

PB83-138024



# NATIONAL TRANSPORTATION SAFETY BOARD

WASHINGTON, D.C. 20594

## AIRCRAFT ACCIDENT REPORT

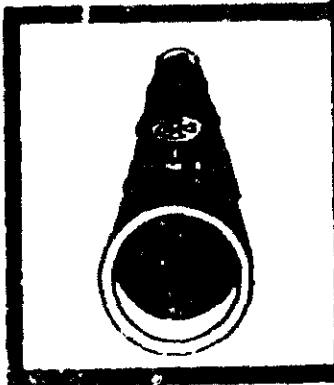
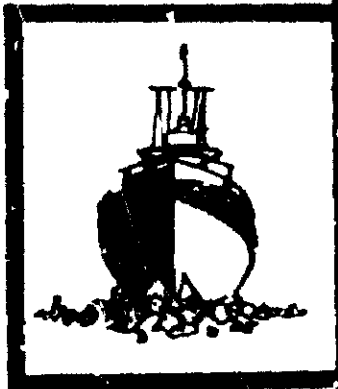
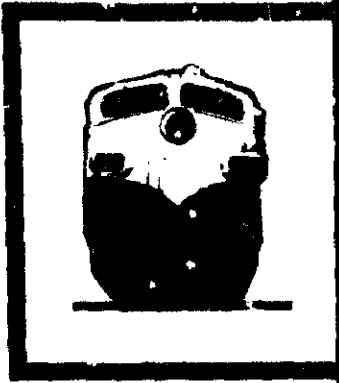
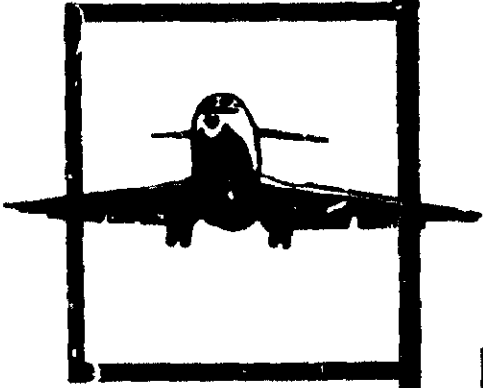
NORTH CENTRAL AIRLINES, INC.  
CONVAIR 580, N4825C  
KALAMAZOO, MICHIGAN  
JULY 25, 1978

(REVISED NOVEMBER 22, 1982)

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16. Abstract At 0702 e.d.t. on July 25, 1978, a North Central Airlines, Inc., Convair 580, operating as Flight 301, crashed after takeoff from Kalamazoo Municipal Airport, Kalamazoo, Michigan. Just as the airplane passed $V_1$ , a bird struck the left engine, and the left propeller autofeathered as the airplane lifted off. The airplane turned to the left and flew for 1 minute 19 seconds before it crashed into a cornfield.  There were 40 passengers, including an infant, and a crew of 3 on board the aircraft. One crewmember and two passengers were injured seriously.  The National Transportation Safety Board determines that the probable cause of this accident was the failure of the captain to follow the prescribed engine-out procedures during instrument meteorological conditions, which allowed the airplane to decelerate into a flight regime from which he could not recover. Contributing to the accident were inadequate cockpit coordination and discipline.			
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AIRCRAFT ACCIDENT REPORT

Adopted: February 22, 1979  
Revised: November 22, 1982

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NORTH CENTRAL AIRLINES, INC.  
CONVAIR 580, N4825C  
KALAMAZOO MUNICIPAL AIRPORT  
KALAMAZOO, MICHIGAN  
JULY 25, 1978

SYNOPSIS

At 0702 e.d.t. on July 25, 1978, a North Central Airlines, Inc., Convair 580, operating as Flight 801, crashed after takeoff from Kalamazoo Municipal Airport, Kalamazoo, Michigan. Just as the airplane passed V<sub>1</sub>, a bird struck the left engine, and the left propeller autofeathered as the airplane lifted off. The airplane turned to the left and flew for 1 minute 19 seconds before it crashed into a cornfield.

There were 40 passengers, including an infant, and a crew of 3 on board the aircraft. One crewmember and two passengers were injured seriously.

The National Transportation Safety Board determines that the probable cause of this accident was the failure of the captain to follow the prescribed engine-out procedures during instrument meteorological conditions, which allowed the airplane to decelerate into a flight regime from which he could not recover. Contributing to the accident were inadequate cockpit coordination and discipline.

1. FACTUAL INFORMATION

1.1 History of Flight

On July 25, 1978, a North Central Airlines Convair 580, N4825C, operated as Flight 801, a scheduled passenger flight from Kalamazoo, Michigan, to Detroit, Michigan.

The flight crew arrived at the airport about 0630 e.d.t. <sup>1/</sup> for a scheduled departure of 0655. While the first officer and flight attendant proceeded to the airplane to attend to preflight duties, the captain went to operations to review the dispatch package and the weather and to sign the flight release. The prestart checklist was completed after the captain arrived at the aircraft.

The first officer called ground control at 0640 to request the instrument flight rules (IFR) flight plan. This call was followed by the crew tuning in the Automated Terminal Information Service; they received the following information: "Kalamazoo information echo one one zero zulu. Weather--indefinite ceiling one hundred, sky obscured, visibility--one half mile, fog, temperature six six, dewpoint six four, wind one six zero at four, altimeter three zero zero three. ILS runway three five approach in use. Landing, departing runway three five. Advise initial contact you have echo."

<sup>1/</sup> All times herein are eastern daylight, based on the 24-hour clock.

The captain informed the first officer that in the event of an engine failure during takeoff, he planned to make an instrument landing system (ILS) to runway 35 at Kalamazoo Airport. Although the ATIS information he had received at 0640 indicated 1/2 mile visibility, the surface weather observations taken by controllers at 0645 indicated a 1/4-mile visibility for runway 35. However, this information was not given to the flightcrew by the controller.

At 0657:07 Flight 801 transmitted, "Ground, NC801 taxi with Echo" and the controller replied, "North Central 801, Kalamazoo Ground, taxi to runway one seven, you're on request."

There were 40 passengers, including an infant, and a crew of three on board when the airplane left the gate. The after-start and before-takeoff checklists were completed during the taxi to runway 17 and 15° of flaps were set. At 0658:12, the tower controller cleared Flight 801 to the Detroit Metropolitan Airport. The clearance was amended once before takeoff. The flightcrew read back the clearance and amendment.

The first officer computed the takeoff speeds based on a weight of 50,000 lbs.  $V_1$  was 107 kts,  $V_R$  was 109 kts, and  $V_2$  was 111 kts. The best single-engine climb (BSEC) speed was 132 kts.

At 0659:22, Flight 801 transmitted, "801's ready to go," and the controller replied, "Roger 801, after departure turn left, proceed direct Litchfield, cleared for takeoff." The time en route to Detroit was 28 min.

At 0659:38, the captain announced, "It's my leg," and at 0659:54, he stated that the turbine inlet temperature (TIT) for the takeoff would be 932°. At 0700:05, the captain commanded "Power," and the airplane began the takeoff roll. The captain advanced the power lever to 800° TIT and the first officer followed him. The first officer trimmed the power to 932° TIT. The first officer stated that he checked and rechecked the engine instruments and all were normal.

The flightcrew believed that the acceleration of the airplane during the takeoff roll was normal. The first officer stated that he thought that both engines indicated "3,000 (horsepower) or a little over:" on the takeoff roll. At 0700:21, the first officer called " $V_1$ ." The flight data recorder (FDR) indicated that the indicated airspeed of the airplane was about 109-110 kts when the call was made. At 0700:22, as the airplane was lifting off, the first officer announced "power loss." Immediately thereafter, the cockpit voice recorder (CVR) recorded engine spooldown sounds.

The first officer stated that he heard a click which he believed to be a propeller feathering itself automatically. He felt no swerve, so he looked at the TIT and RPM gauges and saw the left engine TIT gauge to be about 460 to 470°; horsepower was dropping rapidly.

At 0700:26, the captain announced, "Okay, call the tower." At 0700:28, someone commanded, "Max power." The captain also checked to see if the left propeller had autofeathered. At 0700:29, the first officer transmitted, "tower eight oh one's lost an engine, be returning to the field," and at 0700:32, he stated, "Power set." At 0700:32, the tower cleared Flight 801 to land on runway 17. Based on the FDR altitude readout and the report of a 100-ft. ceiling at the airport, the airplane entered the overcast within seconds after the 0700:29 transmission by the first officer. The FDR also indicates that a heading change to the left began just after liftoff and continued to the left until impact.

The first officer stated that on the command of "Max power" he pushed the power levers full forward. He expected the right engine TIT red warning light to illuminate from an overtemperature of the engine. Although the gauge read 978° TIT, the light did not illuminate. The first officer stated that this was strange, and he looked at it for about 2 seconds. He did not realize that the overtemperature warning light would not illuminate until the temperature reached 980°. The first officer stated that he pushed forward on the power levers again and that he "sensed at that time in my own mind, something just wasn't right, and I remembered looking at the gauges below the TIT, but it's not clear in my mind what I saw, but I remember thinking that the horsepower in the right engine wasn't what I expected it to be for having put on max power. So I sensed in my own mind that perhaps something wasn't exactly right with that engine."

The first officer stated that after he had set maximum power on the right engine, he raised the landing gear at the command of the captain by bringing the gear lever to the up position. This command was not recorded on the CVR, nor was the sound of the gear retracting recorded on the CVR. The captain stated that the first officer's hand position (or signal) confirmed that the gear was up. He also stated that he noted there were no green landing gear lights on.

At 0700:44, the first officer announced that the malfunctioning engine was the left engine. At 0700:49, the first officer stated "V<sub>2</sub>" followed at 0700:51 by the captain's announcing, "(It's) fully feathered." At 0700:52, the first officer again said, "V<sub>2</sub> is 111." He stated that this reference to the V<sub>2</sub> speed of 111 knts was because the airplane was being flown between 108 and 110 knts, which was below the computed V<sub>2</sub> speed. At 0700:52, the captain said, "Yes sir (we're turning) to the \*." The first officer stated that an airframe buffet began shortly after the V<sub>2</sub> calls. The buffet concerned him, and he pushed forward again on the power levers. At 0700:55, the captain said, "Get this sucker on the \*\*\*." At this point, the airplane was flying about 200 feet aboveground level at an indicated airspeed of about 106 knts.

The first officer looked at the attitude indicator and noted that the pitch of the airplane was still at the 8° climb attitude for which the flight director command bar was set. However, this pitch did not result in the expected airspeed. The captain stated that when he could not maintain sufficient airspeed with an 8° climb attitude, he lowered the climb attitude to 5°. However, even at 5°, he stated he could not increase the airspeed or maintain a rate of climb.

At 0700:58, the Ground Proximity Warning System (GPWS) sounded. The FDR recorded a slight increase in altitude and a corresponding decrease in indicated airspeed following the first GPWS warning. At 0700:59, the airplane began to climb from about 200 feet a.g.l. and reached about 260 feet a.g.l. at 0701:09. That was the highest altitude reached during the flight. As the airspeed decreased to about 104 knts, the captain allowed the airplane to descend slightly in order to recover airspeed. The GPWS sounded again and continued for the remaining 42 sec until impact.

The first officer's recollection of 250 feet a.g.l. as the highest altitude the airplane reached was confirmed by the FDR altitude trace. Both crewmembers stated that they were in the overcast for almost all of the flight. However, after 0701:10, as the airplane began to descend, occasional, visual ground contact was acquired. The captain stated that he was aware that the airplane was turning during the flight. He further stated that he had full right aileron applied as he descended through the overcast. However, he did not recall when he applied full rudder, or how much aileron he had used until the airplane broke out of the clouds. He and the first officer stated that full right rudder and aileron were used during the last seconds of flight.



Although the captain did not recall what the bank angle was during the flight, the first officer stated that the airplane was in a left turn. He further stated that there was a "slight bank to the left. . .not a severe one -- but it was in a little bit of a bank." He did recall that just before impact, he realized that the airplane was in a "left swerve." He noted that the airplane was in the swerve when full right aileron and full right rudder were applied. However, the angle of bank to the left was not, in his opinion, severe.

At 0701:18, the captain stated, "Give me flaps 10°." The first officer stated, "Flap 10," and 2 sec later said, "Flaps 10 set." The airplane was about 200 feet a.g.l. and at 104 kts. The first officer did not look at the flap indicator when setting the flaps, but he believed they were positioned at 10° or 11°. Although the airframe buffet became more severe, the first officer noted that the radar altimeter still read 200 to 250 feet.

As the airplane began to descend, both crewmembers recalled having intermittent ground contact. The captain stated that although he could see the ground, he never considered the need to make a forced landing. He stated, "The entire thought was to get the airplane back on the runway." However, when the airplane continued to descend and trees and a house appeared in front of him, he realized that his airplane would not make it back to the runway. He saw the cornfield and positioned the airplane to avoid the obstacles and to land in the field. He stated, "I made a control correction, apparently to the left. I turned the wheel full right to bring my wing up and back, and then forward a little bit."

At 0701:31, the first officer stated, ". . .we're losing (out or altitude)," and the captain responded, "O.K." At 0701:34, the captain said, "Give me everything else." This was followed at 0701:36 by the captain restating, "Get the gear up, quick." The CVR recording ended at 0701:40.

Neither crewmember recalled putting in any aileron or rudder trim at any time during the flight.

The airplane came to rest in a field about 1.7 mi east of the departure end of runway 17. The airplane had flown about 2.7 miles and had turned about 123° to the left before impact. The left wingtip and aft portion of the fuselage struck the ground first. The heading of the airplane at initial impact was 47°.

The left wingtip and aileron separated shortly after impact. Three propeller blades separated from the left propeller, and two blades separated from the right propeller. After impact, the airplane slid about 433 feet before coming to rest on a heading of 290°. The landing gear was in transit at the time of impact, and was partially retracted.

The passengers' observations of the accident sequence differed. Eight passengers were aware that the left engine had "quit;" seven recalled that the airplane was in the clouds most of the flight; and two saw the landing gear down throughout most of the flight. One passenger stated that the landing gear was retracted. Three passengers said the right engine was not performing properly. Two passengers believed the airplane was about to stall just before impact. The passengers estimated that the left propeller feathered when the airplane was between 10 and 30 feet off the runway. Ground witnesses confirmed the limited visibility and stated that they did not hear the operating engine surge.

The accident occurred during daylight hours about 0702. The location of the accident was 42° 13' 11" N and 85° 31' 03" W; the elevation was 865 feet m.s.l.

**1.2 Injuries to Persons**

<u>Injuries</u>	<u>Crew</u>	<u>Passengers</u>	<u>Others</u>
Fatal	0	0	0
Serious	1	2	0
Minor/None	2	38	0

**1.3 Damage to Aircraft**

The airplane was damaged substantially.

**1.4 Other Damage**

The soybean and corn crops were damaged.

**1.5 Personnel Information**

The crewmembers were qualified and certificated for the flight and had received the training required by current regulations. (See appendix B.) The crew had flown N4825C to Kalamazoo the previous evening, arriving at 2118. The crew had been off duty about 9 hrs before reporting for duty for flight 801. On the previous day, they had flown 2.4 hrs, which included four landings.

**1.6 Airplane Information**

N4825C was certificated, maintained, and equipped according to Federal Aviation Administration (FAA) regulations. (See appendix C.) The airplane's gross weight at the time of the accident was 49,130 lbs. The maximum allowable gross takeoff weight was 54,300 lbs, and the maximum allowable landing weight was 53,000 lbs. The flight log contained no uncorrected deficiencies. The airplane had 6,800 lbs of jet-fuel aboard when it left the gate. The airplane was within the acceptable center of gravity range.

**1.7 Meteorological Information**

The area forecast for Michigan, issued by the National Weather Service Forecast Office in Chicago, Illinois, at 2040, on July 24, and valid 2100 through 1500 on July 25 was, in part, as follows:

Cold front extending from extreme Northwestern Minnesota moving slowly southeastward to extreme Northern Lake Superior and West central Minnesota by 1500. No significant clouds or weather except for a few hours around sunrise, patchy visibilities at or below 3 miles, ground fog, haze.

Surface weather observations taken at the Kalamazoo Municipal Airport by FAA personnel on July 25, 1978, were as follows:

0645, record, indefinite ceiling--100 ft sky obscured, visibility--1/2 statute mi, fog, temperature--66° F, dewpoint--64° F, wind--160° at 04 kns, altimeter setting--30.03 in.Hg., runway 35 visibility--1/4 statute mi.



0708, record, indefinite ceiling--100 ft sky obscured, visibility--1/2 statute mi, fog, temperature--66° F, dewpoint--64° F, wind--200° at 04 kns, altimeter setting--30.04 in.Hg., runway 35 visibility--1/4 statute mi.

The weather at the destination airport, Detroit, at 0700 was sky clear, visibility 1 1/2 mi, ground fog, and haze. The terminal forecast for Detroit for the expected time of arrival of Flight 801 was, in part: 5,000 scattered--10,000 scattered layers--variable to broken with a chance of 2-mi visibility--haze until 1100. The 0700 weather observation at O'Hare International Airport, Chicago, Illinois, was VFR. The 0700 weather at Cleveland Hopkins International Airport, was 1,700 ft broken, 2 1/2 mi ground fog, haze.

The accident occurred during the hours of daylight. However, the sky was obscured and fog covered the area.

**1.8 Aids to Navigation**

Not applicable.

**1.9 Communication**

There were no communications problems.

**1.10 Aerodrome Information**

Kalamazoo Municipal Airport, elevation 874 ft m.s.l., was certificated for air carrier service under 14 CFR 139. There are three runways: 17/35, 23/5, and 9/27. Runway 17/35 is 6,500 feet long and has a concrete surface. Runway 17/35 was equipped with high intensity runway lights, which were at the brightest setting when Flight 801 took off. The instrument approach procedure which afforded the lowest landing minimums was the ILS procedure for runway 35. The minimum visibility for the ILS runway 35 was 1/2 mile.

Kalamazoo Airport does not have a history of bird strikes, and bird hazard control is not considered a problem by airport authorities at this time. Its bird hazard control program conforms to 14 CFR 139.67.

**1.11 Flight Recorders**

N4825C was equipped with a Sundstrand cockpit voice recorder AV557B, Serial No. 604. The CVR case was not damaged and the recording tape was intact. The quality of the recording was good. (See appendix D.)

N4825C was equipped with a Sundstrand Data Control model FA-542 flight data recorder, Serial No. 3922. The FDR was not damaged, and all traces were clear and active. (See appendix E.)

**1.12 Wreckage and Impact Information**

The wreckage area was about 433 feet long by 90 feet wide, oriented on a magnetic heading of about 40°. (See appendix G.) There was no evidence of in-flight structural failure of any airplane part.

The left wing outboard of the nacelle separated at the rear spar about 80 feet beyond where the wingtip first hit the ground. The outboard left aileron also separated from the wing. The flap trailing edge measured 17 5/8 ins. from the aft wing skin edge, which corresponds to about a 12° flap setting. The right wing was damaged, but remained attached to the fuselage. The flap trailing edge measured 18 ins. from the aft wing skin edge--about a 12° flap setting.

The outboard gear door on the left engine nacelle and the inboard and outboard gear doors on the right nacelle separated. The landing gear was partially retracted at impact. The right main gear uplock was found in the unlatched position. The unit had been sheared from the spar. The piston rod in the right main gear retract cylinder was extended 6 1/2 ins. from the face of the cylinder to the end of the chrome. The piston rod was bent 45° toward the left wingtip. The left main gear uplock was found unlatched, but free to move. The piston rod in the left main gear retract cylinder was extended 6 1/2 ins. and was bent 45° toward the left wingtip.

The lower fuselage skin was scraped and damaged along the entire length of the fuselage. The nose section forward of station 299 was twisted clockwise 15° to 20° when viewed from the rear, and a hole was torn in the fuselage near seatrows 2 and 3.

The rear service door was operable. The forward entrance door was closed and not operable because of the damage to the fuselage. This entrance, however, was not an emergency exit in gear-up emergency landings. Emergency exits over the left and right wings and the exit aft of the right wing were open.

The empennage remained on the aircraft. There were numerous scrapes and buckles evident on the underside of the horizontal surfaces. The vertical fin and rudder were essentially undamaged. The rudder moved fully to the left and partially to the right.

During the field investigation the rudder was inspected. The rudder had full travel to the left and partial travel to the right. The rudder and torque tube assembly was found free to move on its hinges, and rudder travel was within the prescribed limits. The rudder trim was operable  $\pm 9^\circ$ , and the elevators could be operated through the full range of travel. The elevator trim moved 12° noseup and 9° nosedown. The rudder gustlock was intact and in the unlocked position.

After the airplane was moved from the accident site, the empennage was removed and the control cables were cut. The rudder control system linkages and the cables from the cockpit aft through the fuselage were then examined, and no evidence of operating distress was noted. All linkages and pulleys were intact and operated freely. The aileron/rudder interconnects are located in the area of fuselage station 285.65. The interconnect assemblies were intact, and the clamps were securely attached to the cables.

Both engines remained on the airplane. There was no evidence of any uncontained engine failure throughout the length of either engine. Three propeller blades from the left engine had broken off at the hub. The left propeller appeared to be in the feathered position, and subsequent examination revealed that it was feathered.

Two blades had broken off the right engine propeller. The initial angular positions of the right propeller blades at impact was a nominal 39.3°. These angles were based on piston position and torque piston fixed spline impact marks. The propeller blades of the right engine struck the ground about 130 feet beyond the initial impact point.

The shutoff valves on the left and right main fuel tanks were found open. The engine fuel feedlines were free of foreign material and were intact and continuous from the engines to their respective main fuel tank. The interiors of the left and right fuel tanks were not contaminated.

The indications from the cockpit instruments and indicators were, in part, as follows:

The captain's flight director indicated a right bank of 16°, while the first officer's flight director indicated a right bank of 18°. The pitch command bars for both flight directors were set at 8° up. The left and right fuel and ignition switches were on, and the left and right fuel shutoff handles were open with the crossfeed closed. The gear handle was in the up position. The trim settings on the cockpit trim wheels were: Elevator trim—noseup 1.5°; rudder trim—at zero; aileron trim—full right beyond 10.5° setting. The propeller synchronization switch was found in the SYNC mode. 2/

#### **1.13 Medical and Pathological Information**

There was no evidence of preimpact incapacitation or preexisting physical problems of any of the crewmembers, which could have affected their judgment or performance.

A male passenger, seated in seat 2D, sustained a fracture of the right hip socket. A female passenger, seated near the middle of the cabin, fractured two ribs. The first officer suffered a compression fracture of the L-1 vertebra.

#### **1.14 Fire**

A small fire erupted in the right engine after impact, but was extinguished when the captain fired the fire extinguisher bottles into each engine.

#### **1.15 Survival Aspects**

The accident was survivable.

The flight attendant stated that after the propeller autofeathered, she moved into the cabin area to calm the passengers. When she saw the ground, she immediately sat down in seat 12B. The airplane struck the ground before she could properly fasten the seatbelt. No warning of the crash was given by the cockpit crew, because they stated that they were too busy with the emergency.

During the impact sequence, most of the passengers described two distinct deceleration forces. The first was when the left wing struck the ground, and it was described as a mild jolt. The second was when the fuselage slammed onto the ground. Passengers described it as a severe impact. They said that they were forced down into their seats and to the right.

The interior of the airplane remained intact and passengers were able to move to the exits without significant problems. Two passengers escaped through the hole in the fuselage at row 2. Eight to 10 passengers went out the left overwing exit at seat 4A while one to three went out the right rear exit at seat 9D. The remainder egressed from the left rear service door. The flightcrew exited through the first officer's

2/ The position on the propeller synchronizer control switch which provides a mechanical adjustment of the RPM of the right propeller to the governing RPM of the left propeller.

window since the cockpit door to the cabin was jammed. The first officer went around the right wing and looked inside an open emergency exit. He saw no passengers and received no answer when he called. The captain climbed onto the right wing and looked into the aircraft to determine if all the passengers had been evacuated. He then walked around the tail and entered through the rear cabin door, where he retrieved the first aid kit.

Although the flight attendant did not issue any instructions regarding positions to assume for a possible forced landing, she did supervise the evacuation. The evacuation was orderly and was accomplished in less than 1 min.

The first officer's seat had separated from the inboard floor track, but the seat was still secured to the outboard floor track. No other damage was noted to the cockpit seats. There were no shoulder harnesses installed for the flightdeck crew, nor were any required. The fuselage remained upright and intact except at seatrow 2. Passenger seats in the area of the break were damaged structurally as was one other seat unit in the rear of the cabin. However, all seats remained secured to the floor and no restraint belts failed.

## **1.16 Tests and Research**

### **1.16.1 Flight Instruments and Systems**

Functional tests were performed on the following components at the North Central Airlines maintenance facility: Flight directors, altimeters, vertical gyros, airspeed indicators, flap drive and position indicators, the flap hydraulic drive unit, and the fuel boost pumps. The AC hydraulic pump was tested at different levels of output pressure. The tests indicated that the delivery rate of hydraulic fluid was within limits at an output pressure of 2200 psi. However, at 2450 psi the delivery rate was .02 gallons per minute below limits. At 2700 psi and 2950 psi, the delivery rate was .15 gallons per minute and .55 gallons per minute respectively below limits. All other components tested were found to operate within acceptable limits.

### **1.16.2 Engines and Propellers**

A detailed inspection of the engines and propellers was conducted at the North Central Airlines maintenance facility. The inspection of the right engine revealed no evidence of malfunction of any parts of the propeller, engine, or engine accessories. The autofeather system components were functionally tested, and all portions operated properly.

The right engine exhibited varying degrees of foreign object damage to all compressor blade stages. Pulverized cornstalk deposits had adhered to the piston faces on the 5th and 10th stage compressor bleed air valve and the visible manifold area adjacent to the individual piston faces. The forward stages of the compressor, the inlet sections of the combustion liners, and the interior of the outer combustion case were heavily coated with pulverized cornstalk residue. The turbine-overheat damage resulted from the high fuel-to-air ratio which was caused by blocked airflow while the engine was operating at a high power setting. The airflow was blocked by ingested cornstalks.

The detailed inspection of the left engine revealed no evidence of malfunction of any parts. The inspection of the propeller and its accessories, including the autofeather mechanism, revealed no malfunctions. The left propeller master gear,

feathering reservoir, and the propeller regulator assembly were intact and functioned properly. The oil level was normal, and the magnetic plugs and external oil filters were not contaminated.

The thrust-sensitive switch circuit was tested electrically and found to operate satisfactorily. The propeller regulator linkage was properly attached and checked functionally. Functional checks of the regulator valve components and regulator pumps were within accepted ranges.

The inspection of the hub, regulator, and regulator seal revealed only impact damage. All components of the engine and propellers which function in the autofeather sequence were tested and found to operate normally.

The detailed inspection of the left engine revealed indications of a bird strike. The upper portion of the engine air inlet scoop contained stains which indicated bird ingestion, and the engine air scoop was dented at the stained area. The quick engine change screen on the 5th stage bleed duct contained feather deposits. There were also feathers in the compressor inlet. There was a tan feather in the third stage at the 9 o'clock position.

Organic matter was uniformly deposited on the concave side of the first eight stages of compressor blades and the first six stages of compressor stator vane assemblies. Similar matter had also adhered to the piston faces on the 5th and 10th stage compressor blade air valve and to the visible manifold area adjacent to the individual piston faces. An assessment of the deposits follows:

<u>Portion of Engine</u>	<u>5th Stage</u>	<u>10th Stage</u>
Top	Medium deposit - fuzzy	Clean
Left	Heavy deposit	None
Bottom	Heavy deposit	Heavy deposit
Right	Medium deposit	Small deposit

### **1.16.3 Identification of Feathers**

Feathers found in the left engine were examined at the University of Minnesota. The feathers were positively identified as those of a female sparrow hawk. The average weight of the bird is about 120 grams, or a little over a quarter of a pound. The adult female sparrow hawk is normally 10 ins. long and has a wing spread of 22 or 23 ins.

According to personnel at the University of Minnesota, in the summer sparrow hawks gather in pairs or in groups of 6 or 10 birds. However, even in such groups, the individual birds are likely to fly 10 to 20 yards apart. Open areas, such as airports, provide an ideal habitat for feeding of the sparrow hawks.

No feathers or bird-related matter were found in the right engine.

### **1.16.4 Autofeather Mechanism**

The thrust-sensitive signal (TSS) initiates automatic feathering during takeoff. The system must be armed before takeoff if it is to function, and a blocking circuitry is provided to prevent autofeathering of more than one propeller. The system is activated by the "autofeather arming switch" and a switch actuated by the power lever.



The system is designed to cause the propeller to feather automatically any time the arming switch is on, and the power levers are beyond the arming threshold when the thrust delivered by the propeller is less than 500 lbs. The propeller shaft moves in a forward axial direction as propeller thrust increases. Axial travel is limited by a mechanical stop. Forward movement of the shaft compresses two springs. If power decreases to 500 lbs of thrust, the spring force moves the shaft axially in a rearward direction. This movement is multiplied through mechanical linkage and transmitted mechanically to an electrical switch assembly mounted on the case, where it energizes the feathering circuit.

In 1962, FAA tested the Allison 501-D13/606 turbo-propeller and found that the autofeather system used on the Convair 580 would shut down the engine automatically every time a 6-bird (424 to 533 grams) strike was encountered. On one occasion, a TSS signal was transmitted on a 4-bird (329 gram) strike. FAA tests concluded that the ingestion of as many as three starlings by the test engine would not affect engine operation.

#### 1.16.5 Performance Data

The performance information was derived from the FDR, as correlated with the CVR, and known Convair 580 performance data. (See appendix F.)

A heading change to the left began just after liftoff and continued at approximately 0.7°/sec until power on the right engine increased 9 sec later. The heading change to the left increased as the power was added; it averaged 1.6°/sec for the next 25 sec and increased to 2.3°/sec as the GPWS sounded. The airspeed, which was 109-110 kns at 0700:21, increased to about 111 kns at 0700:26, before it decreased to about 102 kns at 0700:39. The variation in airspeed reflected in the FDR data coincides with flightcrew testimony that the airplane pitch was reduced when airspeed began to decay after reaching  $V_2$  and that the airspeed was then maintained between 102 and 106 Kns. Mode 3 of the GPWS was initiated as altitude decreased. Mode 3 is activated if there is a loss of 10 feet of altitude at 50 feet radio altitude, increasing linearly to 80 feet at 700 feet radio altitude. A momentary pullup in response to the initial GPWS warning was evidenced in all four foil data traces.

The airspeeds recorded by the FDR were consistent with the airspeeds recalled by the flightcrew. However, the actual airspeeds of the airplane cannot be identified exactly and may vary by several knots from the FDR recording and from those which were indicated in the cockpit because of the uncoordinated flight conditions.

Spectral analysis of the CVR recording clearly reflects the rapid deceleration of the left engine as the frequencies reach the region recorded by the CVR. Primary frequencies of the right engine and of the constant speed propeller are outside the frequency range of the CVR. There was no evidence in the form of harmonic frequency change or electrical aberrations to be found in the spectral analysis of the recording related to possible malfunction of the right engine.

At a gross weight of 49,130 lbs, with a 15° flap setting, and in coordinated flight, the following speeds are applicable: 3/

3/ Allison/General Motors Flight Manual, Pro-Jet Convair, approved by FAA July 17, 1967.



$V_1 = 107$  KIAS

$V_2 = 111$  KIAS

$V_S \approx 91$  KIAS (88 kts calibrated airspeed - KCAS) at 1G/zero thrust/gear down

$V_S \approx 98$  KIAS (95 KCAS) at 30° bank/zero thrust/gear down

$V_{mc} \approx 88$  KIAS (85 KCAS) at wings level/unaccelerated flight

At 10° flaps:

$V_S \approx 94$  KIAS (91 KCAS) at 1G/zero thrust/gear down

$V_S \approx 101$  KIAS (98 KCAS) at 30° bank/zero thrust/gear down

$V_{mc} \approx 88$  KIAS (85 KCAS) at wings level/unaccelerated flight

The bank angle of the airplane was calculated throughout the accident profile using the velocity and average heading information used to develop the ground track information presented in appendix F. For the segment of flight from the onset of stall to impact, the bank angle was calculated to average 28°. However, this bank angle assumes a coordinated turn. Since the airplane was not in a coordinated state for most of the flight, the 28 degree computation is indicative only of the amounts of bank likely present during the final stages of the flight. This is very nearly the coordinated flight stall angle of bank for a flap setting of 10° at the airspeed reflected by the PDR at this segment of the accident sequence. While this information is consistent with the prestall airframe buffet and the eventual loss of lateral control, the exact bank angle could not be determined because of the asymmetric thrust condition and unknown amount of sideslip.

The effect of raising the flaps from 15° to 12° (although the captain called for 10° of flaps, the measurement on the flap trailing edges indicated a 12° flap setting at impact) would result in a slight increase in the rate of descent if the pitch attitude, the bank angle, and the airspeed (already near the stall speed) were held constant. An attempt to maintain altitude after repositioning the flaps at 12° would have caused a further loss of airspeed. However, the bank toward the inoperative engine, coupled with the extended landing gear and the low airspeed, were far more significant in the accident sequence than the effect of raising the flaps a few degrees.

Tests in a Convair 580 simulator confirm that if an excessive angle of bank toward the inoperative engine is allowed to develop, and if aileron is introduced to reduce or control the bank, airspeed will not increase beyond  $V_2$  and may well, in fact, decrease if these control inputs continue. Any attempted turn in the direction of the inoperative engine accentuated the problem in maintaining airplane control. These tests were conducted with the gear down and with multiple combinations of control inputs, angles of bank, airspeeds, and flap settings.

For every condition of asymmetric thrust, there is a minimum speed below which it is not possible to maintain equilibrium with aerodynamic controls. The minimum control speed ( $V_{mc}$ ) will vary according to bank angle. If bank angle is to be held at zero with asymmetric thrust, a large amount of rudder is required to maintain a flightpath straight ahead. The deflected rudder generates a side force which pushes the aircraft sideways. A sideslip is developed which generates an equal and opposite fuselage side force to establish equilibrium.

If a slight bank toward the operating engine is held, the resultant horizontal component of the lift vector reduces the side force required from the rudder. This reduces the rudder deflection required and more closely aligns the fuselage centerline with the flightpath. As a result, drag is minimized and the airplane can be flown at a lower minimum control airspeed. This technique is used by manufacturers to establish the minimum control airspeed and to demonstrate compliance with the FAR's. The  $V_{mc}$  is determined by measuring the slowest steady speed at which equilibrium can be achieved with up to  $5^\circ$  bank toward the operating engine, with full rudder deflection, and with the critical engine shut down.

The  $V_{mc}$  determined in initial certification of the Convair 580 was about 38 Kns. The  $V_{mc}$  increases, however, as bank angle toward the operating engine is decreased. The  $V_{mc}$  for the Convair 580 has not been determined under the accident conditions with significant bank angles. However, performance data, wind tunnel tests, and flight tests for other twin-engine airplane indicate that  $V_{mc}$  will be increased as much as 20 or 30 percent of the value for level, unaccelerated flight.

## 1.17 Additional Information

### 1.17.1 North Central Airlines Procedures (Convair 580 Pilot's Handbook)

#### (a) Normal Takeoff Procedures (Not on Checklist)

After 90 kts the pilot flying should allow the elevator control to assume a nearly neutral flying position.

As the airspeed reaches  $V_1$ , the pilot not flying will call "V ONE" as a reminder decision speed has been reached.

The pilot flying should remain aware of his airspeed so as to conform to proper rotation speeds. Any distraction may cause the pilot not flying to miss or call out "V ONE" at an improper airspeed. A couple of knots past  $V_1$  smoothly apply back pressure to cause the airplane to lift off the runway at  $V_R$  or shortly thereafter. Continue an unbroken rotation to smoothly place the airplane in an attitude of  $+8^\circ$  body angle. After noting a positive climb, the pilot flying will call "GEAR UP."

**NOTES & CAUTIONS:** The following apply to various facets of the takeoff, they should be used or noted as conditions warrant:

Too rapid power lever movement will result in overshooting TIT or horsepower or both. A definite relationship exists between overshooting TIT and power section service life, and between overshooting horsepower and reduction gear life. HP gage indications respond at a slower rate than the actual horsepower output so that care must be taken not to exceed limits. TIT indications respond at a faster rate. Too rapid increase of power levers could also cause autofeather if power lever position exceeds  $65^\circ$  before engine thrust reaches a positive 500 pounds.

During takeoff, if birds are observed adjacent to or in the path of the takeoff pattern, disarm the autofeather circuit. This procedure will prevent possible autofeather in event of bird ingestion. It has been

proven that the engine will ingest four or five small birds and recover without flameout. Remember that when the autofeather is armed, feathering will take place with no time delay if a temporary loss of power occurs.

(b) Engine Failure/Fire on Takeoff, Above  $V_1$  Procedure Discussion

If this situation is encountered, the pilot should immediately apply whatever amount of rudder is necessary in order to keep the ball centered. DO NOT USE THE AILERON AS A SUBSTITUTE FOR THE RUDDER. The procedure to be used is as follows:

- \* Call "MAX POWER," pilot not flying will set power to 971° TIT or 4000 HP on the good engine. DO NOT CHANGE FLAPS FROM SETTING (10°, 15° or 20°) USED FOR TAKEOFF.
- \* At  $V_R$ , rotate to a +8° attitude.
- \* After positive rate of climb, call "GEAR UP - CHECK FOR FEATHER OR FIRE."
- \* Check failed engine for full feather or any signs of fire, if it failed to autofeather or fire is noted. Do not rush during any of these steps, FLY THE AIRPLANE FIRST.
- \* If warning ceases, devote attention to flying the airplane until later after METO power is set, then call for "ENGINE FIRE CHECKLIST."
- \* Maintain +8° attitude. Airspeed may slightly increase, do not increase body angle above +8° in this case. However, if airspeed shows a tendency to fall below  $V_2$ , slightly lower nose in order to maintain a minimum of  $V_2$  airspeed for the flap setting involved.
- \* At 400' (or obstruction clearance altitude if higher) lower nose SLIGHTLY and allow airspeed to increase. Retract flaps 5° for each 5 KTS increase above  $V_2$ . DO NOT ALLOW AIRCRAFT TO LEVEL OFF OR SINK DURING FLAP RETRACTION PROCESS.
- \* After attaining BSEC, call "METO POWER," then "ENGINE FIRE CHECKLIST" or "ENGINE FAILURE CHECKLIST" (as appropriate to the situation).
- \* If the engine failure resulted in an autofeather with no signs of fire, it will not be necessary to pull the "E" handle when reading the first item of the ENGINE FAILURE CHECKLIST.
- \* If maximum climb performance is required, continue climb at BSEC. No turns below BSEC. limit bank angle to 15° at airspeeds between BSEC and 150 KTS.
- \* As soon as practicable, increase airspeed to 150 KTS (minimum clean configuration speed) for climbing on single-engine.

### 1.17.2 North Central Airlines Training

The North Central Airlines Flight training program for upgrading to pilot-in-command included actual flight time in the airplane as well as classroom instruction before the final check ride. The course of instruction included a complete review of the airplane and airplane systems, normal and emergency procedures, instrument flight, and use of checklists. The captain of Flight 801 completed the training program according to the published syllabus on February 24, 1978.

The flight training was conducted in Convair 580 airplane, since no flight simulator was available. Single-engine emergencies, including takeoffs, were conducted in the airplane in VFR conditions. A vision-limiting device was placed in front of a pilot in training to simulate instrument conditions.

### 1.18 New Investigative Techniques

None

## 2. ANALYSIS

The airplane was certificated, equipped, and maintained according to applicable regulations. No evidence was discovered to suggest that restricted right rudder travel noted in the field investigation existed before the accident. The rudder restriction was not present when the controls were checked before takeoff, nor was there any history of rudder control problems in the airplane records. The rudder control system linkages and cables were examined and no evidence of operating distress was noted. However, during the accident sequence the fuselage structure had separated at FS 299, and the fuselage had twisted 15 to 20 degrees to the right. The cabin floor above the rudder interconnects had buckled upward. Therefore the Safety Board concludes that the partial rudder restriction noted in the field investigation resulted from impact damage.

The shutdown of the left engine resulted in the loss of the main hydraulic pump. The AC hydraulic pump was the back-up pump to supply hydraulic fluid to the landing gear and the wing flaps. Since the AC hydraulic pump was found to deliver hydraulic fluid at a lower than specified rate, the gear retraction time was possibly slower than that for normal gear retraction time. However, the Safety Board concludes that the gear retraction time did not affect the accident sequence since the gear was not raised until after either 0701:34 or 0701:36, or 4 to 6 seconds before impact. Since the gear was found nearly completely retracted at that point, it appears that the output of the back-up AC hydraulic pump was sufficient to raise the landing gear in an adequate time.

There was evidence of a birdstrike in the left engine. An analysis of a feather removed from the engine revealed that the bird was a female sparrow hawk. The average weight of a sparrow hawk is about 120 grams (one-quarter pound), and the wing spread is 22 to 23 ins. Sparrow hawks normally do not fly in dense flocks and the remains of only one bird was found. The detailed examination of the left engine and propeller did not reveal any internal component failures; only minimal rotational damage to the compressor blades was observed. All engine and propeller components that could induce an autofeather were examined and tested functionally. All engine and propeller components, as well as all components of the autofeather system, performed according to test standards. Therefore, the Safety Board concludes that the left engine shut itself down and the propeller autofeathered when the thrust-sensitive system detected a drop in the thrust level which was less than 500 lbs after ingesting a single sparrow hawk which was still partially intact when it struck the rotating first stage compressor blades.

The engine manufacturer stated that tests of the engine and autofeather system indicated little probability of autofeather with bird strikes significantly smaller than 329 grams. Since the bird ingested by N4825C weighed about 120 grams, in theory the engine should have experienced only a power decay before recovering fully. The North Central Airlines Convair 580 Pilot's Handbook reflects this theory with the statement, "It has been proven that the engine will ingest four or five small birds and recover without flameout." However, the Handbook also states that if a temporary loss of power does occur, feathering will take place with no time delay. Because of the variables involved in a bird strike, it is impossible to determine a maximum ingestion value which can be sustained by an engine without an autofeather. Although the weight of the bird was small compared to the theoretical autofeather probability value, the autofeather system functioned correctly when it autofeathered the propeller after sensing a decay in propeller thrust. The system has a millisecond response time and will, upon sensing a decay in propeller thrust, immediately feather the propeller. The purpose of the immediate response is to avoid a longer 1- to 4-sec delay in autofeather system activation which could result in a windmilling or underpowered propeller. The resultant yawing moment would be critical during takeoff. Since the airplane is capable of operating safely on one engine with the other propeller feathered, the logic of the immediate autofeather mechanism is valid.

The examination of the right engine and propeller indicated that they were operating properly at impact. The disassembly and testing of the components and accessories did not reveal any evidence of preimpact malfunctions.

Tests and examinations do not support the observations of the first officer and some passengers that the right engine was not operating properly. The first officer based his observation on the airplane's inability to accelerate and climb. The position of the landing gear and the manner in which the airplane was being flown, however, were the reasons the airplane was not accelerating properly. The passengers based their observations on the shuddering and yawing of the airplane. This was caused by the low airspeed, which resulted in airframe buffet as the airplane approached the stall speed. Finally, no harmonic frequency change or electrical aberration was recorded in the spectral analysis of the CVR to indicate a power change in the right engine.

The blade angles on the right propeller at initial impact averaged 39.3°. The available shaft horsepower for a 39.3° blade angle was obtained from data provided by the engine manufacturer. The airspeed at impact, based upon the available data, was between 52 and 79 kns, which is equivalent to a 3,220 to 3,700 range of shaft horsepower. As a result, the Safety Board concludes that the right engine was operating properly and was developing sufficient horsepower to sustain the single-engine flight of N4825C.

The flightcrew was properly certificated and qualified to perform their assigned duties. Each crewmember had received the training and off duty time prescribed by applicable regulations. There was no evidence of medical or psychological problems that might have affected their performance.

Crew statements and CVR information indicate that all preflight preparations, before-takeoff checks, and taxi to the runway were normal and accomplished according to North Central Airlines procedures.

The flightcrew stated that the takeoff roll and the acceleration to  $V_1$  was normal. The FDR altitude trace indicated that the captain may have begun rotation before the first officer's call of " $V_1$ ". The first officer made the  $V_1$  call at 0700:21 when the airplane was past  $V_1$  at 109-110 kns. North Central Airlines procedure was to initiate



rotation "a couple of knots past  $V_1$ ," to cause the airplane to lift off the runway at  $V_R$  or shortly thereafter. The captain continued to rotate the airplane, so that when the bird struck the engine the airplane had just become airborne. At 0700:22, when the first officer announced "power loss," the airplane had just lifted off the runway at an indicated airspeed of about 111 kts. As a result, the airplane was about 111 kts when the left propeller feathered because of the bird strike. These airspeeds are confirmed by the FDR and by recollections of the crew about airspeeds.

Although the autofeather of the left propeller and the shut down of the engine were the first in the sequence of events which led to the accident, the actions of the flightcrew ultimately precipitated the accident. The captain correctly ordered maximum power for the right engine when the first officer announced that power had been lost. The next appropriate command would have been "gear up--check for feather or fire." However, 4 seconds after the power loss, the captain instructed the first officer to call the tower. The first officer advised the tower that they had lost an engine and would be returning to land.

The failure to raise the landing gear represented a breakdown in cockpit procedures and discipline and was critical to the sequence of events which led to the accident. The Board believes that the captain failed to issue the proper commands because the autofeather came unexpectedly at a critical point in the flight. He was preoccupied with flying the airplane under extremely difficult conditions while at a critical airspeed and with his immediate task of returning to land. Furthermore, the Safety Board believes that the first officer was initially distracted by the out-of-sequence command to call the tower; later, the first officer became occupied with the possibility of an overtemperature warning on the right engine; and finally, he became concerned with performance of the right engine and the inability of the airplane to accelerate back to  $V_2$ . As a result, the gear was not raised in a timely manner.

The first instruction in the North Central procedure for engine failure above  $V_1$  was to apply necessary rudder to keep the airplane in coordinated flight--aileron was not to be used as a substitute for the rudder. The procedures required that the airplane be flown straight ahead and that no turns be made below the best single-engine climb speed. Once the best single-engine speed limit was reached, the bank angle was to be limited to  $15^\circ$  below 150 kts.

The FDR indicates a turn to the left began nearly coincident with liftoff. The slight turn rate to the left increased just as the first officer stated the intent to return to the airport. About 0700:30, or about 8 sec after liftoff, the airplane entered the base of the overcast.

At no time after the loss of the left engine did the captain use trim to reduce the control forces which were making it difficult to control the airplane. At 0700:35, the decrease in airspeed ceased when pitch attitude was reduced from  $8^\circ$  to  $5^\circ$ . The aircraft leveled off briefly as a result; however, the decrease of pitch soon led to a loss of altitude sufficient to trigger the GPWS at 0700:58. The pullup in response to the GPWS caused altitude to increase and, more significantly, the turning rate to increase and airspeed to decrease.

Relaxation of back pressure on the control wheel at 0701:10 probably accounted for the decrease in altitude, decrease in the rate of turn, and stabilization of airspeed at 102 to 104 KIAS. The comments on the CVR, coupled with the activation of the GPWS in response to loss of altitude and aircrew testimony, suggest that the airplane started to descend at 0701:10 and that visual contact with the ground was regained about



this time. A sharp increase in turning rate at 0701:21 coincided with the point at which aircrew testimony indicated the pilot turned to avoid a house and a stand of trees which were seen when visual contact with the ground was acquired. Flightcrew testimony indicated that full opposite aileron was applied about this point in an attempt to raise the left wing. Evidence that the airplane was close to a stall at this time was provided by: (1) the onset of airframe buffet when the first GPWS alert sounded, (2) the inability to accelerate, and (3) the deterioration of lateral and longitudinal control just before impact.

The airplane would have been capable of satisfactory single engine performance in the latter stages of flight with the gear up if the captain of Flight 801 had held a wings-level attitude, or had banked slightly toward the operating engine. However, a bank toward the inoperative engine would have initially decreased the airplane performance because of the increased drag caused by the greater sideslip angle. Furthermore, tests, analyses and experience confirm that if after engine failure at  $V_1$ , an angle of bank toward the inoperative engine is allowed to develop and aileron is introduced to reduce or control the bank,  $V_{mc}$  will increase significantly. In this case, the Safety Board concludes that the captain permitted the airplane to bank toward the inoperative engine while attempting to regain control of the airplane. Additionally, at some point in the flight the pilot must also have introduced a significant amount of aileron while attempting to control the bank, and this added substantially to the increased drag already caused by sideslip, the rudder, and the landing gear.

These drag forces arrested the critical acceleration of airspeed expected and sought in the single-engine takeoff procedure. The pilot continued these control inputs to a point where the airspeed decreased below  $V_{mc}$ . As a result, recovery was impossible before impact with the ground.

The airspeed of the airplane did not decrease to the minimum control speed for wings-level flight until just before impact. However, the angle of bank toward the left engine, with the gear extended and at an airspeed of less than  $V_2$ , and the use of aileron by the captain aggravated an already severe lateral control problem. The  $V_{mc}$  for the Convair 580, with a bank toward the inoperative engine, was significantly higher than the level flight 88 KIAS which was determined in certification tests. Tests in other twin engine airplane indicate a bank toward the inoperative engine can increase  $V_{mc}$  by as much as 3 kns per degree of bank, and in the Convair 580, by 1 kn per degree of bank.

Therefore, the two most critical procedural errors on the part of the crew were the failure to raise the gear as required by the emergency procedures and the bank toward the inoperative engine. Failure to raise the gear was probably not, in itself, sufficient to preclude a successful takeoff and climb; however, when compounded by a turn toward the inoperative engine, lateral and directional control were sacrificed and drag was increased substantially.

A review of the North Central Convair 580 training program and of the flightcrew's records indicate that adequate flight training was administered to enable the crew to handle the emergency as it developed. All flight training for the Convair 580 is administered in an airplane rather than in a simulator. Single-engine emergency training, including engine failure after  $V_1$ , was administered under VFR conditions. Although the existing training program was sufficient to enable the flightcrew to cope with the engine-out emergency, the 100-ft ceiling and the low visibility added significantly to the cockpit workload, and the complete lack of outside visual references placed a great demand on the skills of the pilot. The level of concentration required to control the airplane and to monitor the flight instruments would have increased significantly. It is likely that this affected adversely the cockpit coordination necessary to accomplish the engine failure checklist.

### 3. CONCLUSIONS

#### 3.1 Findings

1. The flightcrew was certificated and trained properly.
2. The airplane was certificated and maintained according to approved procedures.
3. All flight controls operated properly.
4. The weight and balance were within limits.
5. The takeoff roll acceleration was normal until a bird struck the left engine.
6. The bird strike was sustained on the left engine air inlet scoop when the airplane was about 10 to 30 feet above the runway at an airspeed of about 111 kns.
7. A single bird weighing about 120 grams was ingested and caused a transient compressor stall.
8. The left propeller autofeathered immediately when the TSS sensed that the propeller was delivering less than 500 lbs of positive thrust.
9. The autofeather system of the left propeller operated properly.
10. The right engine operated properly.
11. The right engine was developing sufficient shaft horsepower to maintain single-engine flight after the left propeller autofeathered.
12. The captain failed to follow the required procedures for an engine failure on takeoff.
13. The captain did not call gearup at the proper time, because he was preoccupied with determining if the left propeller autofeathered and with maintaining control of the airplane at a critical phase of flight.
14. The first officer did not note that no gear-up call was made, because he was calling the tower and was concerned with the possibility of an overtemperature warning on the right engine.
15. The captain aggravated the emergency by allowing the airplane to bank toward the left engine.
16. The shuddering and yaw caused by the airframe buffet and the onset of a stall were the basis of passenger reports that the right engine was not operating properly.
17. The airplane failed to accelerate to the best single-engine climb limit speed because the landing gear was extended and the airplane was banked to the left.

18. The use of aileron with excessive angle of bank into the left engine and the gear extended at a speed of less than  $V_2$ , aggravated the sideslip and the lateral control problems and contributed to the further decay of airspeed.
19. Weather conditions caused a significant increase in the cockpit workload.

**3.2 Probable Cause**

The National Transportation Safety Board determines that the probable cause of this accident was the failure of the captain to follow the prescribed engine-out procedures during instrument meteorological conditions, which allowed the airplane to decelerate into a flight regime from which he could not recover. Contributing to the accident were inadequate cockpit coordination and discipline.

**4. SAFETY RECOMMENDATIONS**

None

**BY THE NATIONAL TRANSPORTATION SAFETY BOARD**

/s/ JAMES E. BURNETT, JR.  
Chairman

/s/ PATRICIA A. GOLDMAN  
Member

/s/ FRANCIS A McADAMS  
Member

/s/ G. H. PATRICK BURSLEY  
Member

/s/ DONALD D. ENGEN  
Member

February 22, 1979  
(Revised: November 22, 1982)

5. APPENDIXES

APPENDIX A

INVESTIGATION AND HEARING

1. Investigation

At 0715 e.d.t., on July 25, 1978, the National Transportation Safety Board was notified of the accident by the Federal Aviation Administration Communications Center. An investigative team was dispatched immediately to the scene. Investigative groups were established for operations, ATC, human factors, structures, systems, maintenance records, powerplants, and weather. A performance group, an FDR group, and a CVR group were subsequently formed.

Parties to the investigation were: Federal Aviation Administration, Airline Pilots Association, North Central Airlines, Detroit Diesel Allison and General Dynamics/Convair.

2. Hearing

No public hearing was held.

APPENDIX B

PERSONNEL INFORMATION

Captain Harold R. Moe

Captain Moe, 33, was employed by North Central Airlines on April 29, 1968. He completed initial training in the Convair 580 on June 6, 1968, and in the DC-9 on April 2, 1976. He was upgraded to captain in the Convair 580 on February 24, 1978.

Captain Moe holds Airline Transport Pilot Certificate No. 1601988, issued February 24, 1978, with airplane multi-engine land and Convair A340/A440 <sup>1/</sup> ratings, and commercial privileges for airplane single-engine land. He was also a certified flight instructor. His first-class medical certificate was issued February 6, 1978, with no limitations.

Captain Moe had accumulated about 9,479 total flight-hours of which 5,022 hours were in the Convair 580. He had accrued 946 hours of instrument flight.

He completed General Recurrent Ground Training on October 25, 1977, and DC-9 Recurrent Ground Training on January 25, 1978. During his Convair 580 captain-upgrade program in February 1978, he received training on all emergencies, including single-engine takeoff emergencies.

His last line check was administered on March 3, 1978.

First Officer John P. McFarland

First Officer McFarland, 30, was employed by North Central Airlines on July 18, 1977, and completed the Convair 580 initial training on July 22, 1977. He holds Airline Transport Pilot Certificate No. 343426815, issued January 20, 1977, with airplane multi-engine land rating and commercial privileges for airplane single-engine land and the L-188. His first-class medical certificate was issued May 16, 1978, with no limitations.

First Officer McFarland had flown about 2,490 total flight-hours, 239 of which were in the Convair 580. He had flown 450 hours of instrument time. He attended General Recurrent Ground Training on January 26, 1978, and Convair 580 Recurrent Ground Training on January 27, 1978. His last en route proficiency check was administered on July 27, 1977, and his last proficiency check was on July 22, 1977.

Flight Attendant Constance Anderson

Flight Attendant Anderson, 27, was employed by North Central Airlines on April 29, 1977. Her most recent recurrent training was completed March 10, 1978.

<sup>1/</sup> Includes Convair 580 rating.