altimetry accuracy, and altitude awareness. These are all factors which may exist singularly or in combination. The inability to detect or obtain positive evidence, particularly such evidence as ice accretion or moisture which becomes lost in wreckage, makes it difficult, if not impossible, in many cases to reach conclusions based upon substantial evidence. It is clear that had all ground and airborne navigational systems been operating accurately and had the flight crews been piloting with meticulous reference to properly indicating flight instruments, these accidents would not have occurred.

In this light, and with the number and frequency of approach and landing phase accidents under similar weather and operating environments, we believe that certain immediate accident prevention measures need to be taken. We believe that preliminary to the successful completion of our investigations into the factors and causes of the recent rash of accidents, renewed attention to, and emphasis on recognized good practices will tend to reduce the possibilities of future accidents.

Pilots, operators and the regulatory agencies should renew emphasis on -- and improve wherever possible -- cockpit procedures, crew discipline, and flight management. It is recommended that both the air carrier industry and the FAA review policies, procedures, practices, and training toward increasing crew efficiency and reducing distractions and nonessential crew functions during the approach and landing phase of the flight. It is specifically recommended that crew functions not directly related to the approach and landing, be reduced or eliminated, especially during the last 1000 feet of descent. Accomplishment of the in-range and landing check lists as far as possible in advance of the last 1,000-foot descent will allow for more intense and perhaps more accurate cross checking and monitoring of the descent through these critical altitudes.

It is also recommended that during the final approach one pilot maintain continuous vigilance of flight instruments - inside the cockpit - until positive visual reference is established.

In order to induce a renewed altitude awareness during approaches where less than full precision facilities exist, it is recommended that there be a requirement that during the last 1000' of final approach the pilot not flying call out altitudes in 100-foot decrements above airport elevation (in addition to airspeed and rate-of-descent). To further enhance altitude awareness within the cockpit, it is recommended that there be a requirement to report indicated altitude to Air Traffic Control at various points in the approach procedure such as the outbound procedure turn and at the outer marker position.

Consistent with and in support of the concept inherent in your Notice of Proposed Rulemaking No. 67-53, the Board urges the aviation community to consider expediting development and installation of audible and visible altitude warning devices and the implementation of procedures for their use. Additional improvements, although desirable now, are attainable only through continued research and development.

The reassessment of altimetry systems with particular regard to their susceptibility to insidious interference by forms of precipitation needs to be the subject of attention by the highest level of aeronautical research facilities and personnel. Toward this end, we are meeting with members of your staff, the National Aeronautics and Space Administration and various segments of the aviation community to initiate an assessment of possible failure modes and effects within the static system.

The possibility of development of additional altitude warning systems - external to the aircraft -needs to be explored by the aviation community. One such possibility would be a high intensity visual warning red light beam - projected up along and slightly below the desired approach glide slope - to warn of flight below the desired path.

Likewise, development is needed in the fields of radio/radar, and inertial altimetry and CRT/microwave pictorial display approach aids as possible improved replacement of the barometric altimetry system in the near future.

Modified use of existing approach radar should be further studied with regard to its adaptability as a surveillance--accident prevention--tool for nonprecision instrument approach.

During the time that we press for answers as to the causes of a number of these recent accidents, the Board urges increased surveillance, more frequent and more rigorous inspection and maintenance of altimetry systems by both the air carrier operators and the FAA; and urges also that the FAA reexamine certification requirements and procedures to determine if there is a possibility of a single failure mode of nominally dual systems which, when combined with an already existent passive failure or inadequate cockpit procedures, can invalidate dual failure protection features.

Whereas these problems have been highlighted by air carrier accidents, they should not be construed as being unique to air carrier aviation. The Safety Board considers that they are applicable to all forms of air transportation.

We know that your Administration, as well as other responsible segments of the aviation community, have been working extensively in all of these areas.

We appreciate your continuing emphasis on the safety of air carrier operations as evidenced by recent communications with your inspectors and airline management.

Your views regarding the implementation of our suggestions will be welcome.

Sincerely yours,

Joseph J. O'Connell, Jr.
Chairman

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

WASHINGTON, D.C. 20590

OFFICE OF
THE ADMINISTRATOR

FEB 6 1969

Honorable Joseph J. O'Connell, Jr.
Chairman, National Transportation Safety Board
Department of Transportation
Washington, D.C. 20591

Dear Mr. Chairman:

I have your letter of January 17, 1969, which contained suggestions and recommendations for the prevention of accidents during the approach and landing phase of flight.

My letter of January 28, 1969, commented on a number of the items covered in your January 17 letter. Therefore, I will not repeat them here, except to reiterate that our immediate concern and followup actions are directed to the areas of adherence to established procedures, altitude awareness, winter operating procedures, and cockpit discipline and vigilance.

Our comments concerning the matters discussed in your letter are as follows:

1. Reduce distractions and non-essential crew functions during approach and landing. Instructions to our inspectors require them to review on a continuing basis cockpit check lists and procedures to assure that minimum checking will be done during the more critical periods of flight such as departures, approaches, and landings.

2. Use of in-range and landing check lists. We believe the airlines require all cockpit check procedures, particularly the in-range check list, to be completed well before the last 1,000 feet of descent. However, we will request our inspectors to doublecheck and take action where warranted.

3. Cockpit vigilance. The instructions to our inspectors referred to in item 1 above also require them to assure that cockpit check procedures are arranged so that the pilot flying devotes full attention to flight instruments. As stated in my letter of January 28, 1969, crew vigilance and cockpit discipline is one of the areas stressed in my wire to the airline presidents.

4. Altitude awareness. Over two and one-half ($2\frac{1}{2}$) years ago, instructions were issued to our inspectors to be sure the airlines emphasized in training and included in company manuals altitude awareness procedures to be used during climbs, descents, and instrument approaches. This is one of the areas on which we asked our inspectors to place emphasis during the accelerated inspections mentioned in my January 28 letter.

Your letter recommended that during the last 1,000 feet of the final approach the pilot not flying be required to call out altitudes in 100 foot increments. The altitude awareness procedures that we have asked the carriers to adopt require the pilot not flying to call out, during the final 1,000 feet of the approach, 500 feet above field elevation, 100 feet above minimums, and minimums. We believe this procedure is preferable, since it serves to keep cockpit conversation to a minimum and at the same time, assures pilot altitude awareness. This procedure also reduces pilot workload.

5. Pilot reports to ATC of altitudes during instrument approaches. Adoption of this suggestion would significantly increase frequency congestion and increase crew and controller workload. We believe our efforts in the areas of pilot training and education will prove to be the most beneficial course of action.

6. Altitude alerting devices. I appreciate your support of the rule which became effective on September 28, 1968, which will require by February 28, 1971, both visual and aural altitude alerting signals to warn pilots of jet aircraft when approaching selected altitudes during climbs, descents, and instrument approaches.

7. Altimetry systems. With respect to your suggestion that an assessment be made of possible failure modes of altimeter static systems, we plan to participate with NASA and the aviation industry to assist in such a program. Development and testing to validate such improvements will be required. At this time, we know of no practical replacement for the barometric altimeter.

8. Additional altitude warning systems. Your suggestion concerning visual glide path warning would not provide complete information concerning the optimum glide path as does the Visual Approach Slope Indicator (VASI) systems which are installed at many runways throughout the country. We plan to continue to install these systems in accordance with current criteria within the limits of funds appropriated for this purpose.

9. Development to replace barometric altimeter systems. The use of inertial altimetry could be investigated, but must be considered as a long range R&D program. CRT/microwave pictorial display (radar mapping) has been evaluated by the military as an additional approach aid monitor. The FAA as yet does not have detailed information, since this equipment, until recently, was classified. However, we plan to obtain additional information and will look into the matter further.

10. Modified use of existing approach radar. I would appreciate receiving from you additional details on the modified use you had in mind, so that we can more properly evaluate and respond to your suggestion.

11. Inspection and maintenance of altimeter systems. On January 29, 1969, representatives of our Flight Standards Service met with ATA's Engineering and Maintenance Advisory Committee to review and discuss altimetry problems. The airlines are monitoring the operation of these systems and reviewing their maintenance procedures. ATA advised us at this meeting that few troubles are being experienced or reported by the flight crews. This is confirmed by our analysis of the MRR reports. Nevertheless, ATA has agreed to reactivate its Altimetry and Static System Maintenance Subcommittee to further explore this area and intends to review and update material previously published on this subject.

12. Certification of altimeter systems. On August 16, 1968, we issued a Notice of Proposed Rule Making proposing revisions to Part 25 of the Federal Aviation Regulations to require in systems design means to assure continued safe operation following any single failure or combination of failures not shown to be extremely improbable. Industry comments are now being reviewed and analyzed.

Your interest in these problems is appreciated and I can assure you we will continue to press for solutions to them.

Sincerely,

D. D. Thomas

D. D. Thomas
Acting Administrator

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

SOUTHERN AIRWAYS, INC.
DOUGLAS DC-9-15, N92S
GULFPORT, MISSISSIPPI
FEBRUARY 17, 1971

REPORT NUMBER: NTSB-AAR-71-14

RECOMMENDATIONS

The Board finds that altitude alerting equipment now installed on air carrier aircraft is not used as a ground proximity warning device which has been previously recommended and, therefore, the Board recommends that the Federal Aviation Administration:

1. Develop a ground proximity warning system for use in the approach and landing phases of operation which will warn flightcrews of excessive rates of descent, unwanted/inadvertent descent below Minimum Descent Altitudes, or descent through Decision Height. It would be desirable if the equipment now installed could meet this need; and

2. Develop and implement appropriate operational procedures to provide this type of warning to flightcrews for use during the approach and landing phase of flight.

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

OFFICE OF
THE ADMINISTRATOR

15 NOV 1971

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

Dear Mr. Chairman:

This is in response to the recommendations contained in Report Number NTSB-AAR-71-14, an aircraft accident report concerning a Southern Airways DC-9 at Gulfport, Mississippi, on 17 February 1971 and referred to in your letter dated 3 November 1971.

With respect to the recommendation to develop a ground proximity warning system for use during approach and landing, we believe the present instrumentation and procedures are safe and adequate. This presupposes proper cockpit disciplines are maintained. On this flight the Captain stated that during the approach he read the altimeter at 300 feet. The voice recorder transcript shows the Captain called 150 feet and advised the copilot who was flying the aircraft to "bring it up." The report brings out that the radar altimeter was set for 400 feet and the yellow warning light was observed by the pilot. We believe the pilot was well aware that he was below the Minimum Descent Altitude (MDA). We fail to see how a ground proximity warning could have contributed further to what we believe was already known.

We are, however, reassessing our system requirements for nonprecision straight-in-approach systems with a view to providing additional assistance to the pilot in the form of accurate position information which will make his evaluation of the visual approach segment less susceptible to human error.

With respect to the recommendation to have operational procedures to provide ground proximity warning, the agency has, for many years, had an altitude awareness program. Operators develop and publish in their manuals company procedures to insure altitude awareness during approaches. Southern Airways did have such a procedure, but it was not followed during the approach in question. Additionally, as the nonprecision straight-in-approach system is revised we will consider new or additional procedures to implement the system.

2

With respect to the recommendation to commission the full ILS at Gulfport, grading needed to solve the siting problem is being accomplished by the sponsor. We expect the system to be commissioned in early 1972.

Sincerely,

(signed) K. M. Smith
Acting Administrator

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

WASHINGTON, D.C. 20590

OFFICE OF
THE ADMINISTRATOR

15 MAR 1972

Notation 650

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

Dear Mr. Chairman:

This is in response to the recommendations contained in your Report Number AAR-72-4, an aircraft incident report, involving a Northeast Airlines, Inc., DC-9 at Martha's Vineyard, Massachusetts, on 22 June 1971.

As you state these recommendations parallel those regarding the Southern Airways DC-9 accident at Gulfport, Mississippi. Our position in this regard is the same as stated in our letter of 15 November 1971 concerning the Gulfport accident. We believe that current instrumentation and procedures are safe and adequate assuming that proper cockpit disciplines are maintained. In this incident, as in the Southern accident, according to your reports the company altitude awareness and callout procedures for nonprecision approaches were not followed. Thus, it appears that if these procedures had been followed, the incident would not have happened.

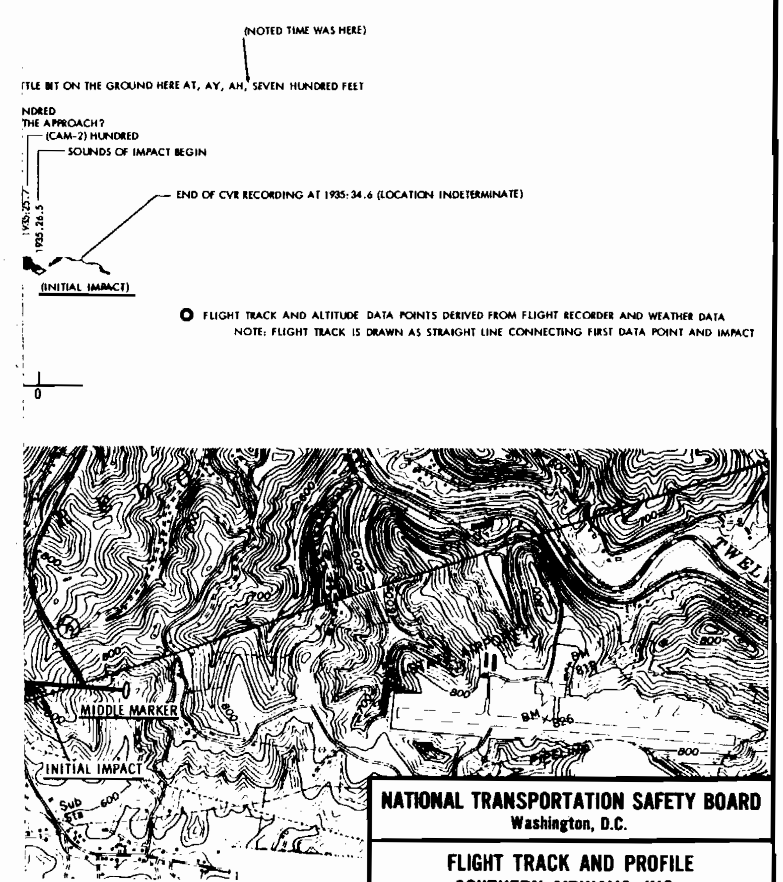
Nevertheless, we have reassessed our system requirements for straight-in nonprecision approaches and are developing new criteria which we propose to be applied to these type approaches. One criterion which we are working on involves establishing a final approach descent fix such as a fan marker or other suitable facility for each straight-in nonprecision approach procedure. This descent fix would be located at a point on the final approach from which a normal descent path of approximately 3° from MDA to touchdown can be commenced, provided the required visual reference is established. The pilot would be required to maintain an altitude at or above the MDA until passing the descent fix. Another criterion which we propose will be to provide VASI for each runway served by this type approach. The VASI will provide visual vertical guidance at normal descent rates for the visual segment of the approach. These new criteria should result in a greater degree of altitude awareness throughout the procedure.

Sincerely,

J. H. Shaffer
Administrator

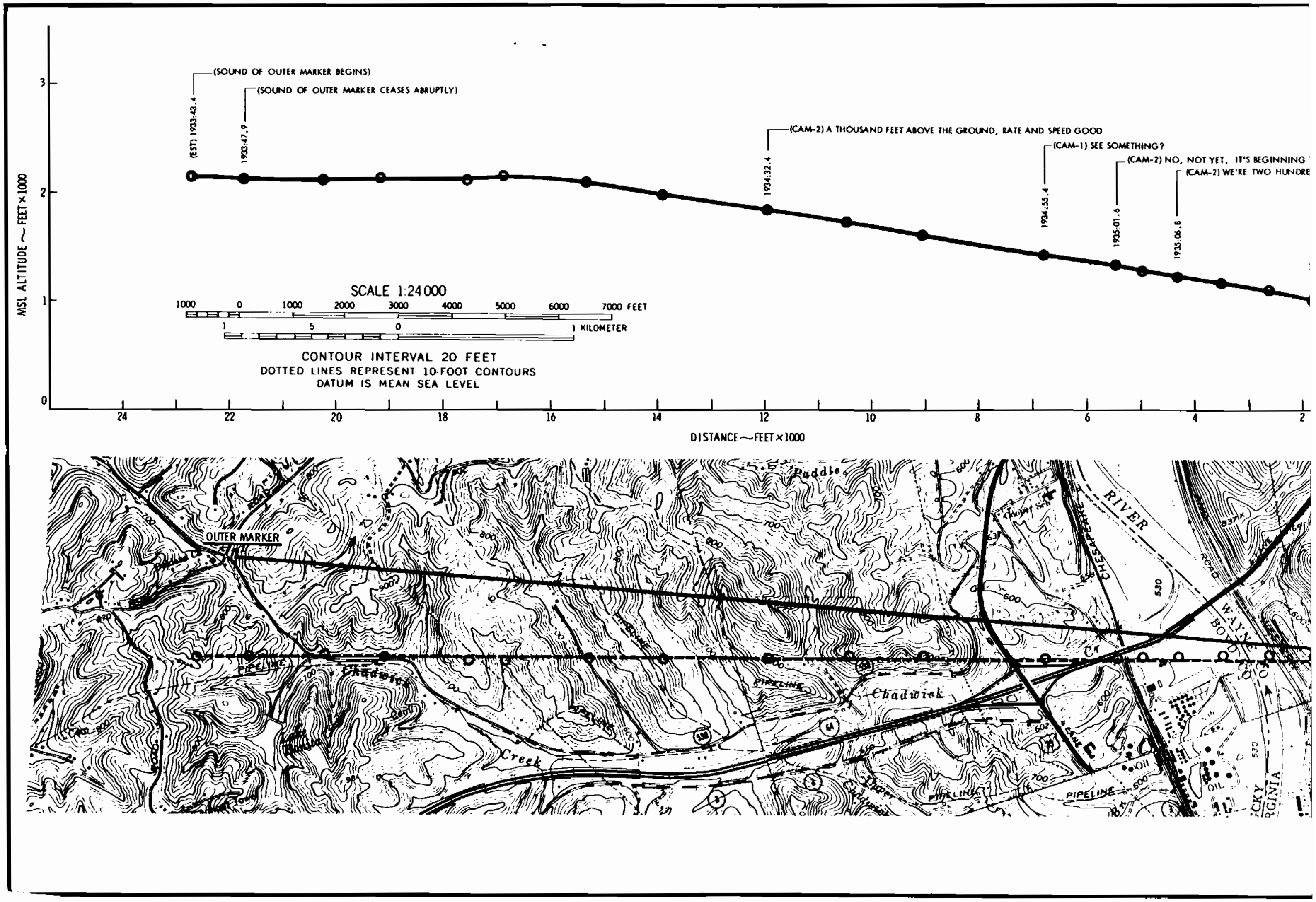
U.S. GOVERNMENT PRINTING OFFICE: 1972 721-491/750 1-3

ATTACHMENT 1

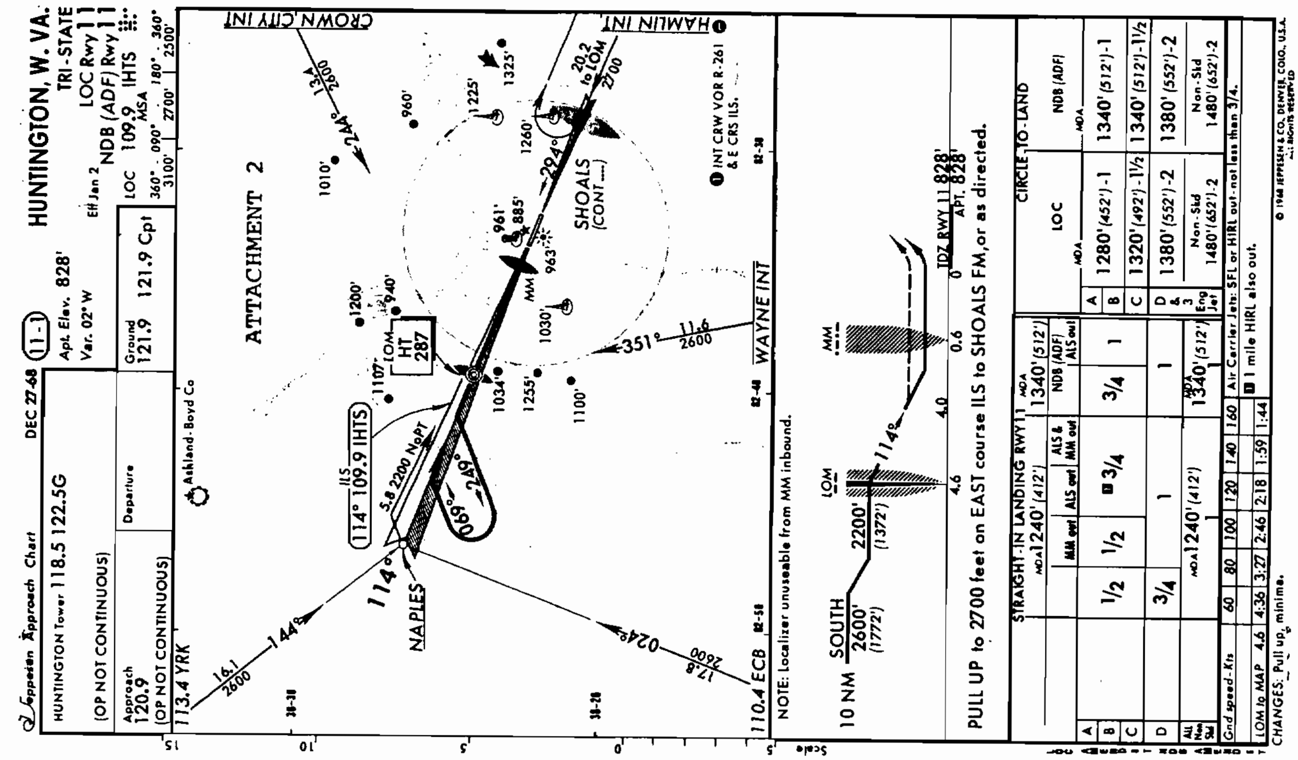


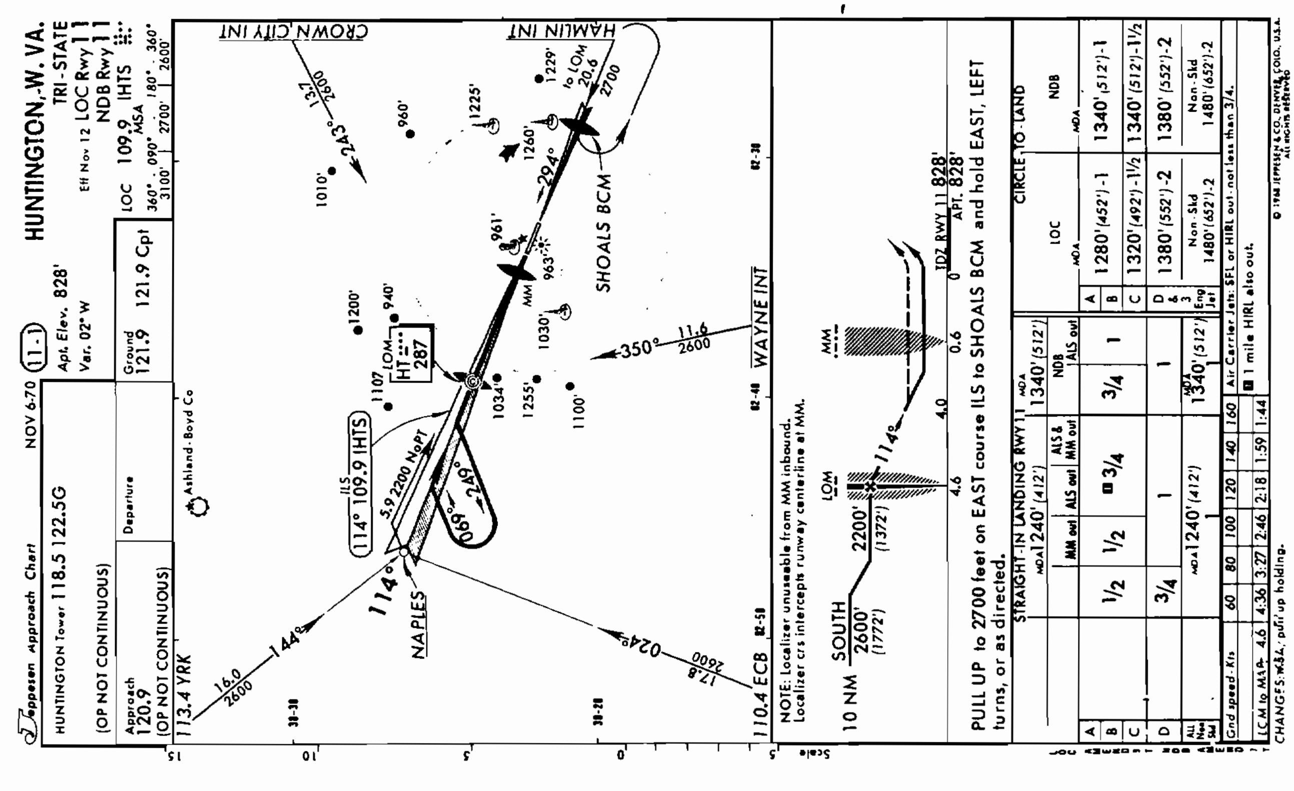
NATIONAL TRANSPORTATION SAFETY BOARD
Washington, D.C.

FLIGHT TRACK AND PROFILE
SOUTHERN AIRWAYS, INC.
DC-9-31, N97S
HUNTINGTON, WEST VIRGINIA
November 14, 1970

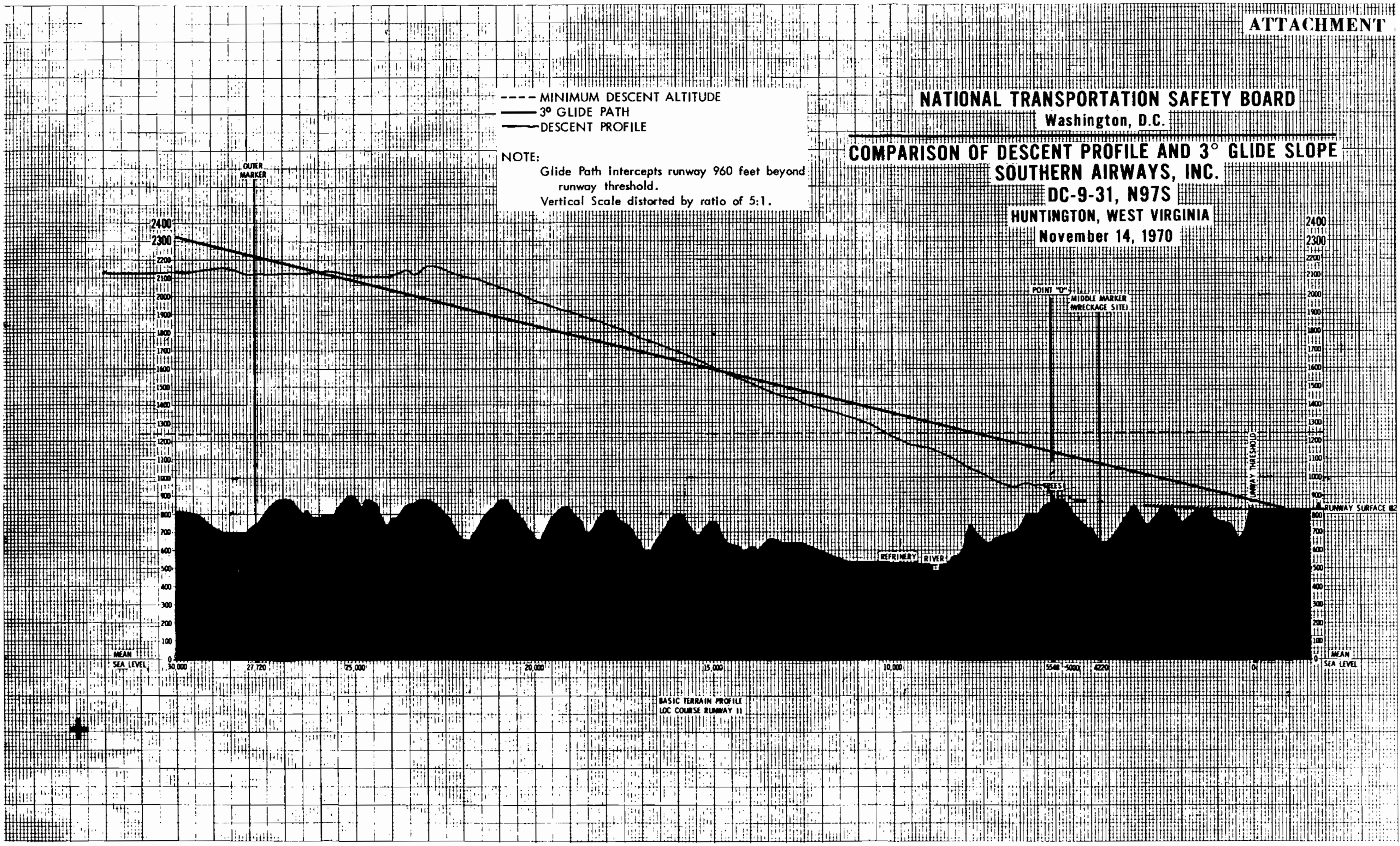

(SOUND OF OUTER MARKER BEGINS)
(SOUND OF OUTER MARKER CEASES ABRUPTLY)
(EST) 1933:43.4
1933:47.9
(CAM-2) A THOUSAND FEET ABOVE THE GROUND, RATE AND SPEED GOOD
1934:32.4
(CAM-1) SEE SOMETHING?
1934:55.4
(CAM-2) NO, NOT YET. IT'S BEGINNING
1935:01.6
(CAM-2) WE'RE TWO HUNDRE
1935:06.8
MSL ALTITUDE ~ FEET × 1000
DISTANCE ~ FEET × 1000
SCALE 1:24000
1 KILOMETER
7000 FEET
CONTOUR INTERVAL 20 FEET
DOTTED LINES REPRESENT 10-FOOT CONTOURS
DATUM IS MEAN SEA LEVEL
OUTER MARKER
RIVER
CHESAPEAKE
PIPELINE
Chadwick
Creek
Paddle

ATTACHMENT 2





ATTACHMENT


NATIONAL TRANSPORTATION SAFETY BOARD
Washington, D.C.
COMPARISON OF DESCENT PROFILE AND 3° GLIDE SLOPE
SOUTHERN AIRWAYS, INC.
DC-9-31, N97S
HUNTINGTON, WEST VIRGINIA
November 14, 1970
MINIMUM DESCENT ALTITUDE
3° GLIDE PATH
DESCENT PROFILE
NOTE:
Glide Path intercepts runway 960 feet beyond runway threshold.
Vertical Scale distorted by ratio of 5:1.
OUTER MARKER
POINT "D"
MIDDLE MARKER (WRECKAGE SITE)
TREES
RUNWAY THRESHOLD
RUNWAY SURFACE
REFINERY
RIVER
MEAN SEA LEVEL
30,000
27,720
25,000
20,000
15,000
10,000
5548
5000
4220
0
BASIC TERRAIN PROFILE
LOC COURSE RUNWAY 11