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AIRCRAFT ACCIDENT REPORT

**North Central Airlines, Inc.
McDonnell Douglas DC-9-31, N954N
and**

**Delta Air Lines, Inc.
Convair CV-880, N8807E
O'Hare International Airport**

Chicago, Illinois

December 20, 1972

Adopted: July 5, 1973

NATIONAL TRANSPORTATION SAFETY BOARD

Washington, D.C. 20591

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16. Abstract A North Central Airlines DC-9-31 and a Delta Air Lines Convair (CV-880) collided at the intersection of Runway 27L and the North-South taxiway on the O'Hare International Airport, Chicago, Illinois, at 1800 central standard time on December 20, 1972. The DC-9 was taking off from Runway 27L, and the CV-880 was taxiing across the runway when the collision occurred. Neither flightcrew saw the other aircraft in time to avoid the collision. Forty-one passengers and four crewmembers were aboard the DC-9. Ten passengers died, and 13 passengers and 2 crewmembers were injured. The DC-9 was destroyed by impact and fire. Eighty-six passengers and seven crewmembers were aboard the CV-880. Two passengers received minor injuries. The CV-880 was substantially damaged. The weather at the O'Hare Airport at the time of the accident was reported, in part, as: ceiling indefinite 200 feet, sky obscured, with visibility 1/4 mile in fog. The National Transportation Safety Board determines that the probable cause of this accident was the failure of the traffic control system to insure separation of aircraft during a period of restricted visibility. This failure included the following: (1) the controller omitted a critical word which made his transmission to the flightcrew of the Delta CV-880 ambiguous; (2) the controller did not use all the available information to determine the location of the CV-880; and (3) the CV-880 flightcrew did not request clarification of the controller's communications.					
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AIRCRAFT ACCIDENT REPORT

Adopted: July 5, 1973

NORTH CENTRAL AIRLINES, INC.
McDONNELL DOUGLAS DC-9-31, N954N
and
DELTA AIR LINES, INC., CONVAIR CV-880, N8807E
O'HARE INTERNATIONAL AIRPORT, CHICAGO, ILLINOIS
DECEMBER 20, 1972

SYNOPSIS

A North Central Airlines DC-9-31 and a Delta Air Lines CV-880 collided at the intersection of Runway 27L and the North-South taxiway on the O'Hare International Airport, Chicago, Illinois, on December 20, 1972, at 1800 central standard time. The DC-9 was taking off on Runway 27L, and the CV-880 was taxiing across the runway when the collision occurred. Neither flightcrew saw the other aircraft in time to avoid the collision.

Forty-one passengers and four crewmembers were aboard the DC-9. Ten passengers received fatal injuries; 13 passengers and 2 crewmembers were injured. The DC-9 was destroyed by impact and fire.

Eighty-six passengers and seven crewmembers were aboard the CV-880. Two passengers received minor injuries; the aircraft was damaged substantially by impact.

The weather at O'Hare International Airport at the time of the accident was reported, in part, as: ceiling indefinite 200 feet, sky obscured, with visibility $\frac{1}{2}$ mile in fog.

The National Transportation Safety Board determines that the probable cause of this accident was the failure of the traffic control system to insure separation of aircraft during a period of restricted visibility. This failure included the following: (1) the controller omitted a critical word which made his transmission to the flightcrew of the Delta CV-880 ambiguous; (2) the controller did not use all the available information to determine the location of the CV-880; and (3) the CV-880 flightcrew did not request clarification of the controller's communications.

As a result of this inquiry, 14 recommendations have been made to the Federal Aviation Administration.

I. INVESTIGATION

1.1 History of the Flights

a. Delta Air Lines Flight 954

Flight 954, a CV-880, N8807E, was a regularly scheduled passenger flight from Tampa, Florida, to O'Hare International Airport, Chicago, Illinois. On December 20, 1972, the flight departed from Tampa at 1541 ^{1/} eastern standard time with 86 passengers and 7 crewmembers aboard. The en route portion of the flight was completed without reported incident.

Flight 954 established radio communication with Chicago Approach Control (CAC) at 1723:10. The flight had heard Automatic Terminal Information Service (ATIS) ^{2/} "Golf" announce that Runway 14R was being used for landings and Runways 14R and 14L for departures. The local weather was reported, in part, to be: ceiling indefinite 200 feet, sky obscured, visibility $\frac{1}{4}$ mile in fog.

At 1739:10, the CAC controller informed all flights under his control that parallel Instrument Landing System approaches would be conducted to Runways 14L and 14R, and that all aircraft under his control would be vectored for the ILS approach to Runway 14L. The Runway Visual Range (RVR) for 14L was 3,000 feet.

After receiving a clearance for the approach, Flight 954 contacted the O'Hare tower local controller at 1746:10. At 1752:30, the local controller cleared the flight to land on Runway 14L and advised the flightcrew that the RVR was 1,800 feet.

At 1755:05, the O'Hare local controller requested Flight 954 to report when clear of Runway 14L. The flightcrew reported clear of the runway at 1756:18; 2 seconds later, the local controller cleared the flight to the ground control frequency. Simultaneously, the ground controller attempted to contact the flight, without success.

At 1757:29, the first officer of Flight 954 established radio communications with the O'Hare ground controller with the transmission, "Delta nine fifty four is with you inside the Bridge and we gotta go to the box. ^{3/} The controller replied, "... OK if you can just pull over to (the) thirty two pad." The first officer replied, "Okay we'll do it." There were no further communications between the ground controller and Flight 954. The controller made an entry on a scratch

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- ^{1/} Unless otherwise specified, all times herein are central standard time, based on the 24-hour clock.
 - ^{2/} A sequential automatic radio transmission of weather and airport traffic information. Each new message is given an identifying letter designator.
 - ^{3/} The "box" is a holding area on the airport, officially designated as the Penalty Box. (See Appendix D.)

sheet which he later stated was to remind him that he had sent the CV-880 to the 32R pad to hold awaiting a gate assignment.

The captain of Flight 954 taxied the aircraft via the Bridge, the Outer Circular, and the North-South taxiways ^{4/} en route to the Runway 32L runup pad.

The ground controller later stated that he did not hear the words "inside the bridge" in the first officer's initial transmission. The ground controller also stated that he thought that the flight was taxiing clear of the runway when he was contacted and in replying, it was his intention to determine whether the flight could hold on the Runway 32R runup pad.

The captain and first officer both stated that they thought the controller wanted them to hold on the Runway 32L runup pad and cleared them to do so. The collision occurred as Flight 954 was crossing Runway 27L en route to the 32L runup pad.

b. North Central Airlines Flight 575

Flight 575, a DC-9, N954N, was a regularly scheduled passenger flight between Chicago, Illinois, and Duluth, Minnesota, with an intermediate stop at Madison, Wisconsin. Forty-one passengers and four crewmembers were aboard. At 1750, the O'Hare ground controller cleared the flight to taxi to Runway 27L for departure.

At 1758:52.3, the O'Hare local controller cleared Flight 575 into the takeoff position on Runway 27L and advised the crew the visibility was one-fourth mile. Twenty-six seconds later, the local controller cleared the flight for takeoff; at 1759:24.3, the captain reported that he was beginning his takeoff roll.

The first officer made the takeoff. The captain stated that the takeoff roll was normal until he called. "Rotate."^{5/}

At that moment, the captain saw another aircraft ahead on the runway, and he immediately assisted the first officer in applying additional control pressure to gain altitude in an attempt to clear the other aircraft. The attempt was unsuccessful. After the collision, the captain decided that his aircraft could not maintain flight, at which time he took control, and flew the aircraft back onto the runway.

The collision occurred at 1800:08.7, December 20, 1972. The geographic coordinates of the accident site are 41°58'9" N. and 87°54'4" W.

^{4/} See Appendix D for the airport taxi chart and taxiway nomenclature.

^{5/} V_R (rotate) the indicated airspeed at which elevator control is applied to establish the angle of attack for liftoff.

The accident occurred at night at an elevation of approximately 667 feet above mean sea level.

1.2 Injuries to Persons

<u>Injuries</u>	<u>Crew</u>	<u>Passengers</u>	<u>Other</u>
Fatal	0	10	0
Nonfatal	2	15	0
None	9	102	

1.3 Damage to Aircraft

The DC-9 was destroyed. The CV-880 was substantially damaged.

1.4 Other Damage

Several runway and taxiway lights were destroyed, and the runway surface was slightly gouged and marred.

1.5 Crew Information

The pilots and copilots of both flights and the flight engineer of the CV-880 were all certificated for their respective duties in accordance with the existing regulations. All crewmembers had received the training required by their respective companies and the regulations of the Federal Aviation Administration (FAA). (See Appendix B for additional information.)

The captains of both flights were familiar with the O'Hare Airport facilities and air traffic control procedures and had used them on many previous flights.

1.6 Aircraft Information.

a. Aircraft N8807E, a Convair CV-880, was owned and operated by Delta Air Lines, Inc. The aircraft was certificated, maintained, and equipped in accordance with approved company procedures and FAA regulations.

b. Aircraft N954N was a McDonnell Douglas DC-9-31, owned and operated by North Central Airlines, Inc. (NCA). The aircraft was certificated, maintained, and equipped in accordance with approved company procedures and FAA regulations. N954N had 22,000 pounds of Jet A aviation kerosene on board. Both the takeoff gross weight of the aircraft and the center of gravity were within prescribed limits. (See Appendix C for additional information.)

1.7 Meteorological Information

The O'Hare weather conditions at 9 minutes before and 10 minutes after the accident were reported, in part, as: ceiling indefinite 200

feet, sky obscured, visibility $\frac{1}{4}$ mile in fog, temperature 35° F., and dew point 34° F.

At 1751, the RVR for Runway 14R was reported as 1,600 feet variable to 1,800 feet. Runway 27L was not equipped with RVR measuring equipment.

When reduced visibility conditions exist at O'Hare, control tower personnel assist the National Weather Service (NWS) observer in determining the prevailing visibility. The controllers are certificated for this purpose by the NWS.

On December 20, 1972, during the period from 10 minutes before until 10 minutes after the accident, the RVR's for Runways 32L, 14L, and 14R were variable between 1,400 feet and 2,700 feet. The prevailing visibility officially determined by the control tower personnel and the NWS observer was one-fourth mile.

1.8 Aids to Navigation

Aids to navigation were not involved in this accident.

1.9 Communications

The O'Hare tower cab floor is approximately 198 feet above the airport ground level. Six control positions were provided, and were manned as follows:

- a. Local controller, frequency 118.1 MHz.
- b. Local controller, frequency 120.7 MHz.
- c. Ground controller (inbound), frequency 121.9 MHz.
- d. Ground controller (outbound). Not used.
- e. Clearance delivery controller. Not involved.
- f. Flight data controller. Not involved.

A tower cab supervisor is responsible for the overall control tower operation.

On the night of the accident, the tower supervisor considered the traffic volume to be low. He decided that only one ground controller was needed to provide service to both the inbound and the outbound traffic. According to tower supervisory personnel, this was normal practice since one controller can provide the necessary service more efficiently when the traffic volume is low.

One hour after the accident, FAA personnel checked the operation of the O'Hare Tower radio transmitters and receivers. All radios, including

those which used frequencies of 118.1, 120.7, and 121.9 MHz, were found to be operating within prescribed tolerances.

1.10 Aerodrome and Ground Facilities

The O'Hare International Airport is located in the western suburbs of Chicago, Illinois. In 1971, 641,429 operations 6/ were conducted at O'Hare.

Three sets of parallel runways and one single runway are available. (See Appendix D for details.) All runways except Runways 4L-22R and 18-36 are equipped with high-intensity runway lights. The lights on Runway 27L were on and set at maximum intensity on the night of the accident.

The taxiways at O'Hare are designated by name rather than the more conventional alphanumeric system. Active runways are designated by a system of lights or other visual signals. Tower controller personnel stated that all the runways are considered to be continually active.

An Airport Surface Detection Equipment-2 (ASDE-2) radar system is installed at the O'Hare tower facility. The radar is a high-resolution, ground-surveillance, dual-channel pulse type. It is used to detect land vehicles and aircraft on airport runways, taxiways, and aircraft parking areas. The basic units of the ASDE-2 radar system are:

- (1) A rotating antenna located on top of the tower cab.
- (2) Two receivers and two transmitters.
- (3) A plan position indicator scope.
- (4) Two "BRITE" 7/ displays in the tower cab.

FAA maintenance personnel examined the ASDE radar system shortly after the accident occurred. The system was operating within prescribed tolerances.

O'Hare tower controller personnel testified that during periods of low visibility, the ASDE-2 radar is used almost exclusively by the local controllers to determine whether approaching aircraft have landed or executed a missed-approach, when and where landing aircraft are clear of the runway, and when departing aircraft begin and complete the takeoff. The ASDE is adjusted and centered by the local controllers for these functions.

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6. An operation is defined to include a takeoff, or a landing, or an overflight controlled by the facility.
 7. "BRITE" display - a television type display of radar data that can be used in daylight conditions.

The tower controllers also testified that they considered the ASDE-2 equipment unreliable for the identification of airport traffic movements because of blind spots, the inability of the equipment to distinguish aircraft from other vehicles, and the derogation of target definition during periods of moderate to heavy precipitation. Tower personnel stated that ground controllers rarely used the ASDE-2 equipment because of these limitations.

The ground controller on duty at the time of the accident was not required to be qualified, nor was he fully qualified, in the operation and use of the ASDE. He said that he did use the radar to assist another flight in locating the Penalty Box, but not to identify the position of the CV-880.

1.11 Flight Recorders

The CV-880 was equipped with a Lockheed Aircraft Service Model 109-C, serial No. 319, Flight Data Recorder (FDR), and a Fairchild Model A-100, serial No. 1402, Cockpit Voice Recorder (CVR).

The DC-9 was equipped with a Sundstrand (UCDD) Model FA-542, FDR, serial No. 3615, and a Model V-557, CVR, serial No. 2039.

All the recorders were recovered and sent to the Board's Washington office for readout.

a. Flight Data Recorders

Examination of the FDR traces from the CV-880 indicated that the aircraft landed on a heading of 144° magnetic, and the recorder was deactivated 16.7 seconds later. The heading remained essentially the same throughout this period of time.

The heading and airspeed traces on the FDR from the DC-9 showed that the indicated airspeed trace decreased from about 18 knots to zero when the heading trace stabilized about 271° magnetic. The heading trace then remained approximately 270° during the 30 seconds it took for the airspeed trace to increase from zero to about 140 knots. In the next 3 seconds, the heading trace increased to 287° and then decreased to 271°; it then remained at 271° until the recording ended 8 seconds later.

b. Cockpit Voice Recorders

(1) CV-880

The transcript of the CV-880 tape shows that the flight called clear of the runway at 1756:18. Two seconds later, the local controller cleared the flight to contact ground control. At 1756:30, the flight engineer called the Delta ramp control agent for information on the length of time the flight would have to hold in the Penalty Box. Six seconds later the Delta ramp control agent informed the flight engineer that he would call back in a few minutes.

At 1757:29, the CV-880 first officer contacted the ground controller. (Ref. Section 1.1.)

At 1800:07.06, in response to a crewmember's statement concerning passenger inquiries about connecting flights, the captain of the CV-880 said, "Ah, we can't even ooh!" Impact sounds were recorded 1.1 seconds after the beginning of that statement. At 1800:13.7, the first officer exclaimed, "That guy crashed!" This exclamation was followed by statements about a fire and "Shut 'em down." The voice recording ended at 1800:26.8.

(2) DC-9

The transcript of the CVR tape from the DC-9 disclosed that at 1759:18.3, the flight was cleared for takeoff on Runway 27L. At 1759:24.3, the captain reported, "Rolling."

After that the captain made several airspeed calls, followed at 1800:03.4 with "Rotate." at 1800:07.2, the captain exclaimed, "Pull 'er up!" At 1800:08.7, the sounds of an impact were recorded, followed by sounds of the stall warning device and three additional impacts. The recording stopped at 1800:18.2.

1.12 Wreckage

a. CV-880

The CV-880 was stopped on the North-South taxiway, on a southerly heading, with the aft end of the fuselage approximately 135 feet south of the Runway 27L centerline. The nosewheel was about 3 feet east of the taxiway centerline, which is located 4,713 feet west of the threshold of Runway 27L. (See Appendix D.)

A large portion of the vertical stabilizer was found near the centerline of Runway 27L and approximately 17 feet west of the intersection of the centerlines of the North-South taxiway and Runway 27L. ^{8/} A narrow strip of tire rubber was imbedded in the lower part of the rear spar of the stabilizer. The left wingtip was found 82 feet east and 84 feet south of the reference point. The upper wingtip structure remaining on the aircraft was corrugated from compression. The upper inboard and lower outboard skin was spotted with black deposits. The top of the aft fuselage was substantially damaged in three areas.

The first area was centered at Fuselage Station (FS) 1192 where the damage consisted of two 22-inch depressions into the top of the fuselage. The combined width of the depressions was 31 inches. A rubber-like substance was deposited on the depressed surfaces. The second area was at the point where the vertical stabilizer fairs into the fuselage.

^{8/} The intersection was used as a reference point, and wreckage locations were plotted from that point.

A large 20-inch V-shaped depression was located 10 feet aft of the first area. The depression was streaked with green-blue paint.

The third area was centered 16 feet, 8 inches aft of the first area. The top of the fuselage between the center and aft spar attachment stations of the vertical stabilizer contained a 28-inch depression. A 6- by 6-inch piece of a tire was found in the fuselage below this area. The piece matched the torn remains of one of the tires on the right main landing gear from the DC-9.

The interior ceiling in the aft cabin was compressed to 38 inches above the cabin floor. Numerous passenger oxygen masks were deployed in this area.

The four emergency exit doors were open, and the evacuation slides were deployed and inflated. The overwing exit windows were closed; they had not been used.

b. DC-9

The DC-9 came to a stop on Runway 32L on a magnetic heading of 352°, approximately 800 feet north of the centerline of Runway 27L and 3,200 feet from the reference point. (See Appendix D.)

The right main landing gear lay 1,583 feet west and 114 feet north of the reference point. One of two sections of the right leading edge flap was found 259 feet west and 140 feet north, and the other, 1,248 feet west and 140 feet north, of the reference point.

A gouge in the surface of Runway 27L, found 394 feet east of the reference point and 2 feet south of the runway centerline, was attributed to the impact of the DC-9 tailskid with the runway at that point.

Dark, rubberlike scrub marks lined part of the surface of Runway 27L, beginning 547 feet west and 25 feet north of the reference point. The marks continued 15 feet farther west. Gouge marks on the runways and adjacent sodded areas indicated that the DC-9 had left Runway 27L and had scribed a curved path to the point where it stopped on Runway 32L.

The DC-9 was found upright with the fuselage resting on the runway surface. The nose gear and left main landing gear had failed rearward.

The fuselage from FS 160 to FS 900 was gutted by fire. The empennage was found intact with evidence of fire damage on the vertical and right horizontal stabilizers. The cockpit was damaged extensively by fire and all overhead control panels were destroyed. The right cockpit escape window was open and the left window was closed. The main entry door at the left forward corner of the cabin was open. The evacuation slide was deployed, but not inflated. The inflation lanyard was found wrapped around the neck of the inflation bottle.

The galley service exit door at the right forward corner of the cabin was closed. The two forward overwing window exits were open. The two aft overwing exits were closed. The jettisonable tail cone exit had not been actuated.

Examination of the engines disclosed no evidence of abnormal operation or malfunction. The No. 1 (left) emergency fuel shutoff valve was nearly closed, and the No. 2 engine emergency shutoff valve was closed.

The No. 1 engine was only slightly damaged, but the No. 2 engine was damaged extensively by fire. An 18-inch piece of a horizontal rib from the CV-880 vertical stabilizer was lodged against the inlet guide vanes of the No. 2 engine.

The aircraft batteries were displaced rearward, but were not damaged. The ground cable lead was found torn from the aircraft structure.

1.13 Fire

The tower personnel saw a flash but could not see the DC-9 burning on Runway 32L. The local controller looked for a target on the radar that he could associate with the DC-9; when no target was visible, he attempted to contact the flight on the departure frequency. No response was received. The control tower team supervisor sounded the crash alarm, about 1802, after pilots reported that something was burning in the area immediately south of the Penalty Box.

The Chicago Fire Department (CFD) units stationed at the airport responded with 11 crash and fire vehicles and 2 ambulances. The first unit reached the DC-9 at 1803. CFD personnel extinguished the fire in approximately 16 minutes. They used 185 gallons of light water, 350 gallons of foam, 5,350 gallons of water, and 1,700 pounds of dry chemical extinguishing agent in the process.

1.14 Survival Aspects

a. CV-880

The captain of the CV-880 stopped the aircraft, shut off the engines, and ordered the evacuation of the passengers. All four main exits were opened and the slides were deployed and inflated. All passengers and crewmembers deplaned via the exits. Two passengers had received minor injuries in the crash. The cabin emergency lighting system functioned normally. The captain estimated that the evacuation was completed in approximately 5 minutes.

Because of the restricted visibility, control tower and crash and rescue personnel were unaware of the CV-880 involvement in the accident until fire department personnel, responding to the DC-9 fire, came upon the CV-880. This occurred about 1828.

b. DC-9

When the airplane touched down, the remaining landing gear collapsed and the aircraft skidded to a stop on Runway 32L. Fire was seen around the aft section of the aircraft as it came to a stop. After pulling the engine fire extinguisher handles, the captain ordered evacuation of the aircraft.

The first stewardess was seated on a folding seat attached to the forward cabin wall, facing aft. The second stewardess was seated in passenger seat 15B rather than on the folding seat attached to the aft cabin bulkhead.

As the airplane came to a stop, the second stewardess opened the left forward overwing exit at seat row 12, through which she exited, and called to the passengers to follow.

The first stewardess opened the main entry door after the airplane stopped. The escape slide deployed, but did not inflate. The first stewardess stated that she was pushed out of the airplane. From the outside, she called out to the passengers and assisted them down to the ground.

The first officer escaped from the airplane through the sliding window on the right side of the cockpit. He went around the nose of the airplane to the main entry door, and from the ground he assisted passengers escaping through that door.

The captain entered the cabin through the cockpit door and called to the passengers to come forward. He then went outside through the main entry door. From a position outside the aircraft, he assisted passengers down to the ground. Then, reentering the airplane, the captain assisted other passengers through the main entry door.

A passenger opened the right forward overwing exit through which he made his escape.

The two aft overwing exits, the galley exit door, and the emergency exit at the tail cone were not opened.

Nine of the 10 fatally injured passengers failed to escape from the aircraft. Two of these passengers who had left their seats were found in the cockpit area. Two others who had left their seats were found in the aft section of the airplane. Five others remained in their seats; one was an invalid who was unable to walk without assistance. These passengers received no traumatic injuries but succumbed instead to the effects of smoke inhalation or burns, or both.

Thirty-two passengers successfully escaped from the airplane; however, one of them succumbed 5 days later. Four passengers followed the second stewardess through the left forward overwing exit. Another escaped through the right forward overwing exit. The other surviving passengers escaped through the main entry door.

The four crewmembers survived. The second stewardess received serious injuries during her escape. The captain received minor injuries when he reentered the cabin.

Passengers testified that there were no lights visible in the cabin during the evacuation. They also stated that the smoke was dense, particularly in the upper portion of the cabin. The portable emergency light, portable power megaphones, and crewmember flashlights were not used during the evacuation.

In an emergency, the DC-9 cabin standby lights can be powered by the aircraft 28-volt batteries or separate emergency lights can be powered by rechargeable 2.5-volt nickel-cadmium batteries. The 28-volt power source provides a much greater light intensity than that produced by the 2.5-volt source.

1.15 Tests and Research

A test was conducted on a DC-9 aircraft to determine whether operation of the cabin standby and emergency lights was affected by the disconnection of the ground lead on the aircraft batteries before the alternating current electrical power was removed from the aircraft system. It was determined that the standby lights would not operate but that the emergency lights would operate; however, their design limited them to power from the 2.5-volt emergency batteries.

1.16 Other Information

a. ASDE Radar

Examination of the ASDE-2 radar displays in the O'Hare control tower revealed no apparent voids or blind spots in the displays, except for a section of taxiway near the bridge on the Bridge Route taxiway. Targets from that particular section did not appear because of the shadowing effect produced by a large building located between the radar antenna and the taxiway. Targets were seen merging with radar returns from the terminal buildings and other ground clutter, which made identification of the aircraft virtually impossible when they were in the terminal area.

Aircraft targets appeared as dots or smears and could be distinguished from fixed objects only when the aircraft were moving. Recognition of moving aircraft, however, required close observation of the targets for several seconds, and even then they could not be distinguished from other vehicular traffic.

Aircraft could be followed on the radar display, however, as they moved from the departure end of Runway 14L along the Bridge Route and Outer Circular taxiways. The targets disappeared from the displays when

the aircraft passed behind the large building near the bridge. Targets were clearly visible at the intersection of the North-South taxiway and Runway 27L.

The maintenance records of the ASDE-2 radar system were examined. No malfunctions had been recorded during the 10-day period preceding the accident.

b. Air Traffic Control (ATC) Phraseology/Terminology

The basic guidance for the use of air traffic control terminology is provided for pilots in the Airman's Information Manual, Part I, and for air traffic controllers in the Terminal Air Traffic Control Handbook. Both are FAA publications and have identical standards of usage and terminology.

Transcripts of the O'Hare tower facility recordings, as well as the testimony of pilots and controllers, have confirmed that in the Chicago area, neither pilots nor controllers adhere strictly to standard ATC phraseology and terminology. Deviations include word omissions, abbreviations, phrase alterations, and colloquialisms.

Controllers and supervisors both stated that deviations were often necessary to serve efficiently the large volume of traffic at O'Hare. It was their belief that strict adherence to published standards would substantially reduce the number of airport operations.

Testimony also indicated that there was little control over the extent of the deviations. Both controllers and pilots originate terms and expressions that are accepted in the common interest of expediting the flow of traffic.

c. Controller Workload

When all of the control positions in the O'Hare tower cab are manned, the two ground controllers coordinate with each other before issuing taxi clearances. This is necessary to preclude conflicts among the taxiing aircraft. Each ground controller in turn coordinates with the appropriate local controller before the control of flights on their respective frequencies is transferred.

Usually, the resulting controller workload is directly proportional to the volume of traffic, but it can be affected by many other factors, including: (1) work environment, (2) volume of traffic, (3) volume of communications, (4) weather conditions, and (5) controller familiarity with the airport.

The O'Hare tower cab is relatively new in design, and incorporates recent improvements in the controller work environment. In this instance, the weather conditions were poor, which accounted for the low volume of traffic and the decision to combine the ground control functions under one controller. The ground controller, though not fully qualified in all control positions, was fully qualified to perform ground control

functions; he was also familiar with the O'Hare airport and its operation.

The ATC transcript of the O'Hare ground control communications disclosed that during the 6-minute period preceding the first transmission of Flight 954 to ground control, the controller was providing service to seven flights--four inbound and three outbound. The outbound flights were transferred to one of the local controllers within the first 2 minutes of that period of time. The ground controller made 29 transmissions while he was providing the necessary service to the seven flights. However, 15 of the 29 transmissions were directed to another Delta flight which was having difficulty finding the Penalty Box.

d. NCA Emergency Evacuation Training

North Central Airlines provided emergency evacuation training to its crewmembers under two separate programs. One program involved the flightcrew members, the other involved the stewardesses. An NCA training instructor testified that much of the stewardess' training involved the use of audio-visual aids. The stewardess trainees operated emergency exits only during initial training. None of the company stewardesses had operated the tail cone exit on the DC-9 aircraft. Stewardesses stated that they were advised during training that they could be among the first to exit the aircraft, if necessary. None of the training they received was conducted under conditions of real or simulated cabin emergency lighting or a smoke-filled environment.

The primary positions and duties of NCA crewmembers during an emergency evacuation of a DC-9 are:

Captain -- in the cabin area: direct and assist passengers as conditions dictate.

First Officer -- At the right forward galley service door: open door and assist passengers through that exit.

First Stewardess -- At the left forward main entry door: open door and assist evacuating passengers through that exit.

Second Stewardess -- Open either the tail cone exit or overwing exits; assist passengers evacuating through those exits.

2. ANALYSIS AND CONCLUSIONS

2.1 Analysis

Both the DC-9 and the CV-880 were equipped, certificated, and maintained in accordance with company procedures and FAA requirements. Both aircraft were capable of normal operation.

All crewmembers of both flights were qualified and certificated for their respective duties. Each had received the training prescribed in

the FAA-approved company training programs. All flightcrew members had received the crew rest opportunities specified in the regulations.

All the involved air traffic controllers were qualified and certificated for their respective duties. Each had received the training prescribed in the FAA training programs.

The captain of the DC-9 was operating the airplane within the scope of a valid clearance, and, under the circumstances, he did all that could be reasonably expected of a pilot to avoid the collision. Because of the restricted visibility and the short time interval available after they saw the CV-880, the flightcrew of the DC-9 was unable to take any other course of action to avoid the collision. Although the exact visibility in the accident area could not be determined, the recorded RVR nearest the accident site was about 2,000 feet or more than one-fourth mile. A review of the recorded visibilities at various points on the airport indicates that the fog was homogeneous, with little variation in visibility at any specific time.

With $\frac{1}{2}$ -mile visibility, the flightcrew of the DC-9 could not have seen the CV-880 until they were approximately 1,600 feet from the collision point. The first officer was making an instrument takeoff which the captain was monitoring, with particular attention to the airspeed. The captain looked outside the aircraft after he called "Rotate" at 1800:03.4. When he saw the CV-880 at 1800:07.2, the captain reacted with the order, "Pull 'er up!" In the 5.3-second interval between "Rotate" and the impact, the captain first had to see the CV-880, next evaluate the probability of a collision, then decide on a course of action, and finally initiate an action; the aircraft had to respond to the control inputs. There was insufficient time for the flightcrew of the DC-9 to avoid the collision; and there was no other reasonable course of action that the captain could have taken in the time and distance available to him.

The attention of the flightcrew of the CV-880 was divided between taxiing the aircraft and intracockpit conversations. They did not see the DC-9 in time to take any action to avoid the collision.

The investigation confirmed that after the collision occurred, the DC-9 was incapable of sustaining flight. The flightcrew's skill in maintaining control of the aircraft most likely averted more serious consequences.

The principal causal area in this accident involved the exchange of communications between the O'Hare ground controller and the flightcrew of the CV-880. However, the sequence of events that established the conditions for the accident probably began when the CV-880 crew listened to ATIS broadcast."Golf."

That broadcast announced to the flightcrew that Runway 14R and Runway 14L were being used for departures. When the O'Hare operation

was subsequently changed to use Runways 14R and 14L for approaches, the flightcrew was not informed that departures had been started on Runway 27L. Consequently, the flightcrew was unaware that Runway 27L had become an active runway, and the information they subsequently received contained nothing to indicate that the runway was being used for takeoffs.

After the CV-880 had landed on Runway 14L, the local controller requested the flight to report when it was clear of the departure end of the runway. The flightcrew acknowledged and complied with that request. While the local controller was clearing the flight to the ground control frequency, the ground controller was attempting simultaneously to contact the flight. Consequently, the ground controller was aware of the flight's arrival and anticipated radio contact with the flightcrew.

Meanwhile, the ground controller was also occupied with another Delta flight, which was having difficulty locating the Penalty Box. Immediately after the other flight appeared to have located the Penalty Box, the first officer of the CV-880 established contact with the ground controller by transmitting "Delta nine fifty four is with you inside the bridge and we gotta go to the box."

The Board is of the opinion that the controller did not hear the words "inside the bridge" in that transmission, but is unable to determine why he failed to hear those words. Had he heard the position given by the CV-880 crew, he would not have directed the crew to the 32R pad, his stated intention. From their reported position, the CV-880 crew would have had to turn the airplane around and taxi against the flow of traffic from 14L toward the terminal. Had the controller intended to direct the CV-880 to the 32L pad, he would have had to coordinate the clearance with the local controller before he could allow the flight to cross Runway 27L. This coordination was not effected. It is significant that when the ground controller directed the CV-880 crew to the 32 pad, he entered on a scratch sheet a written notation that the flight was holding at the 32R pad. For these reasons, the Board concludes that the controller did not hear the full transmission from the CV-880 and that he intended to clear the flight to the 32R pad. The CV-880 crew's response "Okay we'll do it" satisfied the controller and reinforced his belief that the CV-880 was going to the 32R pad.

The controller should have been particularly alert to the position report from the CV-880 because of the limited visibility which prevented him from seeing the airplane. There was no evidence of a physical reason for his not hearing the complete transmission. The transmission was recorded, and a review of the recording showed that the transmission was both audible and intelligible. If the controller did not hear the crew report their position, he should have immediately requested a position report, rather than issuing what constituted a clearance to taxi to a holding point. The controller stated that had he heard the phrase "inside the bridge," he would have asked for additional information regarding the position of the airplane. The transmission without the position report was incomplete in that it did not contain information the controller

needed to control the ground movement of the airplane. It is the Board's opinion that if any transmission is unclear or ambiguous, the recipient should immediately request clarification.

The controller stated that at the time he received the initial transmission from the CV-880 crew, he believed that the airplane was just clear of Runway 14L near the 32R pad. Since the crew had notified the local controller that they were clear of the runway more than a minute before the initial transmission to the ground controller, the Board can find no valid reason for such an assumption. Pilots testified that the normal procedure after clearing a runway was to continue to taxi and call ground control as soon as possible for taxi clearance. Delta aircraft clearing Runway 14L normally taxied via the Bridge taxi route to the terminal. The initial call from an airplane to ground control normally contained the position of the flight and its destination on the airport. The crew of the CV-880 experienced a delay in getting their destination on the airport from the station agent and did not call the ground controller until more than 1 minute after they were clear of the runway. Controllers testified that they commonly received initial radio contact from aircrews at various points on taxiways. The handling of the flight that followed the CV-880 is an example. The flightcrew contacted the ground controller and, in response to the controller's request for their position, reported that "... just getting ready to cross the bridge."

The flightcrew of the CV-880 stated that since they had reported their position "inside the bridge," they believed that the controller was referring to the 32L pad in his transmission. They said it would have been impractical to go to the 32R pad from their position. However, since the controller's transmission was not clear in that it did not specify which 32 pad was to be used as a holding point, the crew should have requested clarification of the transmission before taxiing approximately 1 mile in limited visibility. Separation of aircraft on the ground, as well as in the air, is a joint responsibility of controllers and aircrews. Each has a duty in the interest of safe operations to request either additional information or clarification when transmissions are ambiguous, unclear, or incomplete. In this case, there was a need for a request for additional information and for clarification on the part of both the flightcrew and the controller.

The manner in which the ASDE equipment in the O'Hare tower was used by the controllers did not comply with the provisions of Section 20 9/ of the Terminal Air Traffic Control Handbook and the provisions of O'Hare Tower Order 7110.26.10/ The ground controllers were not required to be

9/ Airport Surface Detection Procedures -- 1680, Equipment Usage -- Use ASDE to observe aircraft movement on runways and taxiways during low visibility conditions or to supplement information obtained by visual observations and pilot reports.

10/ Policy - ASDE shall be turned on and used whenever any area of the airport is not visible due to reduced visibility. It shall also be on and available for use at night whenever the operation is such that the exact position of aircraft cannot be determined by visual reference.

qualified in the use of the ASDE, nor were they encouraged to use it. Although the display in the tower cab did not provide a clear picture of the airport environment, it is the Board's conclusion that the use of the ASDE equipment was mandatory and that it should have been used by the controller. The Board recognizes that the difficulties with the tower cab display might lead to controller reluctance to rely on the equipment, but the Board is also cognizant of the manner in which other facilities use similar equipment to control ground traffic effectively. Consequently, the Board believes that to overcome the limited and discretionary use of the ASDE, and to improve the effectiveness of the equipment, standard operating procedures should be established for all ASDE-equipped facilities. (See Appendix E.)

Fire broke out almost immediately, and smoke developed very rapidly in the DC-9 after it came to a stop. This reduced the time available to effect an evacuation and made a coordinated crew response extremely important in this accident.

The Board concluded that the DC-9 cabin emergency lights did illuminate. However, because the aircraft battery ground lead was severed, the power was supplied by the 2.5-volt batteries, which resulted in low intensity illumination. This made the emergency lights difficult to see in the concentration of smoke near the ceiling of the aircraft.

The emergency evacuation of the DC-9 was impeded by dense smoke and inadequate cabin illumination. Also, the supervision of the evacuation by the flight and cabin crewmembers from a position outside the aircraft delayed the egress of some of the passengers.

The Safety Board concludes that individual crewmember actions and crew coordination during the evacuation were less than adequate and probably detracted from the success of the evacuation. All of the North Central DC-9 crewmembers received FAA-approved emergency evacuation training, which was conducted in much the same manner as many other air carriers train their crewmembers. Such training emphasizes that crewmembers must take control of an evacuation, open all usable exits, direct passengers expeditiously through those exits, and assure that all passengers are out of the aircraft before they themselves exit.

An individual crewmember's response to an emergency situation is almost wholly a product of his training, particularly when time is critical. The assessment and response must be swift and accurate, and the crewmember's actions must be coordinated with little or no direction. In addition, because of the possibility of disabling injuries or unusual circumstances, each crewmember must be prepared to assume command of the evacuation.

Each crewmember must have a firm understanding of the duties of the others so that his efforts will complement theirs. Crewmembers must understand that they are the leaders of the evacuation, and that most passengers will immediately seek their aid and guidance. Passengers also may experience negative panic and may need to be physically aroused to

action. To achieve maximum effectiveness, the crewmembers must remain inside the aircraft as long as possible.

Crewmembers must be familiar with the location and operation of the installed evacuation aids, such as voice amplifiers, portable emergency lights, flashlights, and smoke goggles.

To achieve this degree of efficiency, crewmember evacuation training must be such that individual reaction to an emergency situation will be reflexive. Ideally, such training should be conducted in an environment approximating that of an actual aircraft evacuation. Environmental factors such as lighting, smoke, and confusion should be introduced into evacuation training. Training should be conducted in facilities which simulate an aircraft as closely as possible and should be conducted on a crew basis, rather than on an individual basis, so that each crewmember can become familiar with the duties and responsibilities of the others.

Prior accident experience shows that crewmembers who have received approved emergency evacuation training often exhibit exemplary performance when faced with an emergency situation. This leads the Board to believe that this crew's performance was the result of an inadequate training program. If the evacuation training of this crew had been oriented toward coordinated activities and had been conducted under emergency conditions, simulated more realistically, crew performance during the actual evacuation could have been more effective. The corrective action taken by the FAA regarding the carrier's training program is outlined in section 3 of this report.

A discrepancy was found in the maintenance of the evacuation slide at the main entry door. Examination of the slide after the accident showed that the slide would not have inflated when the inflation lanyard was pulled because the lanyard was wrapped around the neck of the inflation bottle. An evaluation of the effect of not inflating the slide indicates that the escape of those persons who used the main entry door might have been expedited. Had the slide been inflated, it would have extended at a shallow angle because of the attitude of the airplane. Therefore, the evacuees would not have been able to slide out of the aircraft, but rather, they would have had to walk or run out on an unstable slide. This would have increased the possibility of a fall and subsequent injury. On the other hand, had the slide been inflated, it would have been easier for crewmembers to return to the cabin when the flow of passengers slowed or stopped.

There was a 3-minute lapse between the time of the collision and the first communication from the CFD which indicated that they arrived at the DC-9. This delay occurred because the tower personnel did not know at first that an accident had occurred. About 1:50 minutes were required for the controllers to learn that the DC-9 was not visible as a radar target, that the DC-9 flightcrew did not respond to radio calls, and for the pilots on the ground to report a fire on the ground south of the Penalty Box. This fire was not visible from the tower. The CFD response to the

alarm was timely, and the first unit reported "on scene" within 1 minute of the time the alarm was sounded.

2.2 Conclusions

a. Findings

1. The visibility at O'Hare at the time of the accident was one-fourth mile in fog.
2. Airport traffic beyond the confines of the main terminal area could not be observed visually from the control tower.
3. The ASDE "BRITE" equipment at the O'Hare tower provided indistinct displays of airport ground traffic.
4. The ground controller's transmission to the CV-880 was ambiguous because he did not specify which of two similarly numbered runup pads was to be used as a holding point.
5. The flightcrew of the CV-880 did not request clarification of the ground controller's ambiguous transmission.
6. Flightcrews and controllers in the Chicago terminal area both deviated from the prescribed ATC communication procedures.
7. The captain of the DC-9 was operating under a valid clearance.
8. Neither the local controller nor the flightcrew of the DC-9 was aware of the proximity of the CV-880 to Runway 27L.

b. Probable Cause

The National Transportation Safety Board determines that the probable cause of this accident was the failure of the traffic control system to insure separation of aircraft during a period of restricted visibility. This failure included the following: (1) the controller omitted a critical word which made his transmission to the flightcrew of the Delta CV-880 ambiguous; (2) the controller did not use all the available information to determine the location of the CV-880; and (3) the CV-880 flightcrew did not request clarification of the controller's communications.

3. RECOMMENDATIONS

On March 20, 1973, the Federal Aviation Administration issued Air Carrier Operations Bulletin 73-1. This bulletin requested that each Principal Operations Inspector review his assigned carrier's emergency evacuation training program to assure compliance with 14 CFR 121.417. The bulletin recommended that the initial and recurrent training programs

provide for operation of each emergency exit by individual crewmembers either on the aircraft or on a suitable mockup.

On March 21, 1973, the FAA advised North Central Airlines that the portion of its emergency evacuation training program which authorized training by demonstration on the operation and use of emergency exits was cancelled. Also, provisions were set forth that required: (1) all crewmembers individually to operate each type of emergency exit during initial and recurrent training; (2) all DC-9 crewmembers, except those who had done so in the preceding 12 months, to operate the DC-9 tail cone exit within the succeeding 90 days; and (3) North Central Airlines to demonstrate an emergency evacuation of a DC-9 within the succeeding 30 days.

The Board has submitted six recommendations (A-73-21 through 26) to the FAA concerning air traffic control procedures. Correspondence related to these recommendations is included in Appendix E.

Five recommendations (A-73-39 through 43) concerning the crash survival aspects of this accident and two other recent accidents were submitted to the Federal Aviation Administration in a letter issued June 25, 1973. (See Appendix F.)

An additional survival aspect, a need for improved emergency evacuation capability in darkness and smoke conditions, was illustrated by this accident. In the darkness and smoke, the passengers had extreme difficulty in finding their way to the main exit and in locating exits. Four passengers left their seats and apparently attempted to find an exit but were unable to do so under the conditions that existed.

In January 1968, a study entitled, "New Concepts for Emergency Evacuation of Transport Aircraft Following Survivable Accidents" was prepared by North American Rockwell Corp., Aerospace and Systems Group. This study discussed a number of concepts to improve egress from aircraft involved in survivable accidents. These concepts included among others, sonic indicators at emergency exits; "chemical light" to outline aisles, exits and egress devices; revised cabin lighting; floor level lighting; and tactile indicators for exit routes.

Our evaluation of this accident as well as other recent survivable accidents indicates that egress from the aircraft would have been easier and faster if some or all of the above listed items had been available in the aircraft.

Therefore, the National Transportation Safety Board recommends that the Federal Aviation Administration:

1. Amend the existing certification and operating rules for air carrier and air taxi aircraft to include provisions requiring tactile guidance and improved visual guidance to emergency exits,

as well as more efficient methods of indicating the location of emergency exits in a dark or smoke environment. (Recommendation A-73-53)

A major factor in this accident was that the ground controller did not know the position of the CV-880 following initial radio contact because he did not hear the position given by the flightcrew. Additionally, the controller did not use the ASDE to verify or determine the position of the aircraft, the controller did not issue instructions to taxi via a specific route to a specific destination, and the flightcrew did not request additional clarifying information from the controller. To eliminate these problems, the Board recommends that the Federal Aviation Administration:

2. Require flightcrews to report their aircraft position on the airport when establishing radio communications with controllers, and require the controllers to read back the reported aircraft position when it cannot be verified either visually or by means of radar. (Recommendation A-73-54)
3. Require flightcrews to read back taxi clearances when operating in visibilities of less than one-half mile. (Recommendation A-73-55)

BY THE NATIONAL TRANSPORTATION SAFETY BOARD:

/s/ JOHN H. REED
Chairman

/s/ FRANCIS H. McADAMS
Member

/s/ LOUIS M. THAYER
Member

/s/ ISABEL A. BURGESS
Member

/s/ WILLIAM R. HALEY
Member

July 5, 1973

INVESTIGATION AND HEARING

1. Investigation

The National Transportation Safety Board received notification of this accident at 1930 eastern standard time on December 20, 1972. An investigation team was dispatched immediately to the scene. Investigative groups were established for Operations, Air Traffic Control, Weather, Human Factors, Structures, Powerplants, Systems, Flight Data Recorders, and Cockpit Voice Recorders.

The Federal Aviation Administration, Delta Air Lines, Inc., North Central Airlines, Inc., Air Line Pilots Association, Pratt & Whitney Division of United Aircraft, Inc., Douglas Aircraft Company, and the Professional Air Traffic Controllers Organization assisted the Board in this investigation.

2. Hearing and Deposition

A public hearing was held at the Sheraton O'Hare Motor Inn in Rosemont, Illinois, starting on January 17, 1973; it was terminated at the Headquarters, National Transportation Safety Board, Washington, D. C., on February 2, 1973. Several periods of recess were included in the above period. The actual proceedings covered a period of 9 days.

The deposition of one of the North Central Airlines, Inc., stewardesses was taken in Minneapolis, Minnesota, on February 20, 1973.

3. Preliminary Report

No preliminary report was issued in connection with this accident.

AIRMAN INFORMATION

Air Traffic Control Specialist

Mr. Lloyd D. Eastburn was working the local control position at the time of the accident.

Mr. Eastburn was employed by the Federal Aviation Administration in 1961. He began controller duties in the Chicago O'Hare International Airport tower on May 2, 1961. In 1967, Mr. Eastburn transferred to similar duties in Alaska, and, in 1968, he returned to the O'Hare facility. He requalified for duty at O'Hare on August 16, 1968.

Mr. Eastburn held Air Traffic Control Service (tower) Rating No. 1514308. He holds a second-class FAA medical certificate, without limitation, issued on January 17, 1972.

Mr. Patrick M. O'Brien was working both ground control positions at the time of the accident.

Mr. O'Brien was employed by the FAA in 1970, and he was assigned to duty in the O'Hare tower on September 8, 1970. He was qualified as a ground controller, April 2, 1971, and a Visual Flight Rules (VFR) local controller on December 10, 1971. He began radar training on March 31, 1972.

Mr. O'Brien holds Visibility Certificate No. 5815 issued by the National Weather Service. He holds a second-class FAA medical certificate without limitations, issued on September 14, 1972.

AIRMAN INFORMATION

	<u>Captain</u>	<u>First Officer</u>	<u>Second Officer</u>
Name	Robert Earl McDowell	Harry David Greenberg	Claude Francis Fletcher
Date of Birth	May 26, 1936	December 6, 1941	August 12, 1943
Total Flight Time	5,500 hrs.	3,600 hrs.	4,000 hrs.
Total CV-880 Flight Time	2,400 hrs.	500 hrs.	200 hrs.
Airman Cert. Type	A.T.R.	Commercial Pilot	A. T. R.
Airman Cert. No.	1604809	1582270	1747794
Ratings	Amel, Sel, Comm1 CV-880, CV-990, DC-9	Amel, Sel, Instrument	Amel, Sel, Commercial
Certificate Issue Date	August 30, 1972	June 16, 1967	November 21, 1968
Limitations	None	(Amel - CTR. Thrust)	None
Medical Certificate	First Class	First Class	First Class
Medical Certificate Limitations	None	None	None
Last Physical Examination	July 10, 1972	October 24, 1972	September 9, 1972

AIRMAN INFORMATION

North Central Airlines, Inc. Flightcrew

Captain

First Officer

Name	Ordell T. Nordseth	Gerald Dale Adamson
Date of Birth	March 27, 1923	November 25, 1940
Total Flight Time	20,261:00 hrs.	4,537:30
Total DC-9 Flight Time	3,455:00 hrs.	1,601:14
Airman Cert. Type	A. T. R.	Commercial Pilot
Airman Cert. No.	479154	1658097
Ratings	Amel. DC-9 CV240/340/440/DC-3 Comm1. Sel	Amel. Sel Instrument
Certificate Issue Date	May 11, 1968	April 5, 1969
Limitations	None	None
Medical Certificate	First Class	Second Class
Medical Cert. Limitations	Must wear Corr. lenses for near vision	None
Last Physical Examination	July 14, 1972	December 6, 1971

AIRMAN INFORMATION

Flight Attendants

Delta Airlines, Inc.

The senior stewardess, Shelby McRoberts, was first employed by the carrier on November 24, 1969. She completed her initial training on December 19, 1969, and completed her Convair 880 recurrent training on July 3, 1972.

Miriam Ann Tegreeny was first employed by the carrier on July 28, 1969. She completed her initial training on August 22, 1969, and completed her Convair 880 recurrent training on September 9, 1972.

Linda Pryde was first employed by the carrier on June 1, 1970. She completed her initial training on June 26, 1970, and completed her Convair 880 recurrent training on January 25, 1972.

Bonnie Brueck was first employed by the carrier on November 20, 1972. She completed her initial and Convair 880 training on December 15, 1972.

North Central Airlines, Inc.

DeAnn Sutley was first employed by the carrier and completed her initial training on July 14, 1967. She completed her recurrent training on the Douglas DC-9 on September 26, 1972.

Marlys Bertsch was employed by the carrier and completed her initial training on October 8, 1965. She completed her recurrent training on the Douglas DC-9 on September 22, 1972.

AIRCRAFT DATA

(a) Delta Air Lines, Inc.

The airplane, a Convair CV-880, manufacturer's serial No. 29, was manufactured on July 25, 1960, and was assigned U.S. Registry No. N8807E.

The airplane was equipped with four General Electric CJ-805-3 turbo-jet powerplants.

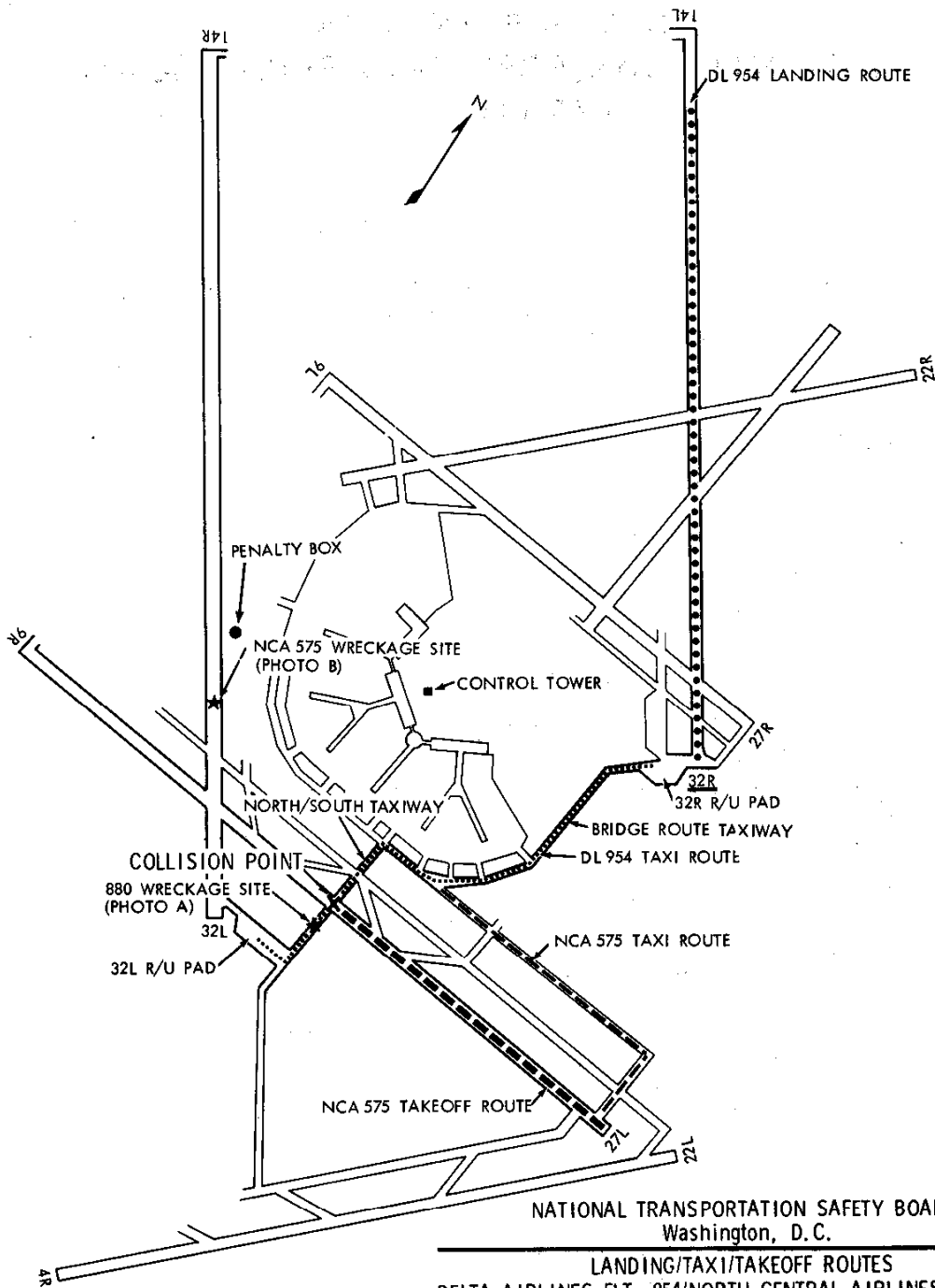
N8807E had accumulated a total flying time of 37,640.1 hours, 1801.3 hours since the last major inspection, and 43.6 hours since the last line maintenance inspection.

(b) North Central Airlines, Inc.

The airplane, a McDonnell Douglas DC-9-31, manufacturer's serial No. 47159, was manufactured on December 27, 1967, and was assigned U. S. Registry No. N954N.

The airplane was equipped with two Pratt & Whitney JT8D-7 Turbofan engines.

N954N had accumulated a total flying time of 11,812:57 hours, 350:41 hours since the last major inspection, and 9:34 hours since the last line maintenance inspection.



NATIONAL TRANSPORTATION SAFETY BOARD
Washington, D.C.

LANDING/TAXI/TAKEOFF ROUTES
DELTA AIRLINES FLT. 954/NORTH CENTRAL AIRLINES FLT. 575
CONVAIR 880 N8807E/McDONNELL DOUGLAS DC-9-31 N954N
Collision at Chicago-O'Hare International Airport
December 20, 1972

UNITED STATES OF AMERICA
NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C.

ISSUED: May 17, 1973

Adopted by the NATIONAL TRANSPORTATION SAFETY BOARD
at its office in Washington, D. C.
on the 26th day of April 1973

FORWARDED TO:)
 Honorable Alexander P. Butterfield)
 Administrator)
 Federal Aviation Administration)
 Washington, D. C. 20591)

SAFETY RECOMMENDATIONS A-73-21 thru 26

During the National Transportation Safety Board's investigation of the ground collision accident which occurred at O'Hare International Airport, Chicago, Illinois, on December 20, 1972, we learned that visibility from the tower cab, officially reported as one-fourth of a mile, limited severely the controllers' ability to see ground traffic on the airport. Therefore, controller personnel concerned with the two aircraft involved in the collision were unable to monitor visually the movements of either aircraft at any time, except for a brief time when the DC-9 taxied from the terminal gate. Under the existing circumstances, no one in the tower cab saw the accident.

At the time of the accident, the Airport Surface Detection Equipment (ASDE) radar installed at O'Hare was operating without reported trouble. ASDE was used by the local controllers to effect separation requirements, as applicable to the local control position, but ASDE was not used by the O'Hare ground controller to control ground traffic, and facility operating procedures did not require that ASDE be used for this purpose.

In view of the fact that ASDE radar is an aid intended to assist controllers to control ground traffic under low visibility conditions, the Board finds it difficult to understand why ground controllers would not want to, and do not, use this aid for "eyes" whenever possible.

Honorable Alexander P. Butterfield

Of the eight FAA facilities equipped with ASDE, three facilities use the "BRITE" display equipment. All three facilities have encountered problems with the "BRITE" display. The picture is degraded on the "BRITE" presentation and is inferior to the picture displayed on the direct view radar.

All three facilities using "BRITE" equipment have had Airways Facility Sector technicians working on the problem to improve the presentation to satisfy controller requirements. Only one of the three facilities appears to have achieved a degree of success.

The Board cannot determine whether the problem is the result of the "BRITE" equipment design, a nonstandard installation, or equipment maintenance. Whatever the problem may be, it should be resolved at the national level. In view of the scheduled installations of new "BRITE" display equipment at those facilities now using the direct view radar display, it is extremely important that the Federal Aviation Administration should have reasonable assurance that the new equipment will provide satisfactory results before it is installed.

At the present time, it appears that the five facilities which are not equipped with the "BRITE" display make more effective use of ASDE radar than those facilities which use the "BRITE" display, despite certain operational disadvantages associated with the use of the direct view radar display. Of special interest to the Board is the fact that each facility has its own procedures with respect to how and when the controllers at that facility are to use the ASDE for controlling ground traffic. The procedures at one facility differ from those at another. It appears also that the procedures used at certain facilities are more effective than those used at others.

The Board believes that FAA should evaluate the ASDE procedures at each of the eight facilities which is equipped with ASDE radar. Optimum operating procedures for ASDE should then be established on the national level, applicable to all facilities where ASDE is installed.

Safer ground operations could be achieved also if specific taxi routes were prescribed for all aircraft taxiing out for takeoff or inbound to the terminal during periods in which visibility is restricted to $\frac{1}{2}$ mile or less. If possible, such outbound and inbound taxi routes should not cross active runways. This would establish an orderly traffic flow, and pilots would know the routes to expect.

Honorable Alexander P. Butterfield

If the controller or pilot should find it advantageous to deviate from the designated route, clearance could be issued for another specific taxi route. If a route crosses an active runway, the pilot should be required to contact ground control before crossing that runway, even though the taxi clearance issued previously contained authorization to cross the runway. When the ground controller observes on ASDE radar that particular aircraft approaching the active runway, he would be expected to reaffirm the pilot's clearance to cross that runway.

Such procedures are believed to be feasible and would provide an added measure of safety under adverse visibility conditions. Therefore, the National Transportation Safety Board recommends that the Federal Aviation Administration:

1. Standardize configurations, alignment techniques, and equipment modifications at the three existing ASDE "BRITE" facilities in an effort to improve the performance of that equipment.
2. Not proceed with the scheduled installation of "BRITE" displays at other ASDE-equipped facilities which now use the direct view radar display until satisfactory operation of "BRITE" equipment is achieved at the three facilities where it is now installed.
3. Contingent upon favorable results of the evaluation of the new model ASDE "BRITE" display currently being conducted by the Transportation Systems Center, install that equipment first at the three locations where "BRITE" equipment is now used.
4. Establish standard procedures for the use of ASDE radar, and publish such procedures in appropriate Air Traffic Handbooks.
5. Establish and publish taxi routes for arriving and departing aircraft to be used during periods of restricted visibility on the order of $\frac{1}{2}$ mile.
6. Require pilots to obtain the controllers' approval before crossing a lighted runway during periods of restricted visibility on the order of $\frac{1}{2}$ mile.

Honorable Alexander P. Butterfield

These recommendations will be released to the public on the issue date shown above. No public dissemination of the contents of this document should be made prior to that date.

Reed, Chairman, McAdams, Thayer, Burgess, and Haley, Members, concurred in the above recommendations.


By John H. Reed
Chairman

WASHINGTON, D.C. 20590



OFFICE OF
THE ADMINISTRATOR

JUN 1 1973

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

Dear Mr. Chairman:

This is in response to the National Transportation Safety Board Safety Recommendations A-73-21 through 26, issued May 17, 1973, based upon information the Board had obtained in the investigation of the ground collision accident at O'Hare International Airport on December 20, 1972.

Following are our comments on your specific Recommendations.

A-73-21

The ASDE BRITE display modifications presently in use at Kennedy, O'Hare and San Francisco are not part of our national program (mentioned in NTSB Recommendation 2). Rather, each of the above three ASDE BRITE systems were configured and installed by the respective regions. Thus, all three are nonstandard installations. However, our Systems Research and Development Service has been working through Transportation Systems Center with Texas Instruments, Inc., on an ASDE-2 RELIABILITY IMPROVEMENT STUDY which encompasses all of the major technical areas mentioned in this item. Texas Instruments is in the process of finalizing its report. When it is received, serious consideration will be given to the modification recommendations and any other recommendations they may make which will improve the performance of the ASDE-2.

A-73-22

Systems Research and Development Service issued an "ASDE Improvements" document which provided that certain improvements be implemented at all ASDE locations to permit continued use of ASDE in the NAS system until such time as a new "all weather" airport ground guidance and control

system is developed. This new system is presently being developed by TSC in close cooperation with FAA. We recognize that the ASDE BRITE presentation is somewhat degraded over the direct view cathode ray tube presentation. However, the advantage of this trade-off is that the BRITE display permits the controller to look at the display without resorting to a hood-type viewer.

A-73-23

We agree that any improvements to ASDE developed by TSC should be implemented first at the three locations, Kennedy, O'Hare and San Francisco. However, in the interim, our Airway Facilities Service is making a concerted effort to update and improve the performance of the present ASDE BRITE.

A-73-24

Preliminary results from a current ASDE staff study by our Air Traffic Service does indicate a need for more specific guidelines concerning "how and when" ASDE should be used. These are being worked on at the present time.

A-73-25

Our Airport Taxi Chart Program was started in 1971 and is progressing to include additional airports as rapidly as possible. We now have 120 published with 230 more proposed. The design of these charts allows the controller to assign specific routes based on the traffic situation at the time using the information which the pilot can follow by referring to his chart. We believe the ever-changing traffic situation precludes publishing a chart for every situation.

A-73-26

If a pilot is cleared "to" a runway, ATC is telling him that traffic conditions permit him to use the appropriate taxiway and to cross all runways en route to the active runway. Controllers should not be required to issue dual clearances to "reinforce" that an inactive runway is clear of traffic. If, while taxiing "to" the active runway, a pilot wants confirmation that he is cleared to cross a runway, it is the pilot's responsibility to ask for confirmation. A continuing requirement to approve each specific crossing of a lighted runway would result in an intolerable communications problem and added controller workload.

With respect to the last two Recommendations, the current ASDE staff study referred to in our comment on A-73-24 includes a review of our policy on the use of "specific taxi route" clearances and the use of routes which should, when operationally feasible, not require an aircraft to cross an active runway when the visibility prevents complete surveillance of the movement area.

I would like to compliment your staff on the quality of the Safety Recommendations. As you can see, we are taking positive action on most of them.

Sincerely,


James E. Dow
Acting Administrator

UNITED STATES OF AMERICA
NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C.

ISSUED: June 25, 1973

Adopted by the NATIONAL TRANSPORTATION SAFETY BOARD
at its office in Washington, D. C.
on the 6th day of June 1973

FORWARDED TO:)
Honorable Alexander P. Butterfield)
Administrator)
Federal Aviation Administration)
Washington, D. C. 20591)

SAFETY RECOMMENDATIONS A-73-39 thru 43

The National Transportation Safety Board has under investigation, three accidents involving: a United Air Lines Boeing 737 at Midway Airport, Chicago, Illinois, on December 8, 1972; a North Central Airlines DC-9, at O'Hare International Airport, also at Chicago, Illinois, on December 20, 1972; and an Eastern Air Lines Lockheed L-1011 at Miami, Florida, on December 29, 1972.

The Safety Board has identified several areas in occupant survival and evacuation common to these accidents which it believes merit remedial action by the Federal Aviation Administration. These areas are delineated below:

Shoulder Harness Restraint. Testimony at the Safety Board's public hearing concerning the United B-737 accident revealed that crew takeoff and before-landing checklists did not contain the item "Shoulder Harness Fastened." The injuries sustained by the captain, as well as the conditions of the captain's and first officer's shoulder harness in the wreckage, indicated that the shoulder harness had not been used.

In the EAL accident, we noted that the shoulder harness on the aft facing cabin attendant seats had been removed. In a letter dated March 12, 1973, the Board, in commenting on your Notice of Proposed Rule Making 73-1, expressed its concern about the absence of a requirement to have shoulder harnesses installed on aft facing seats. We pointed out that in crashes or emergency landings involving multidirectional inertia forces, shoulder harnesses would provide an additional,

and possibly vital, measure of protection for occupants of aft facing seats. The principal advantage of a shoulder harness, both in forward and rearward facing seats, is that it helps to restrain the user in an upright position, thereby keeping the spinal column in a more suitable position from the standpoint of load distribution. Additionally, the shoulder harness prevents the upper body from flailing, a frequent cause of serious injuries in aircraft accidents. The Board believes that increased protection from injury of the flightcrew as well as the cabin attendants is of vital importance, since their availability to guide and aid passengers during evacuation may make the difference between survival and disaster. Therefore, the Safety Board recommends that the Federal Aviation Administration:

1. Take the necessary steps to ensure that all air carrier before-landing and takeoff checklists contain a "Fasten Shoulder Harnesses" item.
2. Amend 14 CFR 25.785(h) to require provisions for a shoulder harness at each cabin attendant seat, and amend 14 CFR 121.321 to require that shoulder harnesses be installed at each cabin attendant seat.

Auxiliary Portable Lighting. During the investigation and public hearing held in connection with the EAL L-1011 accident, testimony indicated that the absence of lighting of any kind at the crash scene seriously hampered survivors' ability to orient themselves and prevented them from searching for and assisting other injured survivors. Additionally, this lack of light prevented cabin attendants from taking effective charge among the surviving passengers. In both Chicago accidents, a similar lighting problem was encountered. Although section 121.549(b) of the Federal Aviation Regulations requires each crewmember to have available a flashlight, cabin attendants usually stow their personal flashlights in their handbags, which tend to become lost in the debris of the wreckage. This, for example, was the case in both Chicago accidents. The Board believes that effective alternate means of lighting, which is not dependent on random stowage and location, should be readily accessible to the flight attendants. Therefore, the Safety Board recommends that the Federal Aviation Administration:

3. Amend 14 CFR 25.812 to require provisions for the stowage of a portable, high-intensity light at cabin attendant stations; and amend 14 CFR 121.310 to require the installation of such portable, high-intensity lights at cabin attendant stations.

Emergency Lighting. Evidence obtained during the investigation of the North Central DC-9 accident and the United B-737 accident in Chicago, indicated that many passengers had difficulties in escaping from the wreckage. These difficulties were a result of inadequate illumination, combined with a heavy smoke condition in one of these accidents. In the United accident, survivors specifically mentioned the absence of any light in the cabin. In the North Central accident, passengers experienced great difficulty in locating the exits, reportedly because of darkness and heavy smoke in the cabin. Yet, the crew testified that the emergency lighting system was armed, and the investigation indicated that they should have been operational. However, four of the nine fatally injured passengers apparently died while they were attempting to find an exit. One passenger was found in the cockpit, one near the cockpit door, and two others were found near the aft end of the cabin. The five remaining fatalities apparently had not left their seats.

Numerous recommendations and proposals to improve occupant escape capabilities in survivable accidents have been made over the years by various Government and industry organizations; and, indeed, significant improvements have occurred. Unfortunately, however, experience indicates that the existing escape potential from aircraft in which postcrash fire is involved is still marginal. These accidents illustrate the vital role that adequate illumination can play in contributing to such postcrash survivability.

A review of 14 CFR 25.811 and 25.812 indicates that paragraph 811(c) requires means to assist occupants in locating exits in conditions of dense smoke. Yet, information from the Civil Aeromedical Institute in Oklahoma City indicates that the illumination levels specified in paragraph 812 are not predicated on a smoky environment, and therefore may be ineffective under conditions of dense smoke. In order to eliminate this inconsistency, the Board believes that illumination levels should be specified in paragraph 812, which are consistent with the requirements of 14 CFR 25.811(c). Moreover, these and other accident experiences have shown that for various reasons aircraft emergency lighting systems often do not work or are proved ineffective in survivable accidents. Therefore, the Safety Board recommends that the Federal Aviation Administration:

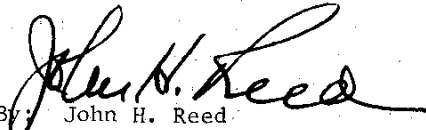
4. Amend 14 CFR 25.812 to require exit sign brightness and general illumination levels in the passenger cabin that are consistent with those necessary to provide adequate visibility in conditions of dense smoke.

5. Amend 14 CFR 25.812 to provide an additional means for activating the main emergency lighting system to provide redundancy and thereby improve its reliability.

Emergency Evacuation Problems: A recurring problem of galley security was encountered in the UAL B-737 accident when, during impact, food and service items fell from the two aft cabin galley units. The impact, which was described by cabin attendants as a series of mild to moderate jolts acting forward and rearward, caused the four oven units and food carriers, the cold food trays, and the liquor supply units to be thrown to the floor near the rear service door. The Board previously has commented on the evacuation hazard caused by loose galley equipment and acknowledges a letter from the FAA dated February 16, 1973, which cites corrective actions to alleviate the galley security problem. Specifically, we are encouraged by recent amendments to Parts 25 and 121 of the Federal Aviation Regulations, which cover the retention of items of mass in passenger and crew compartments. Nevertheless, we wish to reiterate our belief concerning the need for further improvements to ensure the security of galley equipment under crash landing loads. The Board is aware that an amendment to 14 CFR 25.789, which would require the installation of secondary retention devices on galley equipment, is under consideration for rulemaking action. In view of the steps that you have initiated to remedy this safety problem, the Safety Board is not making a formal recommendation at this time. However, we urge you to expedite your consideration of this matter in order that an amended galley retention regulation can be made effective at an early date.

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Reed, Chairman, McAdams, Thayer, and Haley, Members, concurred in the above recommendations. Burgess, Member, was absent, not voting.


By: John H. Reed
Chairman