

AIRCRAFT ACCIDENT REPORT

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NORTHWEST AIRLINES, INC., DOUGLAS DC-6B, N 575,
MINNEAPOLIS, MINNESOTA, AUGUST 28, 1958SYNOPSIS

At approximately 0329^{1/} on August 28, 1958, Northwest Orient Airlines Flight 537, a DC-6B, N 575, crashed on takeoff from Wold-Chamberlain Field, Minneapolis, Minnesota. A number of the 62 persons (including 2 infants) aboard suffered serious injuries but there were no fatalities. Fire, which broke out a short time after all occupants were evacuated, consumed the aircraft.

The aircraft took off normally and climbed to a height of about 100 feet. It then gradually nosed over and entered a descent which continued until it struck the ground. Sky conditions were clear; however, the prevailing visibility was about three miles in fog, and in localized areas around the airport it was reduced to less than a mile by patches of denser fog. Takeoff was made on runway 22 and the climbout was away from a lighted, built-up section toward an open, unlighted area.

The Board believes that the pilot while trying to remain contact in reduced visibility allowed the nose of the aircraft to drop when flaps were retracted because of inattention to flight instruments.

The darkness and reduced visibility during climbout contributed to a sensory illusion which completely obscured the fact of descent from the pilot.

Northwest has revised its takeoff procedures as a result of this accident to prevent the recurrence of such accidents. Among other requirements, pilots must reach a minimum altitude of 200 feet before retracting flaps. Another requirement is that the copilot call altitudes until reaching 500 feet.

Investigation

Northwest Orient Airlines (NWA) Flight 537 is a regular flight from Washington, D. C., to Seattle, Washington, with intermediate stops at Pittsburgh, Pennsylvania; Cleveland, Ohio; Detroit, Michigan; Milwaukee, Wisconsin; Minneapolis, Minnesota; and Portland, Oregon. The trip of August 27 departed Washington and proceeded uneventfully to Minneapolis where a scheduled crew change was made. The relief crew consisting of Captain James Wilkinson, Copilot Verner J. McGinness, Flight Engineer Robert R. Mielke, and Stewardess Margaret C. Gallagher arrived at Operations about an hour and 20 minutes prior

^{1/} All times herein are central daylight based on the 24-hour clock.

to departure time. Routine preparations were made for the flight. An instrument flight rules flight plan was filed and other necessary papers were filled out. The gross weight for takeoff was calculated to be 100,923 pounds, well below the maximum allowable for this flight, 103,540 pounds. The captain and copilot received the current weather reports and forecasts for the route and were briefed by the company meteorologist on duty. They also discussed the local fog situation with the meteorologist and dispatcher on duty.

Over the route the weather was generally good and was forecast to remain so for the duration of the flight. At Minneapolis the sky condition was clear; however, visibility was reduced by a ground fog to a prevailing three miles. In addition, denser patches of drifting ground fog were indicated by the readings from the transmissometer located on the approach end of runway 29L. At 0200 this visibility was recorded at 2-1/4 miles; at 0258 it was variable to 1/4 to 1-1/2 miles; and at 0341, just after the accident, it was 5/8 to 7/8 miles.

When preflight preparations were complete the crew proceeded to the airplane and conducted their preflight inspections. No discrepancies which would affect the airworthiness of the aircraft were noted. Engines were started and the flight was cleared by the tower to taxi to runway 22. In runup position, engines were checked. The flight engineer monitored the run-up on the ignition analyzer and engine operation was normal. Pretakeoff checklists were properly completed and at 0328 the aircraft proceeded onto the runway. The captain applied takeoff power and the airplane responded, accelerating normally. The copilot called the airspeeds identifying V_1 , which had been determined to be 105 knots. The aircraft continued to accelerate and shortly before the copilot called V_2 (115 knots) the captain applied back pressure on the control column. After accelerating through V_2 speed the airplane lifted off the runway. When definitely airborne the captain called for gear up and the copilot complied.

The airplane continued to accelerate in its climb and the copilot continued calling off the airspeeds. At 135 knots the captain called for flaps up and again the copilot complied. The aircraft was performing normally in all respects. Engines were developing full power, and the aircraft was accelerating to normal climb speed.

At 155 knots the captain called for reduction of power to METO (maximum except takeoff). At the same time his outside vision was obscured by the bright reflection of the landing lights against clouds or fog. He said he looked back into the cockpit and that his instruments appeared normal and still indicated a slight climb. He then turned the landing lights off. Almost simultaneously, and when the flight engineer had started reducing power, the copilot saw a fence ahead of them, shouted "pull it up" and at the same time pulled back on the elevator control.

Almost simultaneously with the copilot's action the aircraft hit the fence at the airport boundary. Immediately thereafter it struck the ground, skidding to a stop about 1,600 feet beyond its initial point of contact with the ground.

Several witnesses stated that they saw the aircraft taking off. All were in substantial agreement that the airplane appeared to climb normally

and reach a height of about 75-100 feet at a point near the end of runway 22. It then appeared to nose down gradually and begin to descend. The descent continued without noticeable change until the aircraft struck the ground. All agreed that the engines sounded normal. These witnesses described the weather as hazy because of fog. They estimated the top of the drifting patches of denser fog to be about 50 feet high. All of the witnesses saw the airplane clearly. None noticed any dense fog in the takeoff area and no one saw the aircraft enter clouds of any kind.

The tower controller said he had given Flight 537 clearance to taxi to runway 22 for takeoff. He also transmitted an IFR clearance to the flight. At 0328 the flight was given takeoff clearance. The tower controller observed the first portion of the takeoff run, which appeared normal, and then directed his attention to the departure radar scope to watch the aircraft.

The witness said the departure radar normally would pick up a target from an aircraft departing on runway 22 at a height of about 50 feet, and when no target appeared on the screen he looked back to the runway, saw smoke off the southwestern end, and immediately called the flight by radio. The flight did not answer so he alerted the Air Force crash equipment and the Minneapolis Fire Department.

The witness said there had been drifting fog on the field all night but that runway 22 was open at the time of takeoff. He estimated the patches of dense fog extended from the ground up to a height of about 50 feet and were confined to the northwest and south-southeast portions of the field. He said there were no lights on the southwest corner of the field and he could not tell if there were patches of fog in that area but that he could see the red construction lights at the end of runway 22.

During the investigation the captain and first officer were questioned extensively in order to determine as near as possible the exact sequence of events. The captain stated that the takeoff was made under visual conditions. His only reference to his instruments was primarily for the purpose of monitoring the performance of the aircraft. He said the performance was normal and after the aircraft broke ground a normal climb was established by visual observation and by reference to the rate-of-climb instrument. He observed a thin wispy cloud to the right and above the aircraft, and called it to the attention of the other crew members. About this time the copilot called 155 knots. The captain said he increased back pressure to maintain his climb and ordered METO power; the flight engineer had started the power reduction when his (the captain's) outside vision was obscured by the reflection of the landing lights against clouds or fog. The captain said he looked back into the cockpit to refer to his instruments, noting an airspeed of 155 knots and a rate of climb of about 200-250 feet per minute; all indications appeared normal. He then turned off his landing lights. It was at this instant that the copilot called "pull it up" and pulled back on the yoke. The captain stated that the penetration into the cloud, the copilot's remark, the copilot's action on the controls, and the impact were almost simultaneous. All occurred within a very few seconds.

The copilot testified that he had called the airspeeds at 5-knot intervals and at V_1 and V_2 . Although his attention had been directed primarily inside the cockpit, he did not note any of the flight instruments other than

the airspeed, nor did he see the reflection of the landing lights off the fog. After calling out 155 knots he looked out and saw they were in a formation of fog. When they passed through the fog and it cleared up in front of them, he saw the fence. He also said that the events which followed his calling 155 knots were almost instantaneous.

Both the pilot and copilot said there was no apparent change of attitude in the aircraft when the flaps were raised. The captain said he did not recall having to change the trim or attitude as the flaps came up. He thought that at the time of encountering the fog the aircraft was over the runway at a height of about 75 feet. He said he was watching for the runway threshold lights but never did see them. None of the crew members felt any sensation of descent. The captain testified that he intermittently referred to the rate-of-climb indicator and recalled seeing no indication of descent. The first realization that the aircraft was going down was when the copilot saw the fence.

Both the captain and copilot had received instrument training required by the provisions of Civil Air Regulations and NWA, which includes training in instrument takeoff procedures. For a number of years, NWA, in its training program, has required pilots to accomplish takeoffs under a hood which can be closed when the aircraft reaches V_1 . In addition, both pilots had passed the required instrument proficiency checks and must therefore be presumed to be thoroughly familiar with instrument takeoffs.

Takeoff techniques vary considerably with the pilot. However, NWA procedures in effect at the time of this accident were designed to standardize these techniques as much as possible. Based on these normal operating procedures^{2/} the DC-6B would accelerate to V_2 speed, 115 knots, in approximately 35 seconds and cover a distance of 3,770 feet. After leaving the ground the airplane should be able to climb and accelerate, passing through 100 feet of altitude about 54 seconds after starting the takeoff roll. At that point the aircraft would have covered a horizontal distance of about 7,000 feet and have attained a speed of about 123 knots. Again, under these conditions, in order to accelerate to 155 knots from start of takeoff, about 85 seconds would be required. The aircraft would travel a horizontal distance of approximately 15,000 feet and reach an altitude of about 300 feet.

If the aircraft lifted off the ground at V_2 (115 knots) and climbed at that speed (best angle of climb), it would pass through 100 feet of altitude about 42 seconds after start of takeoff roll and would have covered a horizontal distance of about 5,280 feet.

One further computation which the Board considers significant is that if the aircraft, after lifting off the ground, were allowed to accelerate without climbing, it would attain a speed of about 155 knots when the aircraft had covered a horizontal distance of about 9,400 feet.

The Board realizes that many variables exist in pilot technique which will change the average performance figures. However, it is also aware that

^{2/} It is recognized that there will be variations in takeoff techniques; however, these figures should be fairly representative of the desired performance.

the average performance will be within the two extremes outlined and should approximate the average or desired performance.

Study of the wreckage of N 575 revealed that the aircraft had hit and damaged a chain link fence at the southern airport boundary. Sixty feet southwest of this fence the aircraft contacted the ground in a slightly nose-high right-wing-low attitude. The point of initial ground impact was 2,900 feet from the threshold lights on the southwest end of runway 22 and the wreckage came to rest 1,600 feet farther on. Most of the major components separated from the fuselage as the aircraft skidded along the ground. The fuselage came to rest on its left side and heading about 245 degrees.

Several minutes after the passengers were evacuated, an intense fire developed which consumed approximately 85 percent of the wreckage.

It was determined that the landing gear, flaps, and the landing lights were fully retracted. No evidence was found of inflight structural failure. Separation of the various components was caused by contact with the fence, overloads encountered during the skid, or by contact with objects on the ground.

Destruction of the interior of the fuselage by fire was so extensive that it was impossible to determine the extent of damage incurred from the impact. However, most of the remaining structure was lying on the ground in its relative position, indicating that the supporting structure had burned away after the airplane came to rest.

Examination of the powerplants showed that all engines were operating normally and developing considerable power. All damage was attributable to severe impact forces or ground fire damage. The propeller governors were set at 2,800, confirming the crew testimony that takeoff r. p. m. had not been reduced. The propeller blade shim plates of all propellers were marked by impact at angles from 37 degrees to 39 degrees. Propeller slash marks made in the ground at initial contact were measured to determine the groundspeed, from which the airspeed was calculated to be 154 knots. As a result of the testimony of the crew and examination of the powerplants, it was determined that the powerplants in no way contributed to the cause of this accident.

Evacuation of the passengers was accomplished mainly through a break in the top left side of the forward fuselage. With the aircraft lying almost on its left side it was impossible to utilize any of the emergency exits on that side. One exit on the right side was used by a number of the passengers and several others left the aircraft through the copilot's sliding window in the cockpit.

Most of the seats remained attached to the floor; however, several broke loose and hampered evacuation somewhat. The interior was dimly lighted by the emergency lights and several small fires. These fires, fed by fuel, gradually increased in intensity and engulfed the entire fuselage a short time after the last passenger was evacuated. Fire-fighting equipment which arrived on the scene about this time was unable to save anything other than a small portion of the wreckage.

Analysis

Examination of the wreckage disclosed no evidence of any malfunction or inflight failure of any part of the aircraft. All four engines were uniformly developing considerable power when they struck the ground. Records showed that all maintenance and overhaul work was properly accomplished and was adequately supervised. From this physical evidence, along with the testimony of the crew, the Board determined that no mechanical or structural failure or malfunction occurred which in any way contributed to the cause of this accident.

It is patent that the crew of N 575 were highly experienced. It is also evident that both pilots thought the airplane was climbing out normally and neither realized it was, in fact, descending. With this in mind, the Board has studied the phenomenon of pilot sensory illusion to determine whether such is applicable to this accident. Considerable material on this subject is available from military and civilian aeromedical research organizations.

All of these organizations recognize the existence of misleading physical sensations experienced by pilots under conditions of reduced sensory stimuli. One authority^{3/} concludes that, "the forward acceleration of the aircraft after takeoff causes a sensation of nose-up tilt because the pilot cannot distinguish between the direction of gravity and the resultant of gravity and aircraft acceleration. If the pilot is not fully on instruments, this can cause him to lower the nose, and the acceleration in the resulting dive perpetuates the illusion. The aircraft can enter a shallow dive, with or without turning, and the pilot will still experience a sensation of steady climb." The paper goes on to say, "If it is also very dark and the direction of take-off is away from a built-up lighted area, there is nothing to be seen which can give a horizon reference and the pilot is now very likely to get this false impression of the attitude of the aircraft in pitch. Because it is too dark to see the ground, loss of height is not apparent."

The Board believes that the conditions which existed at the time N 575 took off were ideal for the propagation of this illusory effect. Visibility was reduced by fog and takeoff was made away from a built-up area toward a very dark unlighted space where the pilot had no reference to a horizon by which to determine the attitude of the aircraft. It is important here to recognize that sensory illusions will not necessarily cause a pilot to dive the aircraft but can completely conceal the fact that a descent has commenced.^{4/}

From evidence adduced during the investigation it was shown that the aircraft took off normally, climbing to a height of about 100 feet. The aircraft should be roughly at this altitude as the flaps retract through the 10-8 degree position. This portion of travel of the flaps will produce the greatest change in attitude of the aircraft. At this point the aircraft nosed over and began its descent. Obviously, the pilots were unaware of this

^{3/} Dr. John C. Lane, Superintendent of Aviation Medicine, Department of Civil Aviation, Australia. Reprint circulated by Flight Safety Foundation.

^{4/} On an aspect of the accident, history of aircraft taking off at night, A. R. Collar, ARC Tech. report R&M No. 2277 (9872).

change of attitude and therefore did not initiate any corrective action. It is equally clear that the absence of stimulation to the visual sense was instrumental in effectively concealing this change of attitude. Finally, the continued acceleration of the airplane in its descent sustained the illusion, giving the pilots the impression of a steady climb.

A pilot with the experience of Captain Wilkinson must be familiar with night takeoffs in conditions of reduced visibility and therefore should have realized that full utilization of all the aircraft instruments was mandatory. The rate-of-climb instrument is not a primary instrument during initial lift-off, because of ground effect and the inherent lag in its indications. However, as mentioned before, it would require approximately 15 to 20 seconds for N 575 to reach a height of 100 feet from liftoff. At this time the rate-of-climb instrument would be indicating correctly. Moreover, the artificial horizon, the airspeed indicator and altimeter are instruments which will give positive and immediate indications of attitude. To monitor one instrument to the exclusion of all others indicates a lack of the normal alertness and attention demanded of a pilot.

In addition, all normal procedures require that a positive climb be established before flaps are retracted. In order to maintain this climb, some positive control action must accompany the flap retraction. Again it is elementary that where visual reference to the ground is precluded the use of flight instruments is necessary in order to ensure proper control of the aircraft.

One further indication, which should have been apparent to the pilot through normal alertness, was the extremely rapid acceleration of the aircraft. As stated before, under normal operating procedures it would require approximately 85 seconds for the aircraft to attain a speed of 155 knots and it would have traveled a horizontal distance of 15,000 feet. Here the aircraft speed was 155 knots when it first hit the ground about 7,600 feet horizontally from start of takeoff. According to the Captain's testimony he thought he was still over the runway as he had not seen the threshold lights. To have attained a speed of 155 knots in this distance also should have alerted him that the acceleration was far greater than normal.

Conclusions

It is the Board's determination that the pilot, in view of the reported conditions of restricted visibility and absence of ground reference lights, did not exercise the kind of judgment required by the holder of an airline transport rating during the execution of the takeoff.

The condition of restricted visibility which existed at the time of this accident is not unusual and in no way affects the execution of a safe takeoff; however, it is the Board's conclusion that under such conditions, the pilot should utilize all of the flight instruments available in the aircraft. In this case, if the pilot had devoted his attention to the flight instruments rather than attempting to maintain visual contact during the takeoff, the accident could have been avoided.

Further, it is the Board's conclusion that the copilot did not exercise the best judgment under the circumstances. One of the fundamental reasons

for requiring a copilot in transport-type aircraft is to provide assistance to the pilot. Such assistance is not limited to that of monitoring the air-speed only, as was done in this case. If the copilot had given normal attention to the flight instruments, he would have seen indications that the aircraft was descending and alerted the pilot to this fact. The accident might have been avoided had this been done.

In view of the foregoing, it is the Board's recommendation that the company re-emphasize through its training procedures the proper operating techniques for night takeoff when weather conditions or other factors restrict visibility.

Subsequent to this accident the company revised its takeoff procedures. All pilots are now required to climb the airplane immediately after takeoff at V_2 speed to an altitude of at least 50 feet. The landing gear is retracted when the airplane is definitely airborne. At 50 feet the airplane is allowed to begin to accelerate while still continuing a positive climb. The climb is continued until reaching 200 feet. Upon reaching 200 feet and a speed of at least 125 knots, flaps may be raised. The aircraft is then allowed to accelerate to 140 knots before takeoff power is reduced. In addition, the copilot is now required to monitor the altimeter and call off altitudes every 100 feet until the aircraft reaches 500 feet.

Probable Cause

The Board determines that the probable cause of this accident was the pilot's inattention to flight instruments during takeoff in conditions of reduced visibility.

BY THE CIVIL AERONAUTICS BOARD:

/s/ JAMES R. DURFEE
/s/ CHAN GURNEY
/s/ HARMAR D. DENNY
/s/ G. JOSEPH MINETTI
/s/ LOUIS J. HECTOR

S U P P L E M E N T A L D A T A

Investigation

The Civil Aeronautics Board was notified of the accident at 0355, August 28, 1958. An investigation was immediately begun in accordance with the provisions of Section 702 (a) (2) of the Civil Aeronautics Act of 1938, as amended. Depositions ordered by the Board were taken in Minneapolis, Minnesota, on October 2, 1958.

Air Carrier

Northwest Orient Airlines, Inc., is a Minnesota corporation with its principal offices located in St. Paul, Minnesota. The company possesses the proper certificates of public convenience and necessity issued by the Civil Aeronautics Board and an air carrier operating certificate issued by the Civil Aeronautics Administration (now Federal Aviation Agency) which authorize the carriage of persons, property, and mail over the route described above.

Flight Personnel

Captain James Wilkinson, age 37, was employed by Northwest Orient Airlines February 10, 1943. Captain Wilkinson held a valid airman certificate with an airline transport rating and type ratings in DC-3, DC-4, DC-6, and DC-7 aircraft. In addition, he held a rating as a flight instructor and an instrument rating. He completed transitional training in the DC-6 on September 3, 1957, and received a qualification check for the route involved on September 27, 1957. His last instrument check and pilot proficiency check were passed on March 10, 1958, and his last route check was completed June 4, 1958. According to company records Captain Wilkinson had a total of 12,376 flying hours, of which 572 were in the DC-6. His last first class physical examination was passed on June 20, 1958.

First Officer Verner J. McGinness, age 36, was employed by Northwest Orient Airlines, Inc., July 30, 1952. He held a valid airman certificate with commercial pilot, single- and multi-engine land, flight instructor, and instrument ratings. He had a total of 9,089 flying hours, of which 148 were in DC-6 equipment. His checkout in the DC-6 was completed October 7, 1957, and his latest instrument check was passed May 10, 1958. Mr. McGinness passed his first class physical examination March 12, 1958.

Flight Engineer Robert R. Mielke, age 32, was employed by Northwest Orient Airlines, Inc., on October 3, 1950, as a mechanic, and he was promoted to flight engineer May 29, 1958. He held a valid airman certificate.

Stewardess Margaret C. Gallagher was employed by Northwest Orient Airlines November 11, 1957. She completed her prestewardess training in November 1957. Miss Gallagher received Air-Sea Rescue and emergency procedures in January and July 1958.

The Aircraft

N 575, a Douglas DC-6B, serial number 45200, owned by Northwest Orient Airlines, was manufactured on March 2, 1957, and had 4,471 flying hours at the time of the accident. It was equipped with Pratt & Whitney R-2800-CEL7 engines and Hamilton Standard propellers, models 43E60-451 and 43-E60-303, with blade model 6895E-8.