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16. Abstract About 1712 e.d.t. on June 23, 1976, Allegheny Airlines, Inc., Flight 121, a Douglas DG-9-31, crashed on the Philadelphia International Airport, Philadelphia, Pennsylvania; the wreckage came to rest about 6,000 ft beyond the threshold and about 350 ft to the right of the centerline of runway 27R. Of the 106 persons onboard, 86 persons were injured; there were no fatalities.

The captain of Flight 121 had conducted an instrument approach to runway 27R in visual conditions, as a thunderstorm passed over the airport in a north-northeasterly direction. When near the threshold the captain initiated a go-around from a low altitude and entered rain of increasing intensity. Shortly thereafter, the aircraft was seen descending in a noseup attitude with the landing gear retracted. After striking tail first on a taxiway about 4,000 ft beyond the threshold of runway 27, the aircraft slid about 2,000 ft and stopped.

The National Transportation Safety Board determines that the probable cause of this accident was the aircraft's encounter with severe horizontal and vertical wind shears near the ground as a result of the captain's continued approach into a clearly marginal severe weather condition. The aircraft's ability to cope under these conditions was borderline when flown according to standard operating procedures, however, if the aircraft's full aerodynamic and power capability had been used, the wind shear could probably have been flown through successfully. Contributing to the accident was the tower controller's failure to provide timely below-minimum RVR information.

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NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C. 20594

AIRCRAFT ACCIDENT REPORT

Adopted: January 19, 1978

ALLEGHENY AIRLINES, INC.
DOUGLAS DC-9, N994VJ
PHILADELPHIA INTERNATIONAL AIRPORT
PHILADELPHIA, PENNSYLVANIA
JUNE 23, 1976

SYNOPSIS

About 1712 e.d.t. on June 23, 1976, Allegheny Airlines, Inc., Flight 121, a Douglas DC-9-31, crashed on the Philadelphia International Airport, Philadelphia, Pennsylvania; the wreckage came to rest about 6,000 feet beyond the threshold and about 350 feet to the right of the centerline of runway 27R. Of the 106 persons onboard, 86 persons were injured; there were no fatalities.

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1. FACTUAL INFORMATION

1.1 History of the Flight

About 1458 1/ on June 23, 1976, Allegheny Airlines, Inc., Flight 121, a Douglas DC-9-31, departed Providence, Rhode Island, on a regularly scheduled passenger flight to Memphis, Tennessee. En route stops were scheduled at Windsor Locks, Connecticut, Philadelphia, Pennsylvania, and Nashville, Tennessee.

At 1549, Flight 121 arrived at the Bradley International Airport, Windsor Locks, Connecticut; at 1628, it departed for Philadelphia on an instrument flight rules (IFR) flight plan; there were 4 crewmembers and 102 Passengers aboard. T e flight was routine en route and cruised at an altitude of 16,000 ft 2/ with the captain at the controls.

At 1702, Flight 121 contacted Philadelphia approach control, advised that the flight was descending to 5,000 ft, and stated that they had the automatic terminal information service "Oscar," which read in part "three thousand scattered, twenty-five thousand scattered clouds, visibility 6 miles, haze, temperature 91°, wind two six zero degrees at ten knots, altimeter three zero one six." Approach control advised Flight 121 to maintain 5,000 ft and that the approach in use was the ILS to runway 27R. Subsequently, Flight 121 was told to intercept the localizer course on its present heading and proceed inbound for an instrument landing system (ILS) approach to runway 27R. Based on a landing weight of about 90,000 lbs, the computed approach speed (Vref) for the landing was 122 kns indicated airspeed (KIAS).

At 1705, Philadelphia approach control advised Allegheny Flight 398, a company flight immediately behind Flight 121, that the visibility "just went to 2 miles." According to the cockpit voice recorder (CVR) the captain of Flight 121 remarked, "Two miles." A few seconds later he said, "Part of that storm sitting on the end of the runway." The first officer replied, "Yeah." The captain testified that he remembered seeing a small cell on radar as they approached Philadelphia. The first officer also saw a single cell and said that it was a few miles west of the airport. The captain described it as not being much of a cell and the radar showed no heavy precipitation. However, the first officer later stated that it contoured on the aircraft's weather radar. Because of his distance from the airport and the cell's distance from the airport, the captain believed that they would be able to land before the cell arrived over the airport.

1/ All times are eastern daylight, based on the 24-hour clock.
2/ All altitudes herein are mean sea level, unless otherwise indicated.

At 1706, when about 15 miles from the threshold of runway 27R, Flight 121 intercepted the localizer course, the leading edge slats were extended, and the landing gear was lowered.

At 1707:50, the approach controller cleared the flight to the tower frequency. At 1708, the flight called the tower, but the tower controller did not acknowledge the transmission. At that time Eastern Air Lines Flight 876 was attempting to land on runway 27R. Because rain obstructed his view from the tower, the controller asked the Eastern Flight "...are you on the runway, sir?" Eastern 876 responded that they were "...going around," and the tower acknowledged. According to the CVR the crew of Flight 121 commented on these transmissions by asking, "How come he went around?" and by saying, "Yeah, he probably got a wind--got a wind change."

At 1708:40, Flight 121 overflew the outer marker (OM) and reported this to the tower at 1709:13. Less than a minute later, the first officer said that he could see the runway and that the flaps were extended to 50°--the landing configuration. The captain testified that after passing the OM he realized that he had previously miscalculated how fast the storm was moving. He stated that he could see that it was raining quite heavily on the opposite end of the airport, and that he did not like, "the looks of this mean looking cloud mass..." approaching his touchdown point.

At 1710, the tower cleared Flight 121 to land and reported that the wind was from 230° at 25 kns. The crew acknowledged and the captain commepted, "Twenty-five, huh?" The first officer replied, "yeah, two-thirty at twenty-five."

At 1711:17, 400 ft was called. Three sec later, the tower told another aircraft that the surface wind was 210" at 35 kns. (Based on that wind, the crosswind component for runway 27R was 30 kns.) At 1711:23, the captain of Flight 121 said, "Thirty-five, let's go around." The captain later stated that his decision to go around was based on the 'appearance of the storm and that he made the decision to go around before the wind shift call from the tower. He said, "I was on the verge of going right there, just by looking at the thing. And when the tower gave me this wind shift; that's enough for me, I'm leaving."

The captain said that he applied power and simultaneously activated the speed command system to the go around mode by pressing the palm switch on the power levers. He then rotated to the go-around attitude dictated by the command bars displayed on the flight director instrument and called for 15° flaps. The first officer then moved the flap handle while he "got on the power." The first officer advised the tower that Flight 121 was going around. The crew testified that the landing gear was retracted when the aircraft started to climb.

The captain said that, after gear retraction, the indicated airspeed had dropped to 4 or 5 KIAS below V_{ref}. (Go-around airspeed and takeoff safety speed (V_2) were 132 KIAS.) The captain said that the flight director's command bar on his attitude indicator began to drift downward from about 14° noseup to about 10° or 12° noseup, and he decreased the pitch of the aircraft to match the flight director's command bars. He also noted that the vertical speed indicator was indicating a descent. The captain stated that he maintained the attitude dictated by the command bars until ground impact and that he did not think of increasing aircraft's pitch angle above that indicated by the command bars because the airspeed was "too low." He could not remember the exact speed "except that it was below bug." He added, "you don't want to go any lower than bug, if necessary--1 mean if possible, because the next thing you know you are going to stall. I know we were quite a bit above stall, but 5 kns below bug is slow enough for me in turbulence."

The first officer confirmed the captain's description of the sequence of events. He said he heard the ground proximity warning and called "pull up" several times. Both pilots said that they checked the engine power settings and that they thought the indicated power was ample for the go-around. The first officer testified that he recalled that the actual setting was .05 to .06 engine pressure ratio (EPR) below the preselected setting for takeoff at Windsor Locks, Connecticut, which was 1.92 EPR. The static takeoff thrust setting for takeoff at Philadelphia was about 1.93 EPR. Except for the airspeed drop below V_{ref}, neither the captain nor the first officer could recall any indicated airspeeds or altitudes after initiating the go-around.

While Flight 121 was inbound from the OM, weather-related conversations between the tower and two other flights--Northwest 59 and Ransome 737--were recorded on the CVR. Northwest 59 was cleared into position for takeoff on runway 27L but elected to hold. Ransome 737 preceded Flight 121 on the approach. After their flight had landed, the tower controller told the Ransome flightcrew that he could not see their aircraft because of the rain. The Ransome crew reported their location and said that they "could not see for a minute." Neither the captain nor first officer remembered hearing these conversations.

Another air carrier flight was holding on taxiway C facing south toward runway 27R. Its captain said that the rain was heavy and that he first saw Flight 121 when the aircraft emerged from the rain at 75 to 125 ft above the ground. He said that the aircraft was making a go-around; the landing gear was up, the wings were level, and it had about a 10° noseup attitude. He further stated that Flight 121 appeared to stop flying, descended to the ground with the nose up, struck the ground to the right of runway 27R, and then slid along the ground--passing about 38 ft in front of his aircraft before it came to rest.

The Philadelphia tower controllers first saw Flight 121 when it emerged from heavy rain slightly to the right of runway 27R near the intersection of taxiways D and W. The aircraft was headed west, about 100 ft above the ground, and was descending in a slight noseup attitude with the wings level and the landing gear retracted. The controllers said that the airplane hit the ground near the intersection of runway 27R and taxiway W. The tail section separated from the aircraft shortly after impact, and the aircraft came to rest west of taxiway C. Passengers began to evacuate the aircraft immediately.

1.2 Injuries to Persons

Injuries	Crew	Passengers	Others
Fatal	0	0	0
Serious	4	a2	1
Minor/None	0	20	--

1.3 Damage to Aircraft

The aircraft was destroyed by impact.

1.4 Other Damage

Three taxiway signs were destroyed.

1.5 Personnel Information

The captain, first officer, and the flight attendants were trained and certificated according to current regulations. (See Appendix B.)

1.6 Aircraft Information

N994VJ was certificated, maintained, and equipped according to Federal Aviation Administration (FAA) regulations. (See Appendix C.) The aircraft's weight and center of gravity at the time of the accident were 89,672 lbs and 13.5 percent MAC, respectively; both were within specified limits. The aircraft had been fueled with 18,395 lbs of jet-A fuel; about 12,644 lbs of fuel were onboard the aircraft when it crashed.

1.7 Meteorological Information

A thunderstorm was in progress. Before the accident, the last official weather observation that was made at Philadelphia International Airport was completed at 1708. The observation was as follows:

Special: Ceiling estimated 2,500 ft broken, 8,000 ft broken, visibility--1 mile, thunderstorm, moderate rain-showers, wind 240° at 17 kns, gusts to 41 kns, altimeter setting--30.19 ins., thunderstorm began at 1703, overhead, moving east-northeast, runway 9's runway visual range (RVR)--1,000 ft variable to more than 6,000 ft.

The graph of transmissivity for runway 27R and the RVR - Transmission Conversion Table disclosed that the RVR dropped below 4,000 ft about 1705, increased to almost 4,000 ft about 1707, and then immediately dropped below 4,000 ft again. The RVR continued to drop rapidly to a low of less than 1,000 ft about 1709, began to increase, and reached 4,000 ft at 1716.

The RVR displays in the control tower and IFR room are digital and update electronically every 48 secs. The values displayed on the indicators are representative of RVR values recorded during the previous 48-sec interval. The display readouts are not recorded.

The digital displays have a visual warning system (amber light) and an audible alarm system (bell) to alert the controllers if the RVR goes below a preset value. The controller may insert the RVR value he wishes monitored. The operation of the system is controlled by an on-off switch. When switched "on" the amber light will illuminate if the RVR goes below the preset value and will remain lit while it remains below that value. The alarm bell will sound a single stroke every time the readout updates if the new value is below the preset value. At the time of the accident there were no procedures to establish when the alerting system should be used. None of the controllers could recall observing an RVR below 4,000 ft; consequently, none of the aircraft arriving in the Philadelphia area while the RVR was below minimums was informed of this fact.

The maximum wind speed recorded was 41 kns at 1708. At 1712, the wind speed was 36 kns. The direction of the wind was from the west from 1701 to 1705, from the southwest from 1706 to 1712, from the north from 1716 to 1717, from the northeast from 1718 to 1721, and from the east from 1722 to 1733.

The rainfall weighing gauge showed 0.35 in. of rainfall from 1650 to 1742. The rainfall was reported as light rainshowers at 1650 which continued until 1704 when they were reported as moderate. The rainshowers continued to be reported as moderate until 1720, when they were reported as light again, and remained light until the rain stopped at 1742. However, the rainfall graph showed that between 1704 and 1720, the rainfall should have been reported as heavy.

The log of thunderstorm alerts maintained in the FAA's Central Flow Control in Washington, D.C., showed that, at 1717 the meteorologist received a call from the weather radar specialist in New York City who gave the following report:

> Echo location--just north Philadelphia International Airport, intensity level--5 to 6, configuration and size--8 miles in diameter, top--37,000 ft, movement and speed--190° at 15 kns, facility affected--Philadelphia International Airport, time notified--Philadelphia unable to take call because of aircraft accident. (In later testimony the radar specialist said that the intensity level 5 to 6 was an error and should have been intensity level 4.)

Alerts are required when the intensity level is 3 or higher. Weather radar echoes are reported in six intensity levels: 1--weak, 2--moderate, 3--strong, 4--very strong, 5--intense, and 6--extreme.

None of the other National Weather Service stations in the area reported a storm of greater than level-2 intensity near the time of the accident,

Although the approach control radar was functioning normally, the precipitation associated with the storm over the airport was not being depicted. The approach control radar is located on the airport and is used primarily for separating aircraft. The approach controller cannot see outside from his station.

The first officer stated that as they entered the Philadelphia area they had a storm cell on their radar. The radar was set on the 30 nmi range, and the cell "appeared to be just west of the airport by a couple of miles, perhaps. That is a rough estimate...." The cell contoured on the radar. The first officer said the cell was circular and about 7 miles in diameter. The contour within the cell was circular, and he estimated it was "a quarter of the size of the whole storm."

Firemen and other ground personnel who arrived at the scene shortly after the accident described the weather as severe because of heavy rain and said that the winds were strong and gusty from the west and southwest.

Passengers said that after they had deplaned, it rained hard, the wind was strong, and standing water covered the grass around the aircraft.

1.8 Aids to Navigation

The ILS front course approach to runway 27R is on an inbound heading of 265". The glidepath is intercepted at 2,100 ft (2,089 ft above the touchdown zone). The final approach fix (FAF) is the OM, which is located 6.1 nmi from the runway threshold. The glidepath angle is 3° and crosses the runway threshold 62 ft above the ground. Decision height (DH) is 261 ft (250 ft above the touchdown zone). (See Appendix D.) The minimum in effect at the time of the accident was RVR *4,000* ft or 3/4 of a mile.

On June 24, 1976, the FAA completed its postaccident evaluation and certification of the components of the runway 27R ILS system; all components were found to be operating within the prescribed parameters.

1.9 Communications

There were no communication difficulties.

1.10 Aerodrome Information

Runway 27R at the Philadelphia International Airport is hard-surfaced, is 9,500 ft long and 150 ft wide, and is at an elevation of 23 ft. The runway markings are those prescribed by the FAA for a precision instrument runway. The runway is equipped with RVR and an ILS.

1.11 Flight Recorders

N994VJ was equipped with a Sundstrand Data Control, Model FA-542 flight data recorder (FDR) serial No. 3938. The recorder was recovered undamaged from the severed tail section of the aircraft. The data for the last 5 min of flight were read out and plotted. (See Appendix E.)

From 1710:48 to 1711:48 the FDR's altitude trace indicated that the aircraft descended from 551 ft to 88 ft (1711:20.4), climbed to 371 ft (1711:37.2), and then descended to 136 ft (1711:48). During the same time period, the FDR's airspeed trace disclosed that the indicated airspeed increased from 157 to 162 kns (1711:01.4), decreased to 117 kn (1710:40.8), and then increased to 153 kn (1711:48). During this period the g trace activity changed. The excursions on each side of the reference line increased in amplitude and frequency.

The aircraft was equipped with a Sundstrand Model V557 cockpit voice recorder (CVR), serial No. 2106. Although the CVR was not damaged, the recording was of poor quality. (See Appendix F.)

The CVR transcript disclosed that "500 ft above the runway" was called at 1710:49; the windshield wipers were turned on and the middle marker (MM) sounded at 1711:11; the tower was informed of the go-around at 1711:28; the terrain warning sounded at 1711:43; and the tape ended at 1711:48.

1.12 Wreckage and Impact Information

The wreckage path began about 4,000 ft beyond the threshold of runway 27R and continued west for about 2,000 ft. The wreckage was contained in the area between runway 27R and taxiway A, and between the initial contact point and a point about 450 ft west of taxiway C. (See Appendix G.)

The empennage and aft fuselage section had separated from the rest of the fuselage at a point just aft of the pressure bulkhead. The major portion of the fuselage, including the entire cabin and cockpit, was intact with both wings attached. The fuselage was damaged severely below the cusp line, at the rear pressure bulkhead, and at the engine stub wing-to-fuselage attachments. The fuselage lower nose structure was damaged. The lower skin of the fuselage was torn and abraided, the adjacent frames'were crushed, and the stringers were damaged for the entire length of the aircraft. The cabin floor was buckled upward above the main landing gears (fuselage stations 699 to 756).

The basic wing structures were intact, but the left wing was damaged more heavily. There were no fuel leaks from the wing tanks. The empennage was attached to the aft fuselage section which had separated from the aircraft. The stabilizer was positioned for 9.8° noseup trim. The landing gear was fully retracted, the leading edge slats were fully extended, and the flaps were partially extended. Measurements taken of the flap extension mechanism revealed that the flaps were in the 15" position.

Both engines and their respective pylon stub wings had separated from the aircraft fuselage and were found 200 ft apart. The engines and the tail section were found between taxiway C and the main wreckage.

The engines were examined at the scene and later at the Allegheny Airlines, Inc., facilities in Pittsburgh, Pennsylvania. The fuel control units and pressure ratio bleed controls were examined at the facilities of Hamilton Standard, Division of Pratt & Whitney Aircraft Group of United Technologies Corporation. The examination did not disclose any evidence of either engine malfunction or engine component malfunction; the engine power settings at impact could not be determined.

Most of the electrical equipment in the forward electronic compartment was destroyed. The damage prevented testing of the flight profile comparator which controls the terrain proximity warning system.

Although many of the cockpit switch settings and indicator settings had been moved during crew rescue operations, the following were considered valid:

The captain's and first officer's altimeters both read 30.17, and their airspeed "bug" settings were 118 kns and 122 kns, respectively. The EPR bug settings were 1.89 on both engines; the digital true airspeed reading on the static air temperature indicator was 158 kns; the captain's flight director selector switch was in the ILS mode, and the first officer's was off.

Comparison of the jackscrew measurement with that of another DC-9 aircraft disclosed that the stabilizer trim position was about 9.8" nose up.

1.13 Medical and Pathological Information

The captain and the first officer sustained multiple spinal fractures and contusions. The captain's forehead and left temple were lacerated and his ribs were fractured. The first officer sustained a lacerated tongue and abrasions to both legs.

The flight attendant assigned to the forward jumpseat sustained a lacerated tongue and a compression type spinal fracture. The flight attendant assigned to the rear jumpseat sustained a contusion to her left ankle and left leg, and acute lumbosacral and cervical strains.

Passenger injuries included cervical, thoracic, lumbar, ankle, and arm fractures; cervical and lumbosacral strains; whiplash, facial lacerations, broken teeth, lacerated tongues; and multiple contusions and abrasions to the head, face, and extremities.

A city policeman sprained his back when he slipped from a wing while removing injured passengers.

1.14 Fire

There was no fire.

The first airport fire unit arrived at the scene 1 min 48 secs after the first alarm sounded at 1712. At 1714, a second alarm was sounded to which off-airport rescue and firefighting units responded. The ground around the aircraft was covered with foam as a precaution. Police and fire department personnel assisted in the extrication of the pilots, the forward flight attendants, and 12 passengers.

1.15 Survival Aspects

This was a survivable accident. The cockpit floor was displaced upward, the pilot seats were jammed in their tracks, had separated from their structures, and exhibited compression buckling. The seat pans were compressed downward. The forward flight attendant's jumpseat separated at its outboard linkage, and the linkage assembly was deformed downward and outward.

The main cabin floor was displaced upward at seat rows 4 through 7, at row 10, and at rows 13 through 15. Only 8 of 100 passenger seats were undamaged. Typical damage included compression buckling of seat legs, separated floor fittings, separated lateral support tubes, and torn and separated seatbottom fabric supports.

The forward flight attendant said that she had left her seat to reclose a galley drawer which had opened during the go-around and was standing near the cockpit door when the aircraft crashed. She said she was thrown to the floor and immobilized by the impact. A male passenger came forward and, in response to her oral instructions, attempted to open the main cabin door. In the process of trying to open this door he inflated the escape slide inside the cabin; consequently, the main cabin door could not be opened, and the inflated slide partially covered the injured flight attendant.

The galley service door was opened and its slide was inflated by passengers. The door sill was about 3 to 4 ft above the ground. High winds blew the escape slide almost horizontal to the ground and only one or two passengers escaped through this exit. The four overwing exits were opened by passengers and about 40 persons deplaned through these exits.

The rear cabin door, which led to the rear stairs, was open about 2 ins. after impact and was prevented from opening farther by the upward deformation of the cabin floor. The entire airframe section aft of the rear cabin pressure bulkhead was missing, and the rear door sill was about 4 ft above the ground. The aft flight attendant could not open the rear cabin door and called for assistance. Three male passengers forced the door far enough for the exit to be used, and most of the passengers exited through it.

Baggage and garments were in the aisle during the evacuation and some passengers retrieved their carryon items before they deplaned. Failed seats had come to rest in the aisle or against other seats. The pilots, the forward flight attendants, and 12 passengers who were either immobilized by injuries or trapped by failed seats were still in the cabin when the first firemen arrived. Since there was no fire, the injured passengers and crewmembers were removed cautiously to avoid additional injuries.

At the request of the Safety Board, the Douglas Aircraft Company conducted a failure mode analysis on the failed flight attendant's seat. This was a double attendant's seat which folded upward against the cockpit wall. The seat was spring loaded to the stowed, or upward, position and remained stowed unless occupied.

In order to analyze failure, impact forces sustained along the length of the fuselage were calculated by comparing the failures of the engine pylons, cabin seats, and pilot's seat to failure modes experienced under known acceleration levels.

The failure mode of the engine pylon and debris therefrom indicated that the engines broke away from the fuselage on initial impact. Comparison of the failure mode of the pylon with previous pylons tested indicates that the engine experienced a load factor in excess of 8G.

The type of passenger seat used in the cabin has been tested to a vertical load factor of 8.63G. The damage that resulted to the tested seat was much less than that suffered by the seats in N994VJ. Consequently, the vertical loads experienced along the length of the fuselage substantially exceeded 8.63G. The pilot's seat had also been tested to 8.636 without any apparent damage.

When the flight attendant's seat is stowed, the seat bottom is folded vertically. A spring helps keep the seat in place and, therefore, the vertical acceleration during the impact would not cause the seat to move to the open, or sitting, position. The nose down pitching acceleration would tend to produce an opening moment, but it is unlikely that the seat would open under such acceleration forces because of spring force and friction in the system and sustain the damage that it did.

The flight attendant said she was standing in the galley area when the go-around was initiated and remembered turning toward the seat. Two assumptions were considered: (1) She was still standing when the airplane struck the ground, or (2) she was seated, but had not fastened her seatbelt and shoulder harness. If the flight attendant was not sitting and fell into an open seat at impact, the damage to the seat is easily understood--but not the injuries to the flight attendant. Calculations showed that sufficient kinetic energy is attained with as little as 2 ins. of free motion at the load level experienced during this accident to cause the damage to the seat. However, the flight attendant's injuries indicate that she was sitting upright.

According to the failure analysis computation, the initial pitchdown of the airplane produced a sufficient incremental negative load factor in the forward fuselage to cause the flight attendant to rise vertically. The ensuing vertical impact of the forward fuselage as the pitchdown continued caused a vertical load factor of at least 10G. At this acceleration level, any free travel by the flight attendant of 2 ins. or more would have been sufficient to develop the kinetic energv level required to produce the seat failure.

1.16 Tests and Research

1.16.1 Functional Tests of Specific Systems

Tests of the altimeters and air data computers indicated that they functioned within prescribed limits. When electrical power was terminated by the crash, the No. 1 air data computer's altitude module was indicating 7 ft, and the No. 2 air data computer's altitude module was indicating 26 ft.

The speed command computer was tested functionally at the Safe Flight, Inc., facilities; it operated within test limits in all modes.

1.16.2 Aircraft Performance Analysis

The information from Flight 121's FDR and CVR was analyzed to determine: (1) The probable characteristics of the wind's encountered by the aircraft during the attempted go-around, (2) the approximate flightpath of Flight 121, (3) the probable pitch attitude commands presented by the flight director system, and (4) whether sufficient aircraft performance was available to have successfully completed the go-around in the probable wind conditions.

Derivation of Probable Wind Conditions

The theoretical performance capability of the aircraft was compared with the actual performance of N994VJ, as demonstrated in the accident sequence. The airplane's theoretical performance capability for the conditions existing at the time of the attempted go-around, including weight, configuration, thrust, airspeed, and altitude, was established in terms of rate of climb versus longitudinal acceleration.

The actual performance of Flight 121 was derived from FDR information and from the weight, thrust, and configuration of the aircraft at the time of the attempted go-around as determined from cockpit conversations and other sounds recorded on the CVR. The altitudes and times at which the airplane crossed specific navigation aids and the time of impact were defined through correlation of CVR and FDR data; this information provided time-distance constraints for use in establishing the most likely flightpath profile. The known characteristics of the modes of operation of the flight director and speed command system were also used to the extent that it could be determined that the pilot was following their indications.

An infinite number of combinations of horizontal and vertical wind components could be postulated, each satisfying the equations of motion for the aircraft and the time-distance constraints. Four basic wind profiles were selected to represent **a** reasonable cross section of possible horizontal and vertical combinations for use in further study of the flightpath and the winds affecting it. (See Appendix H.) Each wind profile selected had associated with it an aircraft pitch attitude time history that satisfied the appropriate aircraft equations of motion and time-distance constraints derived from the FDR and CVR. Each wind profile also was adapted to provide two-dimensional wind models for use in computer analyses and simulator studies of various other possible flightpaths. These adaptations assumed that the horizontal winds were a continuation of the symmetric outflow of a storm cell and that the vertical drafts acted over realistic horizontal distances. Realistic wind shear assumptions were used based on empirical evidence collected to date, such as linear decay of vertical velocities to zero as altitude decreases to zero.

Derivation of Probable Flightpath

Computer analyses were then conducted to explore the correlation between various pitch attitude time histories which could be flown in these four wind models, meet the time-distance constraints and conform to the evidence available relative to the pitch attitude time history of the attempted go-around.

Wind model 4a, when combined with the calculated angle of attack and the FDR-derived flightpath, appeared to provide a realistic approximation of events. This combination produced a pitch time history that included an initial pullup to 15°, an immediate decrease in pitch to 10° to 12° (sustained for about 6 secs), and a sudden decrease in pitch with 5 secs remaining to about 2" noseup.

Calculations of the downdrafts that would produce pitch attitudes of **10"** to 15° for the final ***10*** secs of flight before impact and still meet the time distance constraints (witnesses and structural deformation indicate impact occurred at 10° to 12° noseup pitch attitude) resulted in a requirement for unrealistically large downdrafts very near the ground, which indicates that the aircraft could not have maintained such large pitch angles. The FDR data do reflect a sudden increase in normal acceleration and a sudden decrease in airspeed within the final 2 secs of operation, possibly because of a sudden noseup rotation just before impact. Such a rapid rotation in the last seconds before impact would not have caused an appreciable change in the point of impact and, as a result, would not appreciably affect the calculated pitch attitude time-history before the sudden rotation.

The flight director/speed command system pitch command time history was also calculated for the most probable flight profile just described. Calculations indicate that the aircraft was rotated at the initiation of the go-around to the pitch command bars but was then allowed to drop below the pitch attitude commanded by the pitch command bars and remained below the commanded pitch attitude until just before impact. Furthermore, calculations show that the pitch command bars would have moved down when the aircraft's pitch attitude was reduced. If operating properly, however, the pitch command bar would, in this case, always command a pitchup and, if the pilot then responded to the command, the bar would move back up until the proper pitch attitude had been achieved.

Calculations indicate that in the representative wind model the speed command system would have commanded about 15" pitch attitude and that, if this attitude had been maintained, the aircraft could have been flown through the shear successfully. During this encounter the aircraft would have descended to about 50 ft and the airspeed would have decreased to about 119 KIAS. V_2 was 132 KIAS, V_{stall} under these conditions would have been approximately 108 to 110 KIAS (depending on the vertical acceleration), and the V_{stall} warning would have been approximately 109 to 117 KIAS.

1.16.3 Simulator Tests

The Douglas Aircraft Company's Flight Development Motion Base Simulator was programmed with the flight characteristics of the DC-9 series 30 aircraft and used to substantiate the correlation between the flight profile of Flight 121 during its attempted go-around and the wind models developed in the analytical performance study. Various go-around techniques were also flown during which the indications of the speed command system were studied to better understand the most probable performance of that system in severe wind shear conditions and the influence of different techniques in minimizing altitude loss. The simulator was equipped with a color visual display programmed to simulate the low-visibility conditions actually encountered by Flight 121. The captain's flight director instrument display in the simulator was identical to that of Flight 121's. A Safe Flight, Inc., speed command computer provided the speed command logic to the flight director.

The simulator was programmed to accept the four wind models developed in the foregoing performance analysis and incorporated changes in both vertical and horizontal wind components as a function of the aircraft's altitude and its distance from the runway threshold.

Seven pilots participated in three series of tests, including five airline pilots who were either currently or formerly qualified in the DC-9, an FAA representative, and a Douglas test pilot. In the first series of tests, after flying a normal approach and go-around procedure in a no-wind environment, each of the pilots flew one or more approaches through each of the four wind models developed in the aircraft performance study. Each simulator flight was started midway between the OM and MM at 1,000 ft a.g.l. and at 140 KIAS (V_{ref} + 18 kns). The pilots were instructed to conduct a normal flight director ILS approach (3° glidepath) but, at 700 ft a.g.l., to initiate a gradual increase in airspeed to 160 KIAS. They were further instructed to execute a missed approach at 100 ft a.g.l. utilizing the flight director go-around mode and to follow the flight director command as closely as possible. The go-around was to be initiated by the pilot, who was to apply power and simultaneously activate the flight director go-around mode with the throttle palm switch. The copilot, who was a Douglas pilot, was to adjust the engine power to 1.86 EPR. Five secs after initiation of the go-around, the copilot was to retract the flaps to 15°; 14 secs after initiation of the go-around, the. pilot was to retract the landing gear. These conditions were selected to duplicate the timing of these events as they were performed by Flight 121. An additional run was made by each pilot through wind model 5a with the EPR set at 1.93 to examine the effects of using takeoff power rather than the lower power setting probably used in the attempted go-around on Flight 121, as recalled by the first officer.

The first series of tests showed that all runs through wind model 3 were successful; minimum altitudes ranged from 8 ft a.g.l. to 100 ft a.g.l., and minimum airspeeds ranged from 108 KIAS to 122 KIAS. All runs through wind model 4a were successful; minimum altitudes ranged from 45 ft a.g.l. to 200 ft a.g.l.; and the minimum airspeeds ranged from 110 KIAS to 118 KIAS. Five of nine runs through wind model 5a were unsuccessful; minimum altitudes ranged from 0 to 65 ft a.g.l., and the minimum airspeeds ranged from 110 KIAS to 118 KIAS. All runs through wind model 5a, using the go-around EPR of 1.93, were successful; minimum altitudes ranged from 50 ft a.g.l. to 160 ft a.g.l.; the minimum airspeed ranged from 110 KIAS to 120 KIAS.

A second series of simulator flights were performed by the Douglas test pilot who followed, as closely as possible, the first three of the four pitch attitude time histories defined in the Douglas performance study. These profiles were approximations of the pitch attitude time histories flown by Flight 121. The objective of this series was to establish through flight simulation the most probable result of following these pitch attitude time histories and to identify the profile most likely flown by Flight 121. The fourth profile, 4b, was not flown in the simulator; investigators believed that such high downdrafts so near the ground--which would be required to produce this pitch attitude history--were unrealistic.

All runs through wind model 3 were successful; minimum altitudes ranged from 20 ft a.g.l. to 75 ft a.g.l., and the minimum airspeed noted was 125 KIAS. Neither run through wind model 4a was successful; neither run through wind model 5a was successful. A third run through wind model 5a was made with an EPR of 1.93; it was successful. The minimum altitude and airspeed were 40 ft a.g.1. and 118 KIAS.

The aircraft pitch attitude time histories plotted in this series of flight simulations resembled those calculated in the performance study and verified the conclusions reached in the performance analysis that the pitch attitude of Flight 121 was probably lowered to about 2° for several seconds during the attempted go-around.

A third series of flight simulations were performed without the benefit of a flight director system by an Allegheny pilot who used V_2 (132 kns) as a reference in the go-around. Using an EPR of 1.86, simulated flight through wind models 4a and 5a resulted in gross pitch manipulations and collision with the ground as the pilot attempted to maintain V_2. The minimum airspeed in each flight was 120 KIAS. A simulated flight through wind model 5a with an EPR of 1.93 also resulted in gross pitch attitude changes and came within 5 ft of the ground. The minimum airspeed was 118 KIAS. A final run through wind model 5a at a constant go-around EPR of 1.86 was successful, however, flaps and gear were raised earlier rather than as programmed in previous flight simulations. Minimum altitude in the run was 80 ft, minimum airspeed was 123 KIAS. All flight simulations conducted in this third series required more frequent and greater pitch changes than those flight simulations using the flight director in the go-around mode. The pilot flying in this latter series stated that having the flight director in the go-around mode was a definite asset in a go-around situation. (He had participated as one of the pilots in the initial series of flight simulations using the flight director system as the primary pitch reference in the go-around.)

During the simulations, several pilots commented that the continuation of callouts by the copilot of assigned altitudes and vertical speed during the go-around attempts were helpful.

Ground Proximity Warning System Operation

At 1711:43 the ground proximity warning system (GPWS) was activated aboard Flight 121. In order to determine which of the four operational modes activated the GPWS, the aircraft's altitude above the ground, rate of descent, and configuration first had to be determined. The erratic FDR record of altitude during the go-around precluded an accurate assessment of altitudes; therefore, an altitude profile was calculated as a function of time from the normal acceleration trace of the FDR. Comparison of the calculated altitude and descent rate with curves in the DC-9 handbook, which depict performance of the GPWS, indicates that the GPWS could have been activated when the rate of descent exceeded 1,400 ft per minute at 160 ft a.g.1. or, possibly, upon the loss of 25 ft after reaching the maximum altitude attained during the attempted go-around. Both occurred within a second of 1711:43; the accuracy with which the time of any two specific occurrences can be determined, as recorded on the FDR and CVR, precludes the determination of which of the two modes of operation activated the GPWS.

1.17 Other Information

1.17.1 The Flight Director/Speed Command System

The Collins FD-109 flight director system provides visual displays to assist the flightcrew in navigation and control of the aircraft. A flight director indicator (FDI) and course indicator (CI) are provided for each pilot. The FDI provides attitude information through an artificial horizon, and computed pitch and roll information by command bars. The OFF, HDG (heading), N/L (navigation/localizer), or ILS modes are selected by rotation of the selector knob at the FDI. The command bars are biased from view when the selector knob is in the off position.

The command bars display computed bank guidance commands so the pilot can capture and fly selected headings or radio courses, and pitch guidance commands to hold a selected attitude or altitude or to track a glide slope beam.

A glidepath deviation pointer is located on the left side of the instrument, and a speed command pointer is located on the right side to provide an indication of whether the aircraft is flying slower or faster than reference speed.

By pressing either the combined speed command switch and indicating light on the instrument panel or one of two throttle-mounted "palm" switches, the flight director is placed in the go-around mode if its mode selector switch is in any position other than off. Placing the speed command system to the go-around mode does not affect the position of the flight director mode selector knob. The speed command system automatically computes the reference speed for the go-around maneuver. The reference speed is computed as a function of aircraft angle of attack, forward acceleration, pitch, pitch rate, and flap and slat position. If the delta-shaped aircraft reference symbol is kept centered with the command bars, minimum altitude is lost during the transition from approach reference speed to the climbout reference speed as the landing gear and wing flaps are raised. Since the same signal is used for both displays, the same transition can be accomplished by keeping the slow/fast pointer centered. As more thrust becomes available, the speed command system will command a climbout pitch attitude of up to 15°. When the go-around mode is selected and the throttles are advanced the speed command system will command an initial pitch greater than that of the aircraft attitude and will continue to lead the aircraft in pitch magnitude until the aircraft symbol is centered in the command bars, unless--

(1) ...the aircraft pitch exceeds 15°; the reference aircraft symbol will be above the command bars which are limited to 15°, or

(2)...the aircraft decelerates and thus approaches a dangerously low airspeed. The command bars will then command a lower pitch to avoid a stall.

If the aircraft's nose is lowered during the climbout, the command bars are programmed to remain at 15° until the aircraft pitch decreases to 5°. If the aircraft pitch continues to decrease, the command bars will follow about 10° apart, but will continue to command a pitchup.

1.17.2 ATC Controller Procedures

ATC procedures are contained in the Air Traffic Control Handbook 7110.65.

Chapter 2, paragraph 22 of the handbook states: "Duty Priority. Give first priority to separation of aircraft as required in this handbook and to the issuance of safety advisories. Give second priority to other services that are required but do not involve separation of aircraft. Give third priority to additional service7 to the extent possible."

Chapter 5, Section 9, paragraph 1082 of the handbook states, "Issue touchdown RVR or RVV for the runway(s) in use to arriving and departing aircraft as follows: (c) When the RW or RVR indicates the visibility is below the published minima for the particular approach being executed."

1.17.3 Federal Aviation Regulations

14 CFR 121.651 states, in part:

"(b)...no pilot may execute an instrument approach procedure or land under IFR at an airport if the latest U.S. National Weather Service Report, or a source approved by the Weather Bureau for that airport indicates that the visibility is less than that prescribed by the Administrator for landing at that airport.

*****

"d) If a pilot initiates an instrument approach procedure when the current U.S. Weather Bureau or a source approved by the Weather Bureau indicates that the prescribed visibility minimum exists and a later weather report is indicating below minimum conditions is received after the airplane--

(1) Is on an ILS final approach and has passed the outer marker;

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The approach may be continued and a landing may be made, if the pilot-in-command finds, upon reaching the authorized MDA or DH, that actual weather conditions are at least equal to the prescribed minimums."

1.17.4 Operating Procedures

There are two basic company manuals that describe applicable crew procedures for flight operations. The Allegheny Airlines "Flight Operations Manual" contains policy and procedural guidance on operational matters for all company personnel. The "DC-9 Pilot's Handbook" contains guidance and standard operating procedures for flightcrew personnel operating the DC-9 aircraft.

The "DC-9 Pilot's Handbook," page 3-61 states, "The maximum demonstrated crosswind value for a DC-9 landing is 38 kts; however, the Allegheny Airlines crosswind limitation of 25 kts shall be used."

Missed approach or balked landing procedures are contained in the "DC-9 Pilot's Handbook," page 3-78, and state, in part:

"Apply maximum power (takeoff thrust).

"Rotate to maximum 15° pitch attitude. Follow speed command in V-bar when selected. (SC commands wings-level, 15° max. pitch-up with 2 engines....), V_2 with single engine.

"Retract flaps to 15°/EXT.

"Retract landing gear with a positive rate of climb.

"Two Engines: Accelerate towards V_2 (equal to V_{ref} + 10 kts) with a maximum 15° pitch-up attitude...."

The "DC-9 Pilot's Handbook" contains a discussion of takeoff and climbout procedures using the takeoff mode of the speed command system (pages 3-42, 3-43). The discussion contains the following note:

"The airspeed indicators are the primary speed reference throughout the flight regime. The speed command system indicator provides a valuable maneuvering and cross check capability."

The following pertinent weather related data are contained in the company's "Flight Operations Manual." The data cited below are located in the Dispatch Policies and Procedures, and Severe Weather Avoidance subsections of the manual's Specific Procedures section.

On page 516, the manual states the following, in part:

"Severe Thunderstorms and Turbulence Policies

"Flight shall be released and operated only if it appears that area may be avoided.

"Flights should not proceed through an area in which thunderstorm or turbulence of more than moderate intensity are known to exist, unless the captain can alter his flight path to avoid the storm center.

"Flight should be discontinued when weather situations indicate thunderstorms of more than moderate intensity and cloud formations that will not permit the captain to alter his flight path to avoid the storm center.

*****

"Flights shall not take-off, land or approach during or immediately prior to anticipated moderate to severe thunderstorms and turbulent conditions."

On page 566, the manual states, in part:

"General

"The need for exercising prudent judgment with regard to flight through areas of known or forecasted severe weather such as thunderstorm activity severe turbulence and hail, is well recognized by experienced airmen. Flight through severe weather activity should be avoided if possible...."

On page 567, the manual states, in part:

"Recommended Actions

"Avoidance of Known Severe Weather - Recent research has proven beyond any doubt that all thunderstorms are potentially dangerous and should be avoided if possible or penetrated only when the pilot has no other choice.

*****

"Plan ahead to anticipate the need for avoiding areas of known severe weather. If necessary, delay takeoff or landing, as applicable."

2. ANALYSIS

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

The aircraft was certificated, maintained, and equipped according to FAA regulations. There was no evidence of in-flight fire, structural failure, flight control malfunctions, or powerplant malfunctions.

The ILS approach to runway 27R at Philadelphia International Airport conformed to the published approach procedure and the carrier's operations procedures and was performed routinely until the go-around was begun.

While the approach was in progress, a mature thunderstorm with heavy rainshowers and strong gusty winds was moving from southwest to northeast across the airport at a speed of about 15 kns. The ceiling in the storm was between 200 and 400 ft obscured, and the surface visibility was about 1/4 mi. About the time of the accident the surface wind was 14 kns and gusting to 36 kns. The RVR for runway 27R was-about 1,600 ft, and the surface wind was from the southwest.

The storm which developed to its peak intensity rapidly was not considered by radar specialists to be of reportable intensity until 1717--after Flight 121 had crashed. The approach control radar did not depict the area of precipitation because of the nearness of the storm to the radar antenna and because its radar equipment is designed to suppress precipitation returns in order to improve its traffic display. The approach controller could not see outside because his duty station had no windows. Consequently, his knowledge of the immediate weather situation was obtained from communication with flightcrews and control tower personnel.

Though the rain was reported as moderate between 1704 and 1719, the rainfall graph disclosed that heavy rain was in progress. Neither the tower nor the National Weather Service weather observer reported less than 1 mi visibility. The weather reports, performance studies, and the results of simulations indicate that a severe horizontal and vertical wind shear existed along the final approach and missed approach paths. The exact magnitude of the horizontal and vertical components of the winds in the shear could not be determined.

Based on the testimony of ground witnesses and on National Weather Service data, the Safety Board concludes that the storm was of short duration but contained a core of intense rain and strong horizontal and vertical winds buried in a larger area of precipitation. Flight 121 arrived over the threshold of runway 27R almost simultaneously with the most intense portion of the thunderstorm.

The flightcrew of Flight 121 was well aware of the storm since they could see it and contour it on their radar, and, later during the approach, through their windscreen. When they first noticed the cell on their radar, they believed that they could land before it arrived over the airport. Their comments, as recorded on the CVR, indicate that they also knew of the changing visibility, changing wind direction, and changing wind speed. The captain's testimony indicated, as he drew closer to the airport, he realized that the storm was intense and that it was raining quite heavily on the west side of the airport.

The RVR data at the airport also corroborate the position of the Storm at the time of the crash. Flight 121 received no RVR information from ATC. Had the flight been advised that the RVR had gone below minimums before passing the OM, the pilot would have been required to discontinue the approach. The transmissometer recording data disclose that the RVR went below minimums about 1707, and this information should have become available on the digital readout displays sometime after that. Flight 121 was cleared from the approach control frequency at 1707:50. Since it is impossible to fix the exact time that the approach controller would have had the RVR information available to him the Safety Board cannot positively conclude that he had the opportunity to pass this information to the flight before he released the flight to the tower.

Flight 121 called the tower at 1708, but the tower did not acknowledge. The flight overflew the OM at 1708:40, and, because of heavy communications traffic between the tower and two other aircraft, was unable to establish contact and apprise the tower of that fact until 1709:13. At the moment that Flight 121 first called the tower and during the next 40 sec before the OM was crossed, Eastern Airlines Flight 376 was executing a go-around. The controllers were trying to ascertain that flight's position, the pilot's intentions, clear him from the area, and coordinate his missed approach and subsequent routing with departure control. At the same time Ransome 737 was about 1 min behind Flight 376 and was approaching to land on the same runway. Also, another flight was taxiing for takeoff on another runway. Because of the controllers' priorities of traffic separation and the resultant problems created by the go-around of Flight 376, they failed to note that the RVR had fallen below minimums and failed to inform Flight 121 of this fact during the 40 sec before the flight overflew the OM. In fact, the evidence indicated that the controllers were not aware that Flight 121 was on the frequency until after it had passed the OM. The first communication from the flight acknowledged by the tower was their "by the marker" call at 1709:13.

However, the Safety Board concludes that the tower controllers were remiss in their duties by not informing Flight 121 of the RVR values after the flight reported inside the marker. At that time the rain was so intense that the controllers were unable to see landing and taxiing traffic. Under these conditions prudence and common sense dictated that RVR data on the landing runway be checked and transmitted to arriving aircraft as well as the fact that rain was heavy on the airport. Timely transmission of these data would have assisted the crew in their evaluation of the weather. Since rainfall has a direct relationship to RVR, these data would have furnished the crew additional information with which to assess the intensity of the storm and its effects on the touchdown zone.

The Safety Board also concludes that the approach of Flight 121 after the OM was passed was conducted in visual conditions until the go-around was initiated. Although the captain testified that his decision to go-around was based on his visual assessment of the deteriorating weather, he did not execute the missed approach until 3 secs after the tower reported that the wind was from 210° at 35 kns. This wind exceeded Allegheny's maximum crosswind component for landing, and his receipt of that information prompted his decision to go-around.

The evidence disclosed that the core of the storm was over the center of the airfield from 1707 to 1710 and was moving in an easterly direction toward Flight 121's touchdown point. The conversations between the tower and the Northwest and Ransome flights confirm this. At 1709:46, the first officer of Flight 121 said he could see the runway. From that time on, the storm and its associated rainfall was visible to the captain and first officer, and it should have been apparent to them that it was within 1 mi of their touchdown point and moving toward them. They were als aware that there might be unstable wind conditions associated with the rain from the tower's conversation with landing aircraft directly in front of them. Further, they knew another air carrier aircraft ahead of them execut a go-around and they attributed the go-around to a wind shift. Without doubt, the captain was aware at the OM or shortly thereafter that he could not land without approaching the Storm, that his landing rollout most certainly would take him into the area of rain, and that he ran the risk of entering the storm's leading edge before he could land.

Pilots have been exposed constantly to data warning them of the hazards related to wind shifts and extreme gusts preceding thunderstorms, and to information concerning the perils involved in conducting takeoffs and landings within, or in the vicinity of, thunderstorms. The Allegheny

"Flight Operations Manual" also cautioned pilots on this subject. The weather-related information available to the crew throughout the approach provided sufficient data for them to assess the storm's position, to anticipate the presence of a potentially severe low level wind shear, and sufficient time for them to avoid penetrating it at a low altitude.

The Safety Board, therefore, concludes that the approach should have been abandoned at or shortly after passing the OM, and that this action should have been taken before they were in a position that required the missed approach to be conducted within the storm.

The crew of Flight 121 performed the initial go-around precedures by applying power, rotating to a climb attitude, positioning the flaps, and when a positive rate of climb was established, raising the landing gear. The captain said that he maintained the attitude dictated by the command bars on the flight director instrument until the aircraft hit the ground. When the go-around was begun, the airspeed was more than adequate; therefore, based on their knowledge of the power available in the DC-9, the crew could expect the aircraft to climb out without much difficulty. In order to determine why the aircraft did not climb as expected, the Safety Board examined the following: (1) The capability of the aircraft to cope with the existing weather, (2) the adequacy of the crew's procedures for assuring that all of the aircraft's go-around potential was used; and (3) the validity of the aircraft's instrument presentation, particularly that of the speed command system, in a horizontal and vertical wind shear environment.

The results of simulated flights conducted through wind models 3, 4a, and 5a using 1.86 EPR thrust level and a pitch attitude time history designed to approximate that of Flight 121, as determined in the theoretical analysis of the aircraft's flightpath, demonstrated that with these procedures the aircraft was probably not capable of traversing combined horizontal and vertical wind shears of the magnitudes contained in wind models 4a and 5a. The series of flights conducted without the use of the speed command instrumentation and controlling pitch attitude by trying to maintain V_2 speed generally were not successful. These unsuccessful flights support the conclusion that, without precise pitch guidance and control, the aircraft was probably not capable of traversing these horizontal and vertical wind shears.

The simulation program indicated that the aircraft was capable of traversing the wind shears in models 3, 4a, and 5a, when flown with precise adherence to pitch angles commanded by the speed command system. However, this performance required a temporary sacrifice of indicated airspeed to values well below V_2--in some instances approaching the stall speed--to sustain the dictated pitch angles. Simulations indicate that the use of takeoff thrust (1.93 EPR) would have enhanced the aircraft's performance, however, precise adherence to the pitch attitude dictated by the command bars was essential to a successful go-around in the simulated wind conditions, and the minimum speeds attained were still below V_2.

Simulation demonstrated that the flight director command bars functioned as designed in the go-around mode and almost continually commanded a 15° pitch attitude. Those instances where lower angles were commanded occurred after the aircraft's nose had been lowered, and in **no** instance did they precede a change in the aircraft's pitch attitude to command an attitude below that being flown by the pilot. The simulation results indicated that the go-around mode of the speed command system was an effective aid in assisting the pilots to traverse wind shears of the magnitude contained in wind models 3, 4a, and 5a.

The simulation and the captain's testimony tend to confirm that he probably rotated the aircraft to the attitude dictated by the command bars at the beginning of the go-around. However, as his airspeed decreased he lowered the nose to a pitch attitude of about 2° in an attempt to revers the airspeed decay and regain V_2 speed as dictated by his training. As the descent rate and airspeed increased he probably then rotated the aircraft to the pitch angle dictated by the command bars. This probably occurred about 2 to 3 secs before impact and did not arrest the rate of descent. Since the aircraft pitch angle was below 5° at the beginning of the rotation the command bars would have been below 15° at that time but still commanding a positive pitch input. The evidence indicated that the captain's recollection of the command bar's display was erroneous.

Based **on** the first officer's recollection of the go-around power setting, the Safety Board concludes that the flightcrew did not follow pregcribed company procedures for setting their thrust for the go-around.' As a consequence of this the EPR setting was about .06 to .07 EPR below the target level. Thus, the flightcrew did not avail themselves of the full power potential of the engines. However, the simulator and performance studies disclosed that the capability of the aircraft to cope with the wind models was--when the aircraft was flown within the constraints of approved operating procedures for the go-around--marginal even when **1.93** EPR was used.

The captain's testimony indicated that he flew his aircraft in accordance with existing procedures. If, as appears to be indicated by simulation, the aircraft possessed additional aerodynamic potential to counter the effect of the wind shear, the potential existed in a regime of flight of which he may not have been aware and for which he had **no** training. The results of these simulations have been confirmed by other sources. To cite one example, an Eastern Airlines 727 crashed while executing an instrument approach to John F. Kennedy International Airport, New York, through a thunderstorm-related wind shear. Just before the crash an Eastern Lockheed 1011 successfully executed a go-around through the same wind shear. The pilot was "unable to arrest the aircraft's descent until he had established a high noseup attitude and had applied near maximum thrust." The pilot of the 1011 also stated that his airspeed had dropped to about "10 kn below the bug." 3/

The Safety Board also is cognizant of recent wind shear studies conducted by airframe manufacturers. 4/ The studies indicate that aircraft performance in wind shear conditions can be improved by using pitch and airspeed control techniques which exceed those set forth in the recommended procedures for landings, takeoffs, and go-arounds in most air carrier flight and procedure manuals. Since these procedures had not been adopted by either the FAA or the air carriers, the crew of Flight 121 and other air carrier crews have not been officially trained or briefed on these techniaues and may not be aware of them.

The survival of all on board Flight 121 was the result of a combination of several favorable factors. The aircraft hit the ground in a tail-low, wings-level attitude with the landing gear retracted and slid along level terrain. Consequently, the fuel tanks did not rupture. Since the tail section and the engines separated from the fuselage and since likelihood of ignition was reduced, there was no fire. Injuries resulted from vertical loads of at least 10 G's caused by the initial impact of the rear fuselage with the ground, followed by the nose impact. Few if any injuries were caused by the aircraft's sliding on level ground because the aircraft's speed dissipated over a considerable longitudinal distance, which produced low deceleration forces.

The forward flight attendant recalled that she was not in her seat at impact. However, the forward jumpseat will not remain in the down position if it is unoccupied, and the manufacturer's study indicated that the impact forces were not sufficient to unstow it. Therefore, it had to be unstowed by the flight attendant who was either occupying it or in the process of seating herself at impact. The analysis of the failure mode of the seat and the type of compression fracture sustained by the flight attendant support the conclusion that the flight attendant was occupying the jumpseat at impact, but had not yet fastened her seatbelt and shoulder harness.

3/ National Transportation Safety Board Accident Report NTSB-AAR-76-8, Eastern Airlines, Inc., Boeing 727-225, N8845E. John F. Kennedy International Airport, Jamaica, New York, June 24, 1975.

4/ Boeing Airliner, January 1977, "Hazards of Landing Approaches and Takeoffs in a Wind Shear Environment." "Wind Shears on Final Approach" C. A. Whitmore and R. C. Cokely, Lockheed California Company.

3. CONCLUSIONS

3.1 Findings

1. There was no evidence of any failure or malfunction of aircraft structure, flight instruments, flight controls, or powerplants.

2. Flight 121 was conducting an ILS approach to runway 27R. While the approach was in progress a mature thunderstorm with heavy rainshowers and gusty winds was moving from southwest to northeast across the airport. The core of the storm was over the center of the airport between 1707 and 1710.

3. The storm contained severe horizontal and vertical wind shears astride the final approach and missed approach course. The exact magnitude of the horizontal and vertical winds could not be determined.

4. The tower controllers should have delivered the below minimum RVR data when they acknowledged Flight 121's transmission that it was inside the OM or shortly thereafter.

5. The flightcrew had the storm under observation either on their radar or through the cockpit windshield from the time they entered the Philadelphia area. The storm cell was of sufficient intensity to contour on their radar.

6. There was sufficient weather data available for the crew to decide to abandon the approach at, or shortly after, passing the OM.

7. The aircraft was capable of traversing the wind shear speeds in simulated wind models 3, 4a, and 5a at 1.86 EPR only if flown with precise adherence to the pitch angle dictated by the command bars even though indicated airspeeds dropped below V_2.

8. The captain did not maintain the pitch attitude commanded by the command bars throughout the approach. The nose was lowered, probably to a pitch attitude of about 2°, in an effort to regain V_2 speed. The aircraft was probably rotated to the pitch attitude dictated by the command bars just before the crash.

9. Although the crew did not follow prescribed company procedures for setting their thrust for the go-around, the captain otherwise attempted to conduct the go-around in accordance with the procedures contained in his company's manuals.

3.2 Probable Cause

The National Transportation Safety Board determines that the probable cause of this accident was the aircraft's encounter with severe horizontal and vertical wind shears near the ground as a result of the captain's continued approach into a clearly marginal severe weather condition. The aircraft's ability to cope under these conditions was borderline when flown according to standard operating procedures; however, if the aircraft's full aerodynamic and power capability had been used, the wind shear could probably have been flown through successfully. Contributing to the accident was the tower controller's failure to provide timely below-minimum RVR information.

4. SAFETY RECOMMENDATIONS

The National Transportation Safety Board has issued recommendations to the Federal Aviation Administration and to the National Weather Service urging that they initiate a method for displaying precipitation on approach control radarscopes and for classifying these returns so that the controller could relay the classification to the pilot. The controller would, thereby, be relieved of interpreting the returns. These recommendations were made as a result of the investigations of the crash of Flight 121 and a Southern Airways DC-9 at New Hope, Georgia, on April 4, 1977.

On September 27, 1977, the National Transportation Safety Board recommended that the Federal Aviation Administration:

"Expedite the development and implementation of an aviation weather subsystem for both en route and terminal area environments, which is capable of providing a real-time display of either precipitation or ~~turbulence~~ wind shear, or both and which includes a multiple-intensity classification scheme./ Transmit this information to pilots either via the controller as a safety advisory or via an electronic data link. (Class II - Priority Followup) (A-77-63)

"Establish a standard scale of thunderstorm intensity based on the NWS' six-level scale and promote its widespread use as a common language to describe thunderstorm precipitation intensity. Additionally, indoctrinate pilots and air traffic control personnel in the use of this system. (Class II - Priority Followup) (A-77-64)"

The FAA responded to recommendation A-77-63 and 64 on December 8, 1977, stating, in part:

Recommendation A-77-63

"In August 1975, the Air Traffic Service (ATS) initiated an R&D effort requesting: (a) en route and terminal radars be evaluated to ascertain their capabilities to detect and display weather: (b) a comparison of ARSR/ASR and National Weather Service (NWS) radar detection capabilities; (c) identification of modifications to improve ATC radars; and (d) improve ATC radar weather detection without derogation in aircraft detection.

"As of October 1 the following has taken place:

1. R&D has completed 2 years of data collection on the ASR (including New Orleans) and is finalizing a data collection effort on the ARSR. A decision will be made on our proposed solutions to weather detection and display problems, following receipt of an R&D final report to AAT-1, due in April 1978.

2. Three NWS radars have been remoted into the Atlanta ARTCC. (The NWS Tampa radar will be remoted to the Miami FSS.)

3. A comprehensive NWS radar evaluation is in progress in the Atlanta ARTCC. Guidelines for the evaluation of the Enterprise Electronics Corporation WR-100 Radar Data Remoting System being demonstrated are enclosed. (Enclosure 1)

4. ATS has established a $7.6M FY-79 program to improve weather detection and display. This program will provide a system for detecting and displaying radar weather echoes as calibrated contours of varying intensities in ARTCCs. Equipment will be procured to receive and process weather information which will be able to function independently of the radar signal processing used for aircraft target detection. The system will use a digital transmission over narrowband communications lines.

5. ATS has requested the National Oceanic and Atmospheric Administration to staff ARTCCs with meteorologists. The meteorologists will analyze radar weather returns and pilots will be informed by safety advisories.

6. Satellite weather imagery equipment has been validated as an ARTCC program.

7. The supervisory sections of ARTCCs are being remodeled to accommodate the expanded weather functions associated with en route control.

8. ATS and NWS conducted a Severe Thunderstorm Alert Test between June 15 and September 15. The 3-month program was designed to provide pilots available weather intelligence to assist them in avoiding severe thunderstorm areas. A similar test was conducted during the summer of 1976.

A total of 426 thunderstorm alerts were provided on 45 days out of the 93-day test. Considering the 45 days when alerts were provided, the average was over 9 alerts per day. The highest number of alerts in a single day was 37.

Field reports indicated that:. alerts were received long after avoidance actions were taken (reroute, deviations, radar vectors); flights sought to stay clear of areas below VIP Level 4 intensity and this action took place long before receipt of the alert; and, when the alert was received it was either no longer useful, superfluous, or provided at a time when the system was being taxed to its limit. The controller could ill afford to take the time to receive and/or disseminate the alert to the cockpit.

User organizations were alerted and feedback requested; however, no useful comments were received.

While no recommendations are being made for another test because of the apparent impracticability of this alert procedure, ATS will explore the feasibility of computer technology to develop an automated system to transmit storm intensities."

Recommendation A-77-64.

"ATS has taken appropriate steps for implementing the NTSB recommendation to establish a standard scale of thunderstorm intensity, based upon the NWS six-level scale. Action has been taken to promote widespread use throughout the Air Traffic Service of a common language to describe thunderstorm intensity. The DOT/FAA Notice N7110.510 dated June 12 served to acquaint air traffic control specialists with the descriptive terms developed by the NWS, and authorizes their use in the air traffic system.

"Thunderstorm intensity levels were published in the Airman's Information Manual, Part 3A, on September 1 (Enclosure 2). This publication advises pilots of the NWS standard six-level scale and cites examples of standard phraseology to be used by controllers describing thunderstorm intensity levels. Definitions, and an explanation of the standard six-level scale, will also be contained in the Pilot-Controller Glossary of the Air Traffic Control Manual and the Flight Service Station Manual, effective January 1, 1978."

On February 16, 1978, the Safety Board issued the following recommendation to the FAA:

> "Establish a joint Government-industry committee to develop flight techniques for coping with inadvertent encounters with severe wind shears at low altitude. (Class II - Priority Action) (A-78-3)"

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

/s/ KAY BAILEY
Acting Chairman

/s/ FRANCIS H. McADAMS
Member

/s/ JAMES B. KING
Member

PHILIP A. HOGUE, Member, dissenting:

Having reviewed all available information, I have concluded that the probable cause of subject accident should be stated as follows:

> "The National Transportation Safety Board determines that the probable cause of the accident was severe wind shear encountered as the result of a mandatory and unanticipated aborted landing. Contributing was the controller's failure to provide all available weather information in a timely manner."

The Captain, based on the Ransome aircraft's successful landing immediately preceding him, had every right to believe that he could continue his approach and land safely. I do not concur that the Captain "continued approach into a clearly marginal severe weather condition." By the time the Captain knew he was experiencing wind shear, it was too late to avoid it and had he known the true conditions at the time of his final approach, he would have aborted his approach earlier. Further, I do not concur that "if the aircraft's full aerodynamic and power capability had been used, the wind shear could probably have been flown through successfully." The foregoing statement, based on one simulation, is speculative, and will remain so until standard operating procedures for dealing with various degrees of wind shear are proven in the real world under actual conditions.

/s/ PHILIP ALLISON HOGUE
Member

January 19, 1978

APPENDIX A

Investigation and Depositions

1. Investigation

The National Transportation Safety Board was notified of the accident at 1730, June 23, 1976. Investigators were dispatched immediately to Philadelphia.

Working groups were established for structures, systems, powerplants, operations, air traffic control, weather, human factors, witnesses, flight data recorder, cockpit voice recorder, maintenance records, and aircraft performance. Parties to the investigation were Allegheny Airlines, Inc., Federal Aviation Administration, Air Line Pilots Association, Douglas Aircraft Company, Pratt & Whitney Aircraft, Group of United Technologies Corporation, the Association of Flight Attendants, Pennsylvania Department of Transportation, International Association of Machinists, and the Professional Air Traffic Controllers Organization.

Depositions

Depositions were taken of selected witnesses in Cincinnati, Ohio, Philadelphia, Pennsylvania, Pittsburgh, Pennsylvania, and Washington, D.C., on August 17, 18, and 20, and on September 9, 1976.

APPENDIX B

Personnel Information

Captain Carl W. Boyer

Captain Carl W. Boyer, 49, was hired by Allegheny Airlines, Inc., on April 21, 1952. He held an Air Transport Pilot Certificate No. 68249 with airplane multiengine land and type ratings in the DC-3; Convair 340, 440, and 580; and DC-9. He received his DC-9 type rating on October 30, 1969. He held a first-class medical certificate dated February 5, 1976. with the limitation that "holder shall have available a pair of correcting glasses while exercising the privileges of his airman certificate." The captain testified that he used his glasses during the flight to check the approach plate. He had accumulated about 25,000 flight-hours, 6,000 hours of which were in the DC-9 aircraft.

First Officer John R. Spencer

First Officer John R. Spencer, 39, was hired by Allegheny Airlines, Inc., on June 1, 1966. He held a Commercial Pilot Certificate No. 1527561 with airplane single and multiengine land and instrument ratings. He held a first class medical certificate dated April 12, 1976, with no limitations. He received a first officer's initial flight check in the DC-9 on September 26, 1968. He had accumulated about 11,000 flight-hours, 6,000 hours of which were in the DC-9 aircraft.

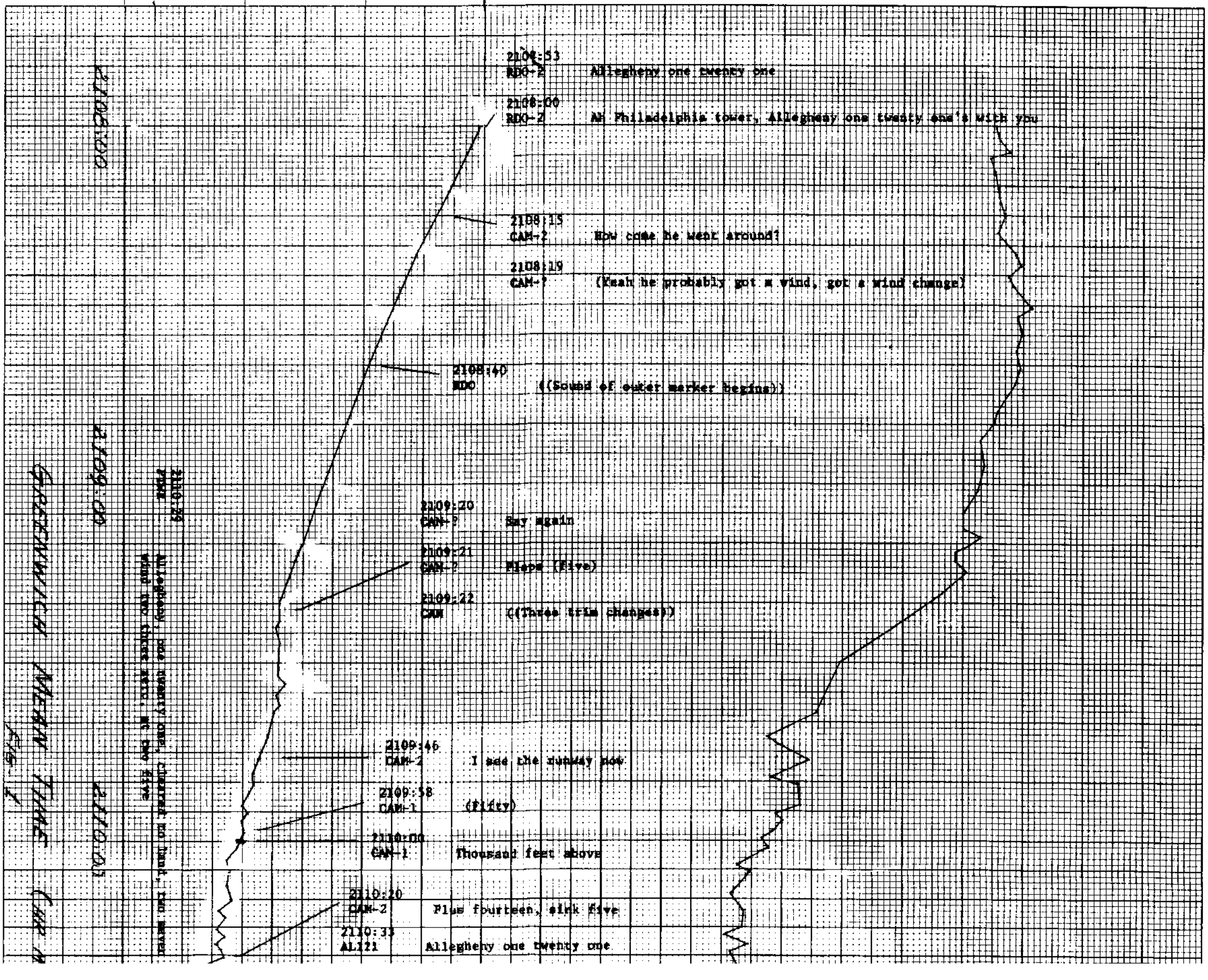
Flight Attendant Ildiko Tovolgyi

Flight Attendant Ildiko Tovolgyi, 34, was hired by Allegheny Airlines, Inc., on May 27, 1964. Her most recent recurrent emergency training was completed successfully on February 16, 1976, and her most recent observation flight check was completed successfully on Yay 18, 1976.

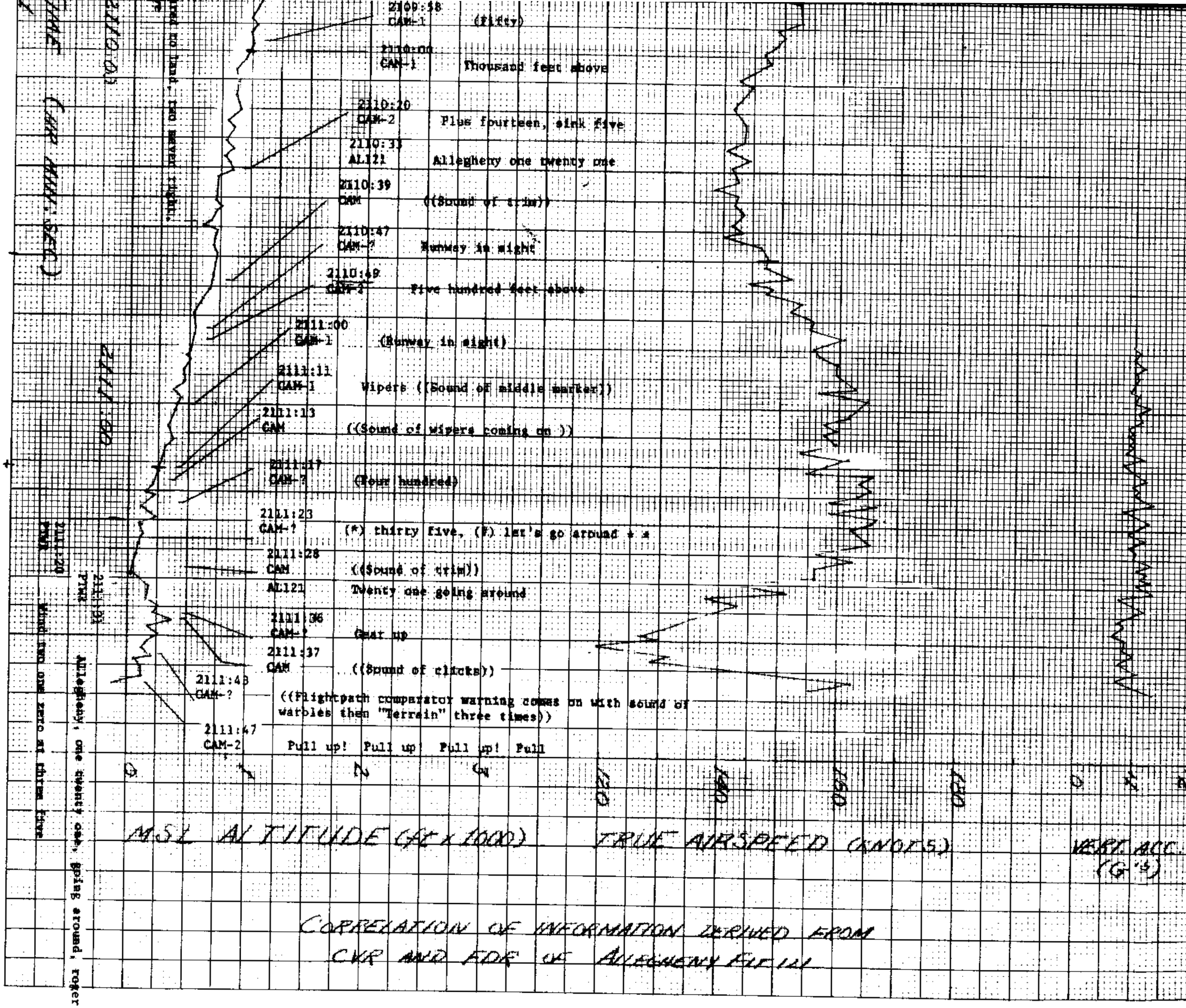
Flight Attendant Marsha Morris

Flight Attendant Marsha Morris, 25, successfully completed her 80-hour initial training on June 16, 1976.

Both flight attendants were qualified on the DC-9-30, and DC-9-50 aircraft.



2107:53
RDO-2 Allegheny one twenty one
2108:00
RDO-2 Ah Philadelphia tower, Allegheny one twenty one's with you
2108:15
CAM-2 How come he went around?
2108:19
CAM-? (Yeah he probably got a wind, got a wind change)
2108:40
RDO ((Sound of outer marker begins))
2109:20
CAM-? Say again
2109:21
CAM-? Flaps (Five)
2109:22
CAM ((Three trim changes))
2109:46
CAM-2 I see the runway now
2109:58
CAM-1 (Fifty)
2110:00
CAM-1 Thousand feet above
2110:20
CAM-2 Plus fourteen, sink five
2110:33
AL121 Allegheny one twenty one
2110:29
PHL Allegheny one twenty one, cleared to land, two seven
wind two three zero at two five
2108:00
2109:00
2110:00
GREENWICH MEAN TIME (HR



CORRELATION OF INFORMATION DERIVED FROM CVR AND FDR OF ALLEGHENY FLT 121

APPENDIX E

APPENDIX C

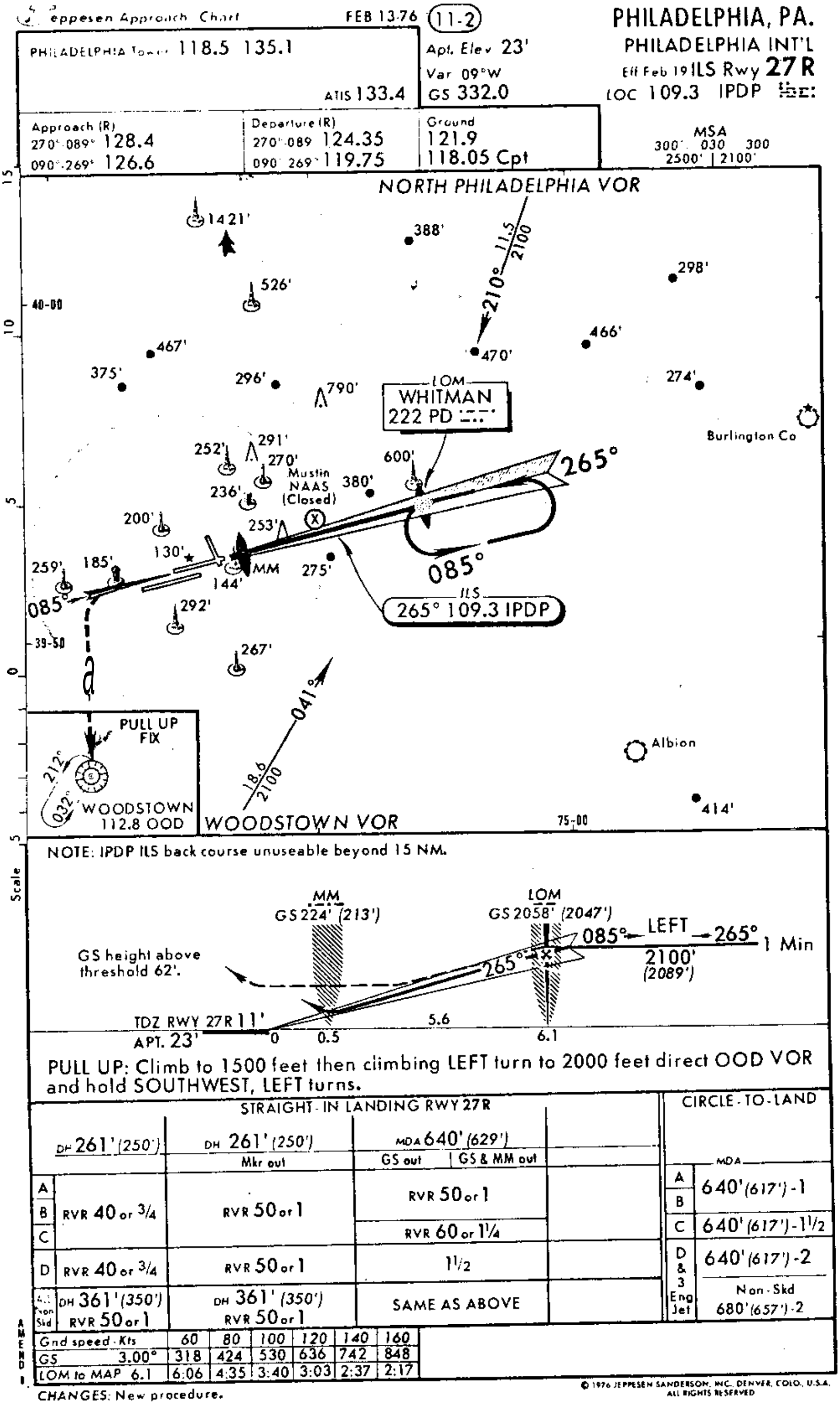
Aircraft Information

The aircraft was a Douglas DC-9-31, N994VJ, manufacturer's serial No. 4733. The aircraft was manufactured by the McDonnell Douglas Company on March 28, 1969. The aircraft had accumulated 21,320 hours. The last transit check was performed on June 23, 1976, at 21,317 hours 50 minutes. The last "A" check (through service) was performed on June 9, 1976, at 21,218 hours.

The aircraft was equipped with two Pratt & Whitney JT8D-7A engines. Engine serial numbers and times follow:

Engine	Serial No.	Total Time (hrs)	Time Since Engine Heavy Maintenance (hrs)
No. 1 (left)	P 657439D	18,528	2,549
No. 2 (right)	P 657473D	18,756	2,531

APPENDIX D



"ILLUSTRATION ONLY - NOT TO BE USED FOR NAVIGATIONAL PURPOSES"

APPENDIX F

TRANSCRIPT OF CVR TAPE FROM AN ALLEGHENY AIRLINES DC-9 WHICH CRASHED AT PHILADELPHIA, PA., ON JUNE 23, 1976

LEGEND

CAM	Cockpit area microphone voice or sound source
RDO	Radio transmission from accident aircraft
-1	Voice identified as Captain
-2	Voice identified as First Officer
-?	Voice unidentified
UNK	Unknown
*	Unintelligible word
	Nonpertinent word
%	Break in continuity
( )	Questionable text
(( ))	Editorial insertion
---	Pause
PAPP	Philadelphia Approach Control
PTWR	Philadelphia Tower
737	Miscellaneous aircraft
A398	Miscellaneous aircraft
53L	Miscellaneous aircraft
E140	Miscellaneous aircraft
E876	Miscellaneous aircraft
NW59	Miscellaneous aircraft
AL121	Radio call from Allegheny 121 which does not appear on the CAM channel
100SR	Miscellaneous aircraft

Note: Times are expressed in Greenwich Mean Time.

TIME & SOURCE	CONTENT
PAPP	Seven thirty seven, your traffic is an Eastern seven twenty seven, right now he's at one o'clock and four miles west-bound at twenty four hundred feet
2103:49 737	Okay we're looking
2103:52 737	Got 'em in sight
2103:53 PAPP	Allegheny three ninety eight, turn left to a heading of, oh, zero seven zero
2103:58 A398	Zero seven zero, three ninety eight
2104:01 PAPP	Allegheny one twenty one, reduce your airspeed to two one zero
2104:04 RDO-2	Two one zero, Allegheny one twenty one, roger
2104:07 PAPP	Eastern eight seventy six, tower one eighteen five
2104:09 CAM-?	Got a hole * *
E185	Eighteen five
2104:11 PAPP	Seven thirty seven, you did say you had Eastern, right?
2104:13 737	Yes sir
2104:14 PAPP	Cleared visual approach, runway two seven right to follow Eastern seven twenty seven
2104:18 737	Roger
2104:19 CAM	((IPDP identifier heard in background))
2104:23 CAM-1	Fuel pump on, crossfeed off, and all that jazz. Brake pressure selector, hydraulic pressures and pumps. (One) one five ninety one (one two ten), altimeter seventeen, shoulder

TIME & SOURCE	CONTENT
2104:42 CAM-?	Harness, three rings. ((Three rings can be heard))
2104:45 CAM-?	* *
2104:56 PAPP	Seven thirty seven call the tower one eighteen five
2104:56 CAM-?	* *
2105:05 CAM-1	* *
2105:09 RDO-2	Philadelphia Allegheny one twenty one's in range
2105:13 RDO-?	One twenty one in range, Philly, gate on the ground
2105:15 CAM-?	* *
2105:20 PAPP	Allegheny one twenty one descend and maintain two thousand one hundred. sir
2105:23 RDO-2	Allegheny one twenty one down to two thousand one hundred, here we go outta five
2105:28 PAPP	Allegheny three ninety (we're going to give) you a visual to put you behind company now on the ILS, the visibility is one to two miles
2105:44 CAM-1	Two miles
2105:46 A398	Okay three ninety eight, ah, believe we have them in sight
2105:47 CAM-?	Part of that storm sitting on the end of the runway
2105:49 CAM-2	Yeah

TIME & SOURCE	CONTENT
2105:53 PAPP	He's coming up off your twelve up o'clock position now, about five miles
2105:58 A398	Ah okay
2106:06 PAPP	Twenty one you should be intercepting the localizer about another mile and a half. Let me know if you're receivin' the localizer there, okay?
2106:12 RDO-2	One twenty one
2106:13 PAPP	Okay start reducing your airspeed to a hundred and eighty, sir
2106:18 CAM-1	(Slats)
2106:19 RDO-2	One eighty, for Allegheny one twenty one, coming up
2106:20 PAPP	One twenty one, you coming into it now?
2106:22 CAM-1	That's affirm, yeah
2106:23 RDO-2	Affirm, it shows coming in
2106:28 CAM-1	We're fourteen miles from the end of the runway
2106:30 CAM-2	Yeah
2106:32 CAM-1	So that storm (* * *), I hope
2106:38 CAM-1	And the gear
2106:39 PAPP	Allegheny one two one, you are cleared for the approach, you're five miles from the outer marker, cross the outer marker at twenty one hundred

TIME & SOURCE	CONTENT
2106:42 CAM	((Sound resembling gear extension))
2106:44 RDO-2	Allegheny one twenty one is cleared for the approach, ah, on the right side
2106:47 PAPP	Two seven right
2106:52 E140	Philadelphia Approach Eastern one forty, six thousand
2106:56 PAPP	One firty, roger, say your heading
2106:58 E140	Zero eight zero
2107:03 PAPP	One forty cay heading again, sir
2107:05 E140	Zero eight zero
2107:07 PAPP	Zero eight zero, okay, thank you
2107:09 E140	How about ninety degrees?
2107:13 PAPP	Ninety degrees, all right, one forty
2107:15 E140	Okay, fine
2107:26 PAPP	Allegheny three ninety eight, turn left, heading, three six zero
2107:30 A398	Three six zero, three ninety eight
2107:37 PAPP	(One hundred sugar) romeo, turn right to a heading of two five zero, intercept the localizer. Fly it inbound, sir
2107:42 100SR	All right, two five zero, intercept the localizer inbound, one hundred SR

TIME & SOURCE	CONTENT
2107:50 PAPP	Allegheny, one twenty one, you're three from the marker now. Tower one eighteen five
2107:53 RDO-2	Allegheny one twenty one
2108:00 RDO-2	Ah Philadelphia tower, Allegheny one twenty one's with you
2108:05 PTWR	Eight seventy six re-- are you on the runway, sir?
2108:06 CAM	((Sound of altitude alert))
2108:09 E876	Eastern eight seventy six going around
2108:10 PTWR	Eastern eight seventy six, understand, going around
2108:15 CAM-2	How come he went around?
2108:19 CAM-?	(Yeah he probably got a wind, got a wind change)
2108:22 CAM-?	(Yeah)
2108:27 CAM-?	(Do you want high speeds closed)?
2108:30 CAM-?	(**) yeah. ((Clunk))
2108:35 PTWR	Eastern eight seventy six, proceed direct Woodstown at two and contact departure, correction, contact approach one two six point six
2108:40 RDO	((Sound of outer marker begins))
2108:44 E876	Direct Woodstown at two, one two six point six, Eastern eight seventy six
2108:47 PTWR	Northwest fifty nine, ah, Northwest fifty nine, are you still on the runway, sir?

TIME & SOURCE	CONTENT
2108:53 Nw59	Yes sir we're in takeoff position on the end of the runway
2108:54 CAM	((Altitude alert at word "position"))
2108:55 PTWR	And you're not going to take off, is that right sir? The RVR now two eight
2108:59 Nw59	Oh, no way
2109:00 PTWR	All right
2109:02 PTWR	* seven thirty seven * do you have the runway in sight
2109:06 737	Ah, we're about to touch down
2109:08 PTWR	Cleared to land, wind two two zero at three five, thank you
2109:10 CAM-2	(Two two zero at three five)
2109:13 RDO-2	Allegheny, one twenty one, is by the marker
2109:14 PTWR	One twenty one roger, continue for the right side
2109:17 PTWR	Northwest fifty nine, Philadelphia
2109:09 CAM-?	Get the flaps *
2109:20 CAM-?	Say again
2109:21 CAM-?	Flaps (five)
2109:22 CAM	((Three trim changes))
Note	((Radio transmission in background The radios ceased recording at this point))

TIME & SOURCE	CONTENT
2109:29 NW59	Okay
2109:39 AL398	Philly tower, Allegheny three nienty eight's, with you
2109:43 PTWR	Allegheny, two ninety eight, three ninety eight, roger continue
2109:46 CAM-2	I see the runway now
2109:48 PTWR	Ransome, seven thirty seven, clear at bravo and report clear of the runway for me
2109:50 CAM-1	The left side though, is it?
2109:53 CAM-2	No, the right side
2109:54 CAM	((Sound of trim))
2109:55 CAM-1	Is it? Oh yeah
2109:58 CAM-1	(Fifty)
PTWR	Ransome seven thirty seven, Philadelphia tower, what is your position on the runway
2110:00 CAM-1	Thousand feet above
2110:01 CAM-2	(Ah, yeah)
2110:02 CAM-1	Okay
737	Okay we're on the runway now and ah, we'll be getting off here in a second
2110:05 PTWR	At what position, sir?

TIME & SOURCE	CONTENT
2110:07 CAM	((Sound of trim))
2110:08 737	Ah we're between whiskey and, ah, charlie, we couldn't see there for a minute
2110:12 PTWR	Okay strai-- strai-- straight ahead, straight ahead and turn right at bravo, with no delay, sir
2110:14 CAM-?	(* * *)
2110:19 737	Okay
2110:20 CAM-2	Plus fourteen. sink five
2110:26 CAM-1	Twenty five (knots of wind) huh?
2110:27 CAM-2	Yeah (two thirty) at twenty five
2110:28 CAM-?	Yeah
2110:29 PTWR	Allegheny, one twenty one, cleared to land, two seven right, wind two three zero, at two five
2110:33 AL121	Allegheny one twenty one
2110:34 CAM-?	* *
2110:35 PTWR	Northwest fifty nine report clear of the runway
2110:37 NW59	Roger
2110:39 CAM	((Sound of trim))
2110:47 CAM-?	Runway in sight

TIME & SOURCE	CONTENT
2110:48 56L	Philadelphia, five six lima, I'd like to go back to Atlantic'. Can I, ah, go out on the runway to get turned around
2110:49 CAM-2	Five hundred feet above
2110:55 PTWR	Five six lima, roger, taxi on runway one seven
2110:58 56L	Okay
2111:00 CAM-1	(Runway in sight)
2111:04 PTWR	Five six lima, turn right off the runway, contact ground one two one point nine
2111:09 56L	Okay
2111:11 CAM-1	Wipers ((Sound of middle marker))
2111:13 CAM	((Sound of wipers coming one))
2111:17 CAM-?	(Four hundred)
2111:20 PTWR	Wind two one zero at three five
2111:23 CAM-?	(*) thirty five, (#) let's go around * *
2111:28 CAM	((Sound of trim))
AL121	Twenty one going around
2111:31 PTWR	Allegheny, one twenty one, going around, roger
2111:36 CAM-?	Gear up
2111:37 CAM	((Sound of clicks))

APPENDIX F

TIME & SOURCE	CONTENT
CAM	((Cockpit gets quiet))
2111:43 CAM–?	((Flightpath comparator warning comes on with sound of warbles then "Terrain" three times))
2111:47 CAM–2	Pull up! Pull up! Pull up! Pull
2111:48	((End of tape))

Note: ((The condition of the tape is poor enough that identification of the crewmembers is the best available but not to be considered final)).

NATIONAL TRANSPORTATION SAFETY BOARD
Bureau of Aviation Safety
Washington, D. C.

September 20, 1976

AMENDMENT TO SPECIALIST'S FACTUAL REPORT
COCKPIT VOICE RECORDER

A. ACCIDENT

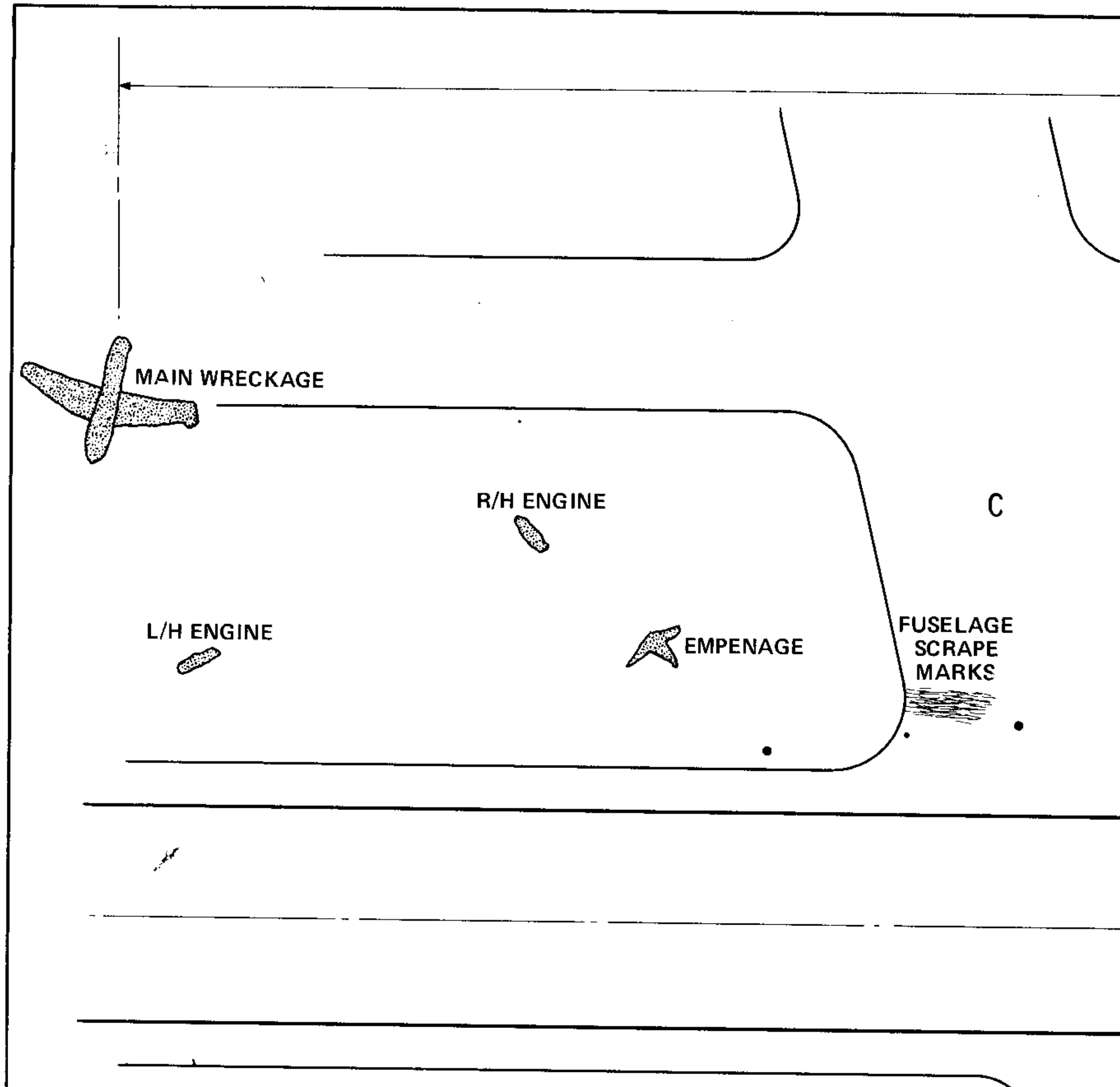
Location: Philadelphia, Pennsylvania
Date : June 23, 1976
Operator: Allegheny Airlines
Aircraft: DC-9
CVR : Sunstrand V557, S/N 2106
NTSB No.: DCA 76-A-2029

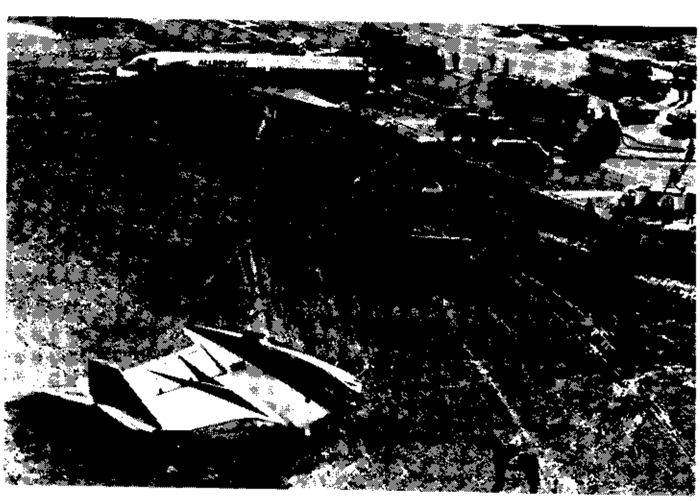
The following change should be made to the factual report and transcript.

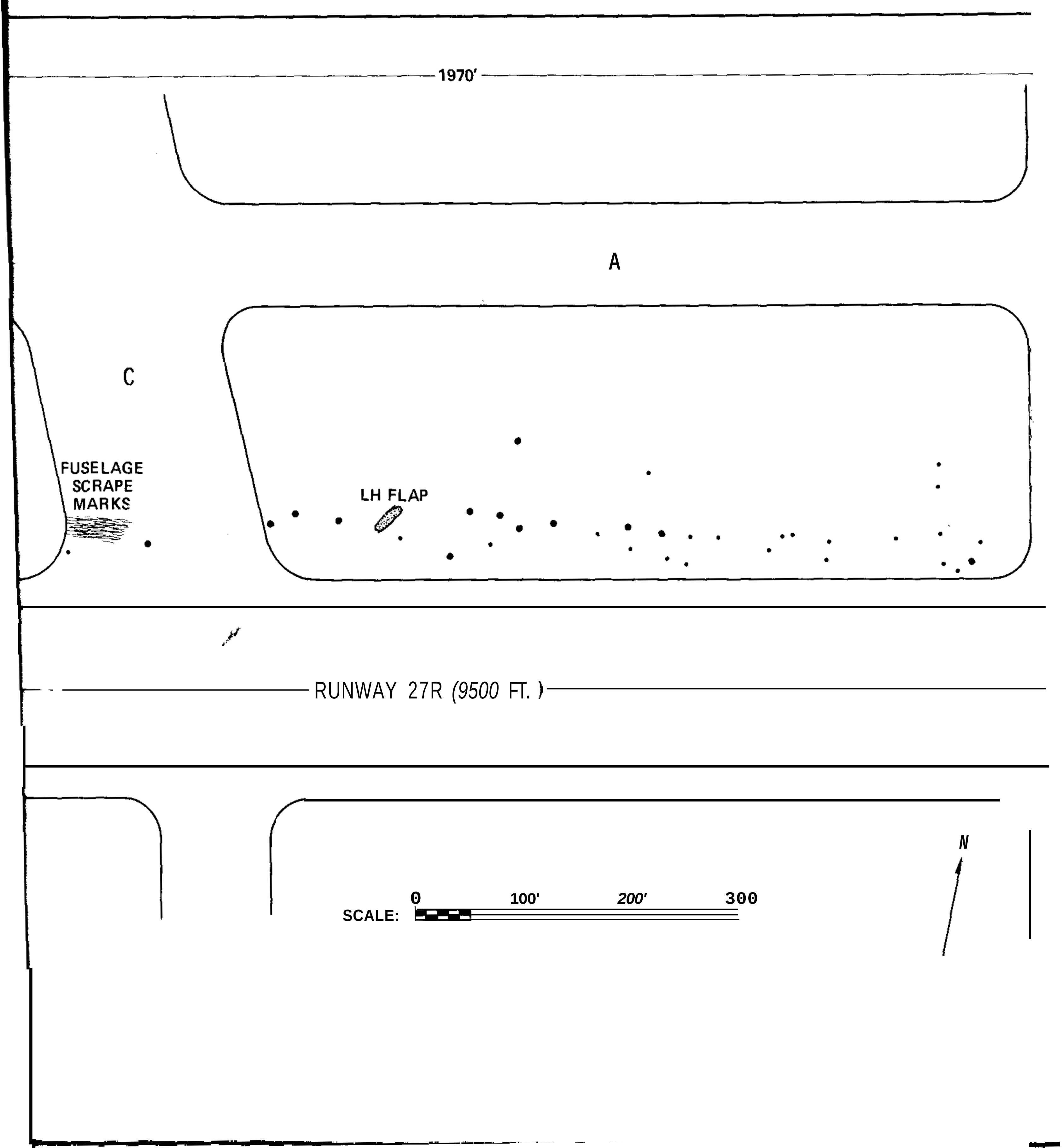
Reference paragraph "C. DETAILS OF INVESTIGATION"

The second paragraph stated that the track assignment was improper. In reality, the track numbering by Sunstrand is not the same as the audio lab and the CAM channel was in the normal position as, was presumably, the captain's radio channel. Therefore, delete the last two sentences which refer to the track assignment.

Paul C. Turner
Paul C. Turner
Aerospace Engineer


MAIN WRECKAGE
R/H ENGINE
C
L/H ENGINE
EMPENAGE
FUSELAGE
SCRAPE
MARKS




1970'
A
C
FUSELAGE SCRAPE MARKS
LH FLAP
RUNWAY 27R (9500 FT.)
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SCALE:
0
100'
200'
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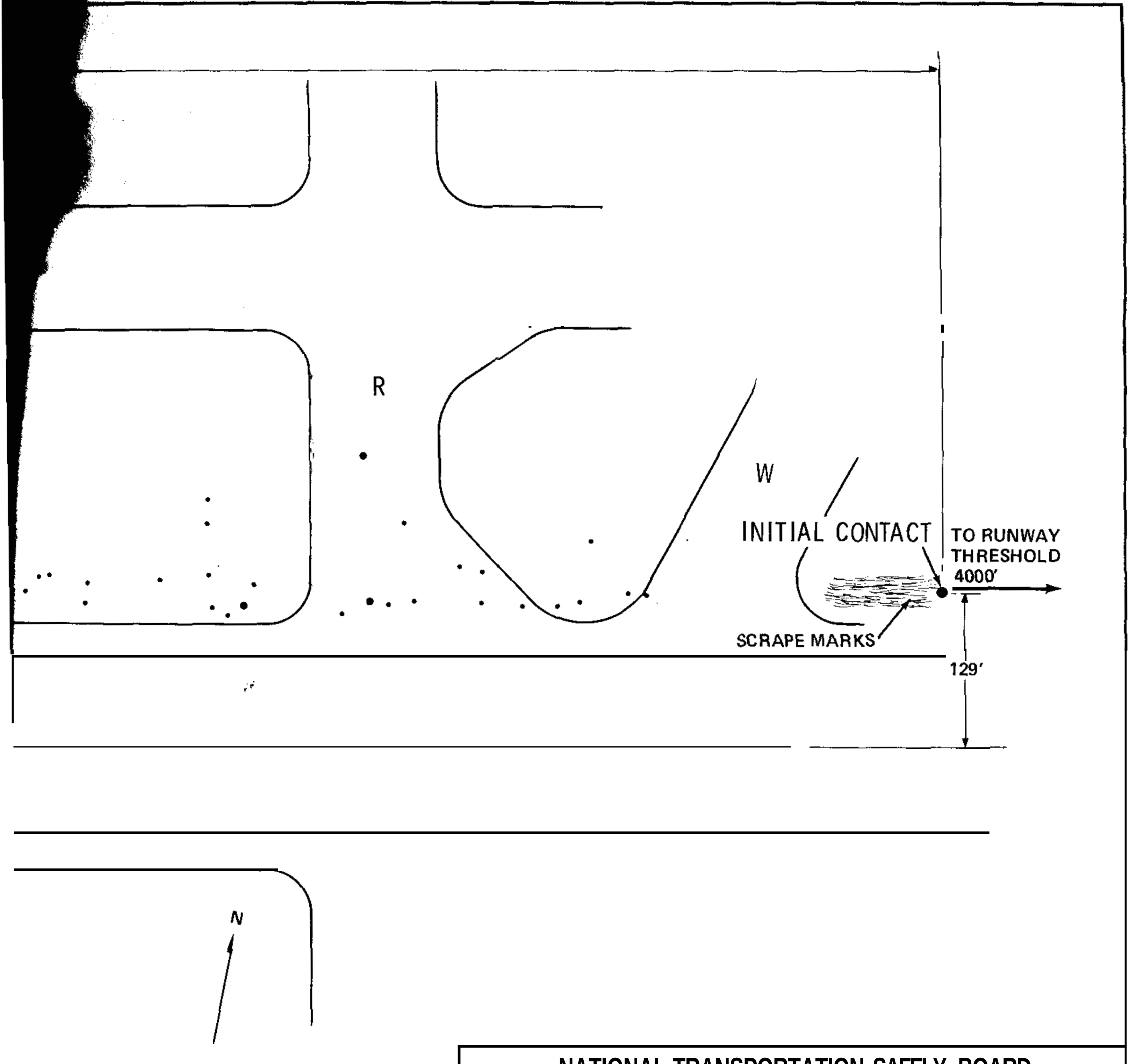

NATIONAL TRANSPORTATION SAFELY BOARD
WASHINGTON, D.C.

WRECKAGE DISTRIBUTION CHART
ALLEGHENY AIRLINES, INC. DOUGLAS DC-9-30-N994VJ
PHILADELPHIA INTERNATIONAL AIRPORT, PENNSYLVANIA
23 JUNE 1976

APPENDIX H

Simulated Wind Models

The horizontal wind velocities in these models are expressed in either headwind (+) or tailwind (-) values. All vertical velocities are downward in direction and are expressed in ft per second (fps). The location of the wind changes are expressed in feet before the runway threshold (BT) and past the threshold (PT).

All wind models begin with a constant headwind of +12.5 kns from the OM to a point 12,700 ft BT.

Model A

No Wind

Model 3

Horizontal Winds: From 12,700 BT to 600 BT, the wind increases from +12.5 kns to +64 kns; from 600 BT to 2,700 PT, the wind decreases from +64 kns to -2 kns; from 2,700 PT to 3,700 PT, the wind increases from -2 kns to +9 kns; and from 3,700 PT to 4,000 PT, the wind decreases to zero. This model does not contain vertical winds.

Model 4a

Horizontal Winds: From 12,700 BT to 2,400 BT, the wind increases from +12.5 kns to +52 kns and remains constant at +52 kns until 400 BT, from 400 BT to 2,700 PT, the wind decreases from +52 kns to 12 kns; from 2,700 PT to 3,700 PT, the wind increases from 12 kns to 30 kns; and, from 3,700 PT to 4,000 PT, it decreases from 30 kns to 20 kns.

Vertical Winds: Between 300 BT to 2,000 PT, the velocity increases from zero to 30 fps and remains constant at that value to 3,200 PT. Between 3,200 PT and 4,000 PT, the velocity decreases from 30 fps to zero.

Model 5a

Horizontal Winds: The same as in Model 4a.

Vertical Winds: Between 1,500 BT to 900 PT, the velocity increases from zero to 20 fps and remains constant at 20 fps to 3,100 PT. Between 3,100 PT and 4,000 PT, the velocity decreases to zero.

Model 4b

Horizontal Winds: The same as in Model 4a to 2,700 PT, from 2,700 PT to 3,800 PT the wind increases from 12 kns to 38 kns; and, from 3,800 PT to 4,000 PT the wind decreases from 38 kns to 34 kns.

Vertical Winds: Between 300 PT to 2,000 PT the velocity increases from zero to 30 fps and remains constant at 30 fps to 3,100 PT; between 3,100 PT and 3,600 PT the velocity increases from 30 fps to 64 fps; and, between 3,600 PT and 4,000 PT the velocity decreases from 64 fps to 44 fps.