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16. Abstract

On November 16, 1976, Texas International Flight 987, a McDonnell Douglas DC-9-14, crashed after rejecting a takeoff from runway 8 right at Stapleton International Airport, Denver, Colorado. The takeoff was rejected when the stall warning stick-shaker activated after the aircraft had rotated for takeoff. When the pilot was unable to stop the aircraft within the confines of the runway, it overran the runway, traversed drainage ditches, struck approach light stanchions, and stopped.

Eighty-one passengers and five crewmembers evacuated the aircraft, which had been damaged severely by impact and fire; 14 persons were injured.

The National Transportation Safety Board determines that the probable cause of this accident was a malfunction of the stall warning system for undetermined reasons which resulted in a false stall warning and an unsuccessful attempt to reject the takeoff after the aircraft had accelerated beyond refusal and rotation speeds.

The decision to reject the takeoff, although not consistent with standard operating procedures and training, was reasonable in this instant case based upon the unusual circumstances in which the crew found themselves, the minimal time available for decision, and the crew's judgment concerning a potentially catastrophic situation.

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NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C. 20594

AIRCRAFT ACCIDENT REPORT

Adopted: October 27, 1977

TEXAS INTERNATIONAL AIRLINES, INC.
DOUGLAS DC-9-14, N9104
STAPLETON INTERNATIONAL AIRPORT
DENVER, COLORADO
NOVEMBER 16, 1976

SYNOPSIS

Texas International Flight 987, a McDonnell Douglas DC-9-14, crashed after rejecting a takeoff from runway 8 right at Stapleton International Airport, Denver, Colorado. The takeoff was rejected when the stall warning stickshaker activated after the aircraft had rotated for takeoff. When the pilot was unable to stop the aircraft within the confines of the runway, it overran the runway, traversed drainage ditches, struck approach light stanchions, and stopped.

Eighty-one passengers and five crewmembers evacuated the aircraft, which had been damaged severely by impact and fire; fourteen persons were injured.

The National Transportation Safety Board determines that the probable cause of this accident was a malfunction of the stall warning system for undetermined reasons which resulted in a false stall warning and an unsuccessful attempt to reject the takeoff after the aircraft had accelerated beyond refusal and rotation speeds.

The decision to reject the takeoff, although not consistent with standard operating procedures and training, was reasonable in this instant case, based upon the unusual circumstances in which the crew found themselves, the minimal time available for decision, and the crew's judgment concerning a potentially catastrophic situation.

1. FACTUAL INFORMATION

1.1 History of the Flight

On November 16, 1976, Texas International Flight 987, a McDonnell Douglas DC-9-14, N9104, operated as a scheduled passenger flight from Salt Lake City, Utah, to Houston, Texas, with an intermediate stop at Denver, Colorado. The flight was routine to Stapleton International Airport, Denver, Colorado. The flight left the gate at Stapleton International Airport with 81 passengers and 5 crewmembers aboard.

When Flight 987 was cleared to taxi to runway 8R for takeoff, the weather was clear, the wind was from 130' at 7 kns, and the temperature was 40° F. At 1726:33, 1/ the tower cleared the flight to take the runway and to hold while two light aircraft took off from a nearby intersection. At 1729:13, Flight 987 was cleared for takeoff, and at 1729:15 the flight reported "rolling."

The first officer was making the takeoff and, upon receipt of the clearance,, he advanced the throttles to a position commanding 1.4 EPR and released the brakes. After the engines stabilized at 1.4 EPR, the first officer advanced the throttles to the takeoff thrust position. Upon reaching this position, he relinquished control of the throttles and placed his left hand on the control yoke. The captain guarded the throttles until rotation speed (V_R) was reached.

The pilots described the takeoff roll to rotation as "normal." The captain monitored the engine instruments and noted no abnormal readings. He said he called out 100 KIAS, 130 KIAS, V_1, V_R, V_2; the cockpit voice recorder (CVR) readout corroborated his statement.

The first officer stated that when the captain called V_R, he checked his airspeed indicator before he moved his control column aft and saw 149 or 150 KIAS either at, or just before, he began to rotate the aircraft. He stated that he rotated the aircraft at a normal rate to a target pitch angle of 10° which he determined from his attitude indicator; he estimated that this took about 3 to 4 seconds. About halfway through the rotation--about a 5° pitch angle--the stall warning system's stickshaker activated. The first officer stated that once it began it was continuous. He said he continued the rotation to what he believed to be about 10° and the stickshaker continued to operate. He saw that although the airspeed was beyond 150 KIAS, the aircraft did not lift off. Since it had accelerated to a speed greater than V_1, the first officer said that he tried to get it airborne. He could not recall how long he maintained the pitch angle, but he believed it was adequate to get the aircraft off the runway. When he concluded that the aircraft was not going to fly, he rejected the takeoff.

1/ All times herein are mountain standard based on the 24-hour clock.

The captain stated that rotation was normal and that as rotation was begun there were a couple of "clacks" from the Btickshaker. As the rotation continued, the stickshaker began to operate continuously. He saw about 10° pitch angle on his attitude indicator and 152 KIAS on the airspeed indicator. All other instrument indications were normal. The stickshaker continued to operate and he believed that the aircraft would not lift off. At this point, with the airspeed well past V_2, he decided to reject the takeoff. His actions to reject the takeoff were simultaneous with those of the first officer.

When the first officer began to abort the takeoff, he reached over and, in what he described as one continuous motion, pulled the throttles to idle and applied full reverse thrust. Almost simultaneous with his initiation of the power reduction, he felt the captain's hand on top of his. He said that he had already started to apply forward pressure on the yoke to lower the nose. When he felt the captain's hand on his, he realized that the captain was assuming control of the aircraft and he removed his own hand from the thrust levers and placed it on the yoke. He described the lowering of the nosewheel to the runway as rapid, and once it was on the ground he pushed the yoke forward to hold the nosewheel there and applied brakes. The stickshaker had stopped, but neither pilot could recall exactly when.

When the nose was lowered, full reverse thrust and maximum wheel braking were applied; however, the ground spoilers were not deployed. The captain estimated that there was 2,500 to 3,000 ft of runway remaining when the takeoff was rejected. He later noted that they were in the amber lighted area of the runway when the abort began. The first officer said that all he could see were the amber runway edge lights when the nose was lowered. The amber coded runway edge lights on 8R begin 2,000 ft from the eastern threshold of the runway.

The captain stated that he steered the aircraft toward the right side of the runway to avoid the approach light stanchions for runway 26L. The aircraft left the runway, continued another 1,050 ft, traversed two drainage ditches, struck approach light stanchions, turned left, and stopped headed in a northerly direction.

After the aircraft stopped, the captain ordered the first officer to proceed into the cabin and assist the flight attendants with the passenger evacuation. The captain then cleaned up the cockpit and carried out the emergency engine shutdown procedures. The engines were shut down, the fuel shutoff valves were closed, the engine fire handles were pulled, the fire extinguishing agent was discharged, and battery and ignition switches were turned off.

1.2 Injuries To Persons

Injuries	Crew	Passengers	Others
Fatal	0	0	0
Serious	0	2	0
Minor/None	5	79	

1.3 Damage **To** Aircraft

The aircraft was damaged severely by impact and fire.

1.4 Other Damage

Several runway approach light stanchions and two standard glide slope antennas near the runway boundary were broken.

1.5 Personnel Information

The flightcrew was certificated and qualified in accordance with Federal Aviation Administration (FAA) requirements. The cabin attendants were qualified in accordance with FAA and company requirements. (See Appendix B.)

1.6 Aircraft Information

The aircraft was certificated, equipped, and maintained in accordance with FAA requirements. (See Appendix C.) N9104 was a Douglas DC-9-14, and was acquired from Hughes Air West. The aircraft allowable ramp weight computation form, (TI Form 374-A) disclosed that the computed takeoff gross weight was 87,243 lbs. The takeoff flap setting was 10° and the computed takeoff speeds were as follows: Refusal speed (VI) was 138 kns indicated airspeed (KIAS); rotation speed (V_R) was 146 KIAS; and takeoff safety speed (V_2) was 149 KIAS. A reduced thrust takeoff was made using an engine pressure ratio (EPR) setting of 1.95.

Computations were based on a projected runway temperature of 45° F. The aircraft's operating empty weight was 51,590 lbs. The estimated baggage and cargo weight was 4,023 lbs; 2,714 lbs was loaded in the forward cargo bin, and 1,309 lbs in the aft cargo bin. Application of the prescribed winter weight of 170 lbs per passenger for 80 passengers produced a total weight of 13,600 lbs and 130 lbs was added for the third flight attendant.

There were 18,300 lbs of JP-1 fuel in the two wing tanks. The computed weight of the aircraft on the ramp when the engines were started and the taxi begun was 87,643 lbs. The estimated fuel burnoff for taxi was 400 lbs; the estimated takeoff gross weight was 87,243 lbs.

The maximum weight and c.g. limits for the takeoff were 90,600 lbs, from 15.8 percent to 31 percent MAC, respectively. Flight 987 was within those limits. (See Appendix C.)

The setting of the stabilizer trim on the aircraft can be read off the stabilizer trim race both in degrees and aircraft c.g. in percentage of MAC. The postaccident examination of the cockpit disclosed that the stabilizer trim was set at 4.2° aircraft nose up (ANU), and 19 percent MAC. This setting was corroborated by measurements of the stabilizer jackscrew.

1.7 Meteorological Information

Surface weather observations for Denver were as follows for the times indicated:

1651, clear, visibility--40 miles, temperature--40° F, dewpoint--17° F, wind--130° 7 kns, altimeter setting--30.22 inches, few cirrus.

1742, Local, clear, visibility--20 miles, temperature--38" F, dewpoint--17° F, wind--140° 7 kns, altimeter setting--30.23 inches (aircraft mishap).

From 1700 to 1800, winds were from the southeast. At the time of the accident, wind speed record for Stapleton showed 7 kns; the speed had been 6 to 7 kns for the preceding 5 minutes.

Recorded wind information was obtained from two observing stations located on the Rocky Mountain Arsenal. The record from station No. 6, which is located just east of the midpoint of runway 35R, showed the following at 1730:

Direction 130° to 140° and speed about 3 mph. The record from station No. 7, which is located just west of the north end of runway 35L, showed the following: Direction 155°; speed 7 mph.

There were no pilot reports regarding low level weather conditions.

1.8 Aids To Navigation

Not applicable.

1.9 Communications

There were no communication difficulties between the flightcrew and the control tower.

1.10 Aerodrome Information

Stapleton International Airport is located 5.6 mi east of Denver, Colorado; field elevation is 5,330 ft m.s.l. Runway 8R is 10,010 ft long and 150 ft wide. It is bordered by white high-intensity runway lights, except for the last 2,000 feet which is bordered by aviation yellow lights. The average elevation of runway 8R is 5,317 ft. The last 4,000 ft of the runway rise 24 ft. The airport was certificated under provisions of 14 CFR 139.

Runway 8R is surfaced with porous friction asphalt. The runway was cleaned (water blasted) during the week of October 11, 1976. The coefficient of friction over the eastern half of the runway was measured on November 19, 1976. A Mu-meter was run over the last 5,000 ft of the runway on each side of the centerline. The resultant readings for the test ranged from 0.8 to 0.9.

After leaving the runway, the aircraft struck several steel approach light structures and two ditches. According to 14 CFR 139.45 governing runway safety areas, runway 8R should have a "ZOO-foot... cleared, drained, and graded area beyond the end of the runway." This area must be clear of hazardous ruts, depressions, and bumps. Because of exemptions contained in 14 CFR 139.45, runway 8R was not required to meet the extended safety area requirements of 800 feet beyond the 200-foot area as specified in Advisory Circular 150/5335-4.

DOT-FAA Order No. 6850.9, dated April 9, 1975, outlines FAA policy regarding frangible structures on approach light systems. The row of approach lights 100 feet from the end of the paved overrun of runway 8R at Stapleton, which is 400 feet from the end of the runway, was of frangible construction. The remainder of the structures hit by the aircraft were not frangible.

1.11 Flight Recorders

The aircraft was equipped with a Fairchild model 5424 flight data recorder, serial No. 2485, and Fairchild model A-100 cockpit voice recorder serial No. 2047. Both recorders were installed in a pressurized area in the rear of the passenger cabin and were satisfactory for readout. A readout was made of both recorders. (See Appendixes D and E.)

A readout was also performed on the recorded flight record from Braniff International Airlines Flight 982, a Boeing B-727, N276, which had executed a missed approach from runway 17 and, in the process, had passed over runway 8R about 3.5 minutes before Texas International Flight 987 started its takeoff roll. (See Appendix F for analysis of B-727 vortex wake.)

A correlation was made of the CVR and FDR data starting from the radio call "rolling" (a known transmission point). (See Appendix **G**). **This** correlation shows that 31 seconds after the call "rolling", the call, "through a hundred" occurs (at a FDR indication of 96 KIAS). The call, "Okay there's a hundred and thirty," occurs 9 seconds later at 40 seconds elapsed time (at a FDR indication of 120 KIAS). Three seconds later, at 43 seconds elapsed time, the V_1 call occurs (at a FDR indication of 142 KIAS), the V_2 call occurs 1 second later at 44 seconds elapsed time (at a FDR indication of ***142*** KIAS), and the V_2 call occurs 2 seconds later at 46 seconds elapsed time (at a FDR indication of 146 KIAS).

The stall warning commences 2 seconds after the V_2 call at 48 seconds elapsed time and continues for approximately 6.5 seconds.

If the takeoff is assumed to have started at the call "Okay you're stable left and right" (CVR indicates near maximum power), the FDR indications of aircraft acceleration time are as follows:

	V_1	V_R	V_2
Time:	36 sec	39 sec	40.5 sec

1.12 Wreckage and Impact Information

The aircraft came to rest 1,050 ft beyond the east end of runway 8R and slightly to the right of the extended runway centerline on a magnetic heading of 5°. The aircraft struck the runway 26 nonfrangible approach light stanchions, two ditches, and the standard glide slope screens. All of the wreckage was confined to an area 840 ft long and **120** ft wide. (See Appendix H.)

Faint tire tracks from the right main landing gear were evident on the right side of the runway centerline beginning about **7,270** ft from the takeoff end of runway 8R. The left main landing gear tracks became visible on the left side of the runway centerline about 8,470 ft from the takeoff end of runway 8R. The left and right main landing gear tracks were continuous from their respective starting points up to where the aircraft came to rest. The nose gear tracks became visible **on** the right side of the runway centerline for about **7** ft at 8,515 ft from the takeoff end of runway 8R. The nose gear track became visible again on the runway overrun about ***65*** ft from the departure end of runway 8R. From this point **on**, the nose wheel tracks were continuous up to where the aircraft came to rest.

Tire tracks from the landing gear showed that the aircraft turned to the right just before it rolled onto the overrun area but remained essentially on the runway centerline. After leaving the overrun, the aircraft struck numerous approach light stanchions before it stopped.

After a postcrash fire, the fuselage was found tilted 15° to the left. The wings, engines, and entire empennage remained attached to the fuselage. The lower fuselage structure from the radome to the nose gear was damaged heavily. The fuselage was burned through on the left side in the area of the left wing root. The nose gear failed rearward and the wheels came to rest in the electrical and electronics compartment. The left main landing gear supporting structure failed, allowing the gear to trail aft from its normal down position. The right main landing gear remained attached and extended. The left wing was on the ground; the wingtip separated. The left aileron and flaps remained attached to the wing; the left wing root and fairing were burned.

All flight control surfaces were in place. The fuselage structure around the main cabin entry door was deformed. The left side of the fuselage was burned through except for stringers and frames between FS 390 and FS 584. The fire damage extended vertically from the top of the left wing up to fuselage stringer No. 19. The right side of the fuselage between FS 256 and FS 718 had been punctured in several places; orange paint smears were found around the punctures and in other locations on the fuselage.

The main cabin entry door was intact and operable. The right forward galley door was intact and operable and all door placards were legible. The left and right cockpit sliding windows were intact and operable. The left overwing exit remained installed in the locked position. This exit was nearly consumed by fire. The right overwing exit had been removed during the evacuation and was located in the row aft of the right overwing exit. The fuselage tail cone separated from its attaching structure. The rear pressure bulkhead exit door had also been removed during the evacuation and was found aft of the rear pressure bulkhead in the tail cone area.

Both elevators and elevator tabs were intact. The rudder and rudder tab were intact. The rudder was deflected about 25° to the left; the rudder trim tab was deflected about 15° to the left. All flight control cables remained intact and in place on their respective pulleys. All flight control cables moved freely when the control columns and rudder pedals were moved. The control wheel for the aileron could not be moved. All flight control push-pull rods and bellcranks remained intact, except for those in the aileron system which were damaged by impact.

The left and right wing trailing edge flap panels remained attached to the wings. The inboard and outboard hydraulic flap actuators measured 13 inches between the actuator housing mounting bolt centerline and the piston bolt centerline. This measurement corresponded to a 10° flap extension.

The horizontal stabilizer and elevators remained intact and attached to the vertical fin. The horizontal stabilizer's jackscrew position between the index rivet on the vertical fin and the two reference rivets on the horizontal stabilizer leading edge was 4 5/32 in with the stabilizer leading edge down, which corresponded to a stabilizer cockpit indicator setting of 4.0" to 4.5° ANU.

All spoiler panels were down and locked down. The ailerons remained attached to the wings, and the trim tabs were in the neutral position.

Both engine thrust reversers were deployed and locked. The No. 1 engine's first-stage fan blades showed signs of foreign object damage. Only one blade of the No. 2 engine's first-stage fan blades was damaged. Fourth stage turbine blades and engine mounted components and accessories of both engines were not damaged. The engine and auxiliary parer unit fuel fire shutoff valves were closed. The four main wheel brakes exhibited fire and impact damage.

The high pressure elevator accumulator gauge indicated 700 p.s.i. The low-pressure accumulator gauge indicated 15 p.s.i. These were normal pressures.

The elevator actuators were in place and intact and operated freely with elevator movement. Slight fluid leakage was evident. The rudder actuator was in place and intact and also operated freely with rudder movement.

1.13 Medical and Pathological Information

The medical histories of the flightcrew members disclosed no evidence of any conditions which would have affected their performance.

Two flight attendants sustained sprains and abrasions. The flight attendant at the rear tail cone exit twice was either pushed by a passenger or fell off the catwalk leading to the tail cone exit. She was injured during these falls.

Although none of the passengers' injuries were serious, two passengers were hospitalized for more than 48 hours and were classified as "serious" because of the length of their confinement. Other passengers sustained minor sprains and abrasions during the evacuation.

1.14 Fire

Fire erupted on the left side of the aircraft after the left main landing gear traversed the ditch and severed the left main landing gear's attaching structure on the left main fuel tank's rear bulkhead. Fuel escaped from this tank, burned, and caused massive damage to the left side of the fuselage and inboard section of the left wing. The cabin interior was damaged heavily throughout by smoke and soot.

The airport crash/fire/rescue facilities responded and extinguished the fire. Although the distance from the firehouse to the crash site was about 3 miles, they were on scene in about 5 minutes, but not before everyone had evacuated the aircraft. The fire was extinguished rapidly, preventing additional property loss.

The airport emergency plan, required by 14 CFR 139, was implemented according to the various preplanned provisions. A delay encountered in removing passengers from the runway area involved members of Texas International's staff who were not familiar with their duties and responsibilities under the emergency plan; specifically, it was not clear as to who was responsible for providing emergency transportation from the runway.

1.15 Survival Aspects

This was a survivable accident. The occupiable area of the aircraft was intact; decelerative forces were minor and within human tolerance. There were no failures to the passenger or crewmember restraint systems; the only danger to occupants was fire and smoke. The evacuation was conducted with little delay and all passengers were out of the aircraft in 2 minutes; all exits, except the left overwing exit, were used.

The tail cone area of the DC-9-14 is equipped with two emergency lights; one comes on when normal electrical power is lost and the other comes on when the tail cone is released. The light source is located above the end of the catwalk. In this accident, when the flight attendant opened the plug door leading to the tail cone exit, she was startled by the low intensity of lighting in the tail cone area, and once in the tail cone, she was unable to find the release handle because of the darkness.

Postaccident examination disclosed that the tail cone exit emergency evacuation slide was rigged for "manual" operation instead of the required "automatic" operation. After the accident, the slide was properly rigged and deployed; it operated as designed. It is not possible for the slide to fall out of the exit and not deploy if installed properly. The aircraft came to rest on its belly with the exit opening only 48 inches from the ground, thus eliminating the need for the slide.

There was no impact damage to the interior of the passenger cabin. Only two problems were encountered in the interior of the aircraft. (1) One of the ovens in the galley came loose and fell to the floor, but created no obstacle to the evacuation and (2) the passenger information card used by Texas International Airlines did not meet the requirements of 14 CFR 121.571b. 2/ The card did not depict the method of operating the tail cone exit. In this accident a passenger with crewmember direction

2/ Each certificate holder shall carry on each passenger-carrying airplane, in convenient locations for use of each passenger, printed cards supplementing the oral briefing and containing--(1) Diagrams of, and methods of operating, the emergency exits....

located the handle and successfully deployed the tail cone. In another accident in December 1972, involving another air carrier, two passengers died in the tail cone area because of delays with opening this exit. 3/

Testimony received from the **FAA** principal inspector assigned to Texas International disclosed that critical safety information identified in a North Central Airlines accident over 4 years ago had not been brought to his attention.

1.16 Tests and Research

1.16.1 Stall Warning System Tests

The **stall** warning system continuously monitors wing lift and automatically provides an audible and vibratory (stickshaker) indication to the crew when the aircraft approaches **a** stall. The stall warning system is a dual installation consisting of two lift transducers, one mounted **on** each wing; two signal summing units; two control column shakers; and two sets of flap position switches mounted in the left and right wing flap linkages.

The lift transducers with associated circuitry develop a lift signal which is applied to the signal summing units. This lift signal is modified by a signal for the effect of flaps on lift. When these signals reach a preset value, the magnetic amplifier output energizes the shaker's relay. Either signal summing unit shaker relay will operate both control column shakers. Actuation is fixed at a percentage of angle of attack below stall. This percentage remains constant despite changes of gross weight, power settings, or flap position.

Ground activation of the stall warning system is inhibited by the action of the left and right ground control relays. The opening and closing of these relays is governed by the action of the ground shift cables on the nose strut. During takeoff, changeover from ground to air logic occurs when the nose strut is 1 5/8 in. from full extension. At the takeoff gross weight of 87,400 lbs the nose strut would be *so* extended at a fuselage pitch angle of 1° 10'. Therefore, the stickshaker cannot actuate until the nose strut is within 2 in. of full extension. Compressing the strut to less than a 2-hextension will cause stall warning system to stop.

All of the stall warning system components, except for the right andrleft wing flap position switches, were removed from the aircraft and tested functionally. The left wing flap position switches were destroyed by fire. The right wing flap position switches were

3/ North Central Airlines, Inc., McDonnell Douglas DC-9-31 and Delta Airlines, Inc., Convair CV880, December 20, 1972, Report No. NTSB-AAR-73-15.

examined while still attached to the flap linkage. The 5° to 15° switch was closed. The 0° to 5° and the 15° to 50° switches were open. This is the proper switch configuration for 10° of flaps.

The right wing lift transducer vane was damaged by impact and smeared with orange paint. When the unit was tested, the vane would stick magnetically at the forward stop and was out of tolerance at the aft stop. However, the vane would trigger the system electrically at the correct tip gram load values.

The left wing lift transducer was damaged severely by fire and impact and could not be tested. The two signal summing units were tested functionally and operated within the manufacturer's specified tolerances. The two control column shakers were also tested and they operated normally.

1.16.2 Takeoff Performance, Engine Response, and Stopping Distance

1. Takeoff Performance

Computation of the takeoff performance data was based on takeoff thrust used at Denver (1.95 EPR) during the accident flight and the actual runway slope and ambient weather conditions which existed during the takeoff. The winds before and after the accident were 130° 7 kns and 140° 7 kns, respectively.

The Texas International wind component chart produced a headwind component of 2.5 to 3 kns. Using a 5-kn headwind, the following times and distances were required to attain V_1 (138 KIAS), V_R (146 KIAS), and V_2 (149 KIAS):

	V_1	V_R	V_2
Time:	36 sec	38.5 sec	40 sec
Distance:	4,700 ft	5,350 ft	5,600 ft

2. Stopping Distance

According to Douglas, the exact stopping distance data for the speed at which the takeoff was rejected are not available. However, the stopping distance for the aircraft based on its weight and configuration at Denver was calculated based on a rejected takeoff at V_1. The parameters used for the computations were identical to those used for the takeoff calculations and, in addition, the following time delays from V_1 were assumed.

Delay	Seconds
Throttle retardation and brake application	1
Spoiler actuation	2
To achieve full braking configuration	3
To achieve full spoiler configuration	4

Based on these parameters, the following stopping distances were calculated:

Condition	Feet
Reverse thrust, wheel brakes, and spoilers	- 2,935
Reverse thrust, wheel brakes, and no spoilers	- 3,265

Since the flight data recorder indicated that the takeoff was rejected at 157 KIAS, the effect of this increased velocity on the stopping distance was computed. The following stopping distances resulted:

Condition	Feet
Reverse thrust, wheel brakes, and spoilers	3,797.8
Reverse thrust, wheel brakes, and no spoilers	4,224.9

3. Engine Response

Douglas test data disclosed that, during the transition of the throttles from the takeoff-thrust position to the full-reverse thrust position, there are several time delays which will affect engine response. When the throttles are retarded to the reverse position, they are locked in the reverse idle detent until the reversers unstow and move into position; this operation requires 2 seconds.

Manufacturer's test pilots estimated that a nominal time to move the throttles from the takeoff position to the reverse idle position would be about 1 second, and another 1 second would be required to move them from the reverse idle to the full reverse position. This estimate was further corroborated by testimony of an FAA test pilot.

The engine will decelerate from 100 percent to 20 percent thrust within 2 seconds and 5 to 7 seconds are required to reaccelerate from 20 percent to 100 percent. According to these data, 7 to 9 seconds would be required for the engines to go from takeoff power to full reverse thrust.

1.16.3 Other Tests

The Pitot-static system, main landing gear brake assemblies, and vertical speed indicators were recovered and examined. The components of each of these systems exhibited either impact or fire damage, or both. All components tested were found to be functional.

1.17 Additional Information

1.17.1 Performance of DC-9 Stall Warning Systems

At the Safety Board's request, the Douglas Aircraft Company, Texas International Airlines, Inc., and the Federal Aviation Administration furnished the following data concerning DC-9 aircraft stall warning system performance:

> McDonnell Douglas plotted the estimated performance of a nominal stall warning system in ground effect. DC-9 stall warning charts furnished by Texas International disclosed that the stalling speed for a DC-9-14 aircraft at 87,400 lbs using 10° flap is about 125 KIAS.
>
> The plot disclosed that the stall pitch angle of the aircraft with 10° flap is 11.8°. With this flap setting, it was estimated that within the speed range of 140 to 157 KEAS, the stall warning stickshaker would activate at pitch angles of 11.8° and 11.6°, respectively. Computations show that the difference between KEAS and KIAS in this flight regime is negligible. The tail will contact with the ground at 11.8° with the shock struts fully compressed, and at 15.5° when they are extended fully.
>
> The Douglas Aircraft Company also computed the effect of vertical wind velocity on the stall warning system and produced the estimated incremental vertical wind velocity required to trigger the stall warning system. At 150 KEAS and at a pitch attitude of 5°, a vertical velocity of 30 feet/second up would be required to trigger the stickshaker. At the same airspeed and at a pitch angle of 3°, about 39 feet/second would be required for triggering the system. The performance data also disclosed that the vertical velocity components increase the angle of attack or pitch angle; this, a 30 feet/second vertical velocity component would increase the existing angle of attack by about 6.8°, and the 39 feet/second would increase it 7.8°.
>
> The manufacturer indicated that it had received occasional reports of momentary stall-warning activations, and they further disclosed that the lift tranducer was the most failure-prone component in the system. Both pilots of Flight 987 disclosed that they had observed momentary stall warning activations in the past.

Douglas determined that there are numerous possible malfunctions within the stall warning system which could cause the system to trigger immediately after the changeover from ground logic to air logic and remain operative until the system was disabled, that is either returning to ground logic or pulling the applicable circuit breaker. Among the possible malfunctions were deformation of the lift transducers or an open flap switch.

A review of DC-9 service history disclosed that there have been several cases of nuisance stall warnings reported on the DC-9-10 series aircraft. These have been, however, either of short duration or intermittent. Such warnings have stopped whenever the transient condition causing the system's activation has ceased. These transient warnings were caused by either.transient gusts or an excessively rapid rotation rate. A rotation rate of 5° per second or more is considered a rapid rotation by FAA and manufacturer's flight test personnel.

1.17.2 Texas International's Flight Training

Texas International conducts all stall training in the simulator, and the training is administered in accordance with FAA regulations and requirements. Stall training is limited to the in-flight environment. The pilot is taught that all stall warnings must be treated as valid warnings, and that the nose should be lowered, thrust applied, and the aircraft accelerated away from the stall.

Since the stall warning system is not designed to operate during the takeoff roll, 14 CFR 121 does not address itself to, or require, the company to conduct training on responses to a stall warning during this regime.

The FAA, the carrier, and the Douglas Aircraft Company were aware of the numerous false stall warnings occurring on DC-9 aircraft during takeoff. There have been no publications issued by any of these organizations discussing this phenomenon, nor do the FAA-approved airplane flight manual's emergency or abnormal procedures sections contain any discussion of this possibility or recommend crew actions for coping with such malfunctions.

Testimony was given by several pilots and a test pilot regarding the effect of the actuation of the stickshaker during rotation for takeoff on a flightcrew's rotational technique and reaction. Nearly all agreed that the rearward movement of the control column would be halted, and several indicated that they would have instinctively lowered the nose. Several pilots indicated that, based on their training, they would have rejected the takeoff. An FAA test pilot stated that his initial reaction to the stall warning would probably have been similar. However, he added that he would have checked his airspeed and since it was well beyond V_2 and well above the stall speed, he would have continued the takeoff.

1.17.3 Texas International's Emergency Evacuation Training--DC-9 Aircraft

The Safety Board examined the carrier's emergency training program and the FAA's approval of that program. Specifically, training related to the operation of the tail cone exit emergency door was examined. Examination and subsequent testimony disclosed that the carrier has been providing "hands on" training for flight attendants during their initial training over the past year, but no such training was being given as part of the recurrent training program.

One flight attendant indicated that she had never received "hands on" training on aircraft. She had operated an ovewing exit in a mockup, recalled seeing films of emergency exit operation and indicated that she was surprised at the additional force required to open the door with a slide attached. With regard to the tail cone exit, she thought that the exit release handle was shoulder high. She stated that she had never been in the tail cone of a DC-9.

One flight attendant indicated that before she worked for Texas International, she had worked for TWA and had operated aircraft exits at some time during her training. She had been in a DC-9 tail cone but not recently. She stated that her last recurrent training was largely audio-visual, but she had operated a mockup of an overwing exit.

On March 20, 1973, after a DC-9 aircraft accident where evacuation problems were encountered and fatalities occurred, the Federal Aviation Administration issued Air Carrier Operations Bulletin 73-1. (See Appendix I.) This bulletin requested that each Principal Operations Inspector review his assigned carrier's emergency evacuation training program to assure compliance with crewmembers emergency training provisions of 14 CFR 121.417. The bulletin recommended that the initial and recurrent training program provide for operation of each emergency exit by individual crewmembers either on the aircraft or on a suitable mockup.

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

Correspondence between the FAA and the Association of Flight Sttendants after the Air Carrier Operations Bulletin was issued (July and August 1974), indicates that confusion and perhaps misunderstanding of the requirements for the use of the **DC-9** tail cone exit continued. For that reason the Safety Board issued additional safety recommendations regarding emergency evacuations.

1.18 New Investigative Techniques

None

2. ANALYSIS

There was **no** evidence of any malfunction of the aircraft or its flight control system, brakes, tires, propulsion system, or antiskid system before the stall warning. The aircraft had been maintained in accordance with FAA-approved procedures, was certified properly, and was equipped properly for the flight.

The flight crewmembers were qualified to perform their assigned duties. The cabin crewmembers were not fully qualified with respect to the use of the tail cone emergency exit; although they were trained in accordance with the FAA-approved company training program.

There was **no** evidence that flightcrew performance, cabin crew performance, or any medical factors related to the flightcrew or cabin crew played a part in this accident.

The actuation of the stall warning stickshaker initiated the accident sequence. The stickshaker activated after V_2 speed had been reached and resulted in the crew's decision to reject the takeoff.

In order to determine the cause of this accident, the reasons for the actuation of the stickshaker must be determined, as well as the appropriateness of the flightcrew's reaction to the stall warning.

The flight data recorder indicates that the maximum speed reached during the takeoff was **157** KIAS. The distance required to accelerate to that speed would have been about ***6,400*** ft. The takeoff distance used together with the optimum stopping distance from **157 KIAS** results in a total necessary distance of ***10,147*** ft. Thus, the aircraft could not have been stopped on the runway. The failure of the flightcrew to deploy the spoilers during the rejected takeoff caused the aircraft to leave the runway at an increased velocity and added an estimated ***427*** ft to the necessary stopping distance.

The stall warning system of the DC-9-10(-14) is designed to warn of an impending stall after the aircraft is airborne and to eleiminate nuisance warnings during ground operation. The system is intended to be inoperative until the aircraft is rotated and the changeover from ground to air logic occurs. Since the logic changes within the first 2° of pitch attitude elevation, the system becomes operative even though the main landing gear trucks have not left the runway. It can then be activated aerodynamically or by a system component malfunction.

In the subject case, the stall warning did not begin until, or shortly after, rotation. The engines at this time were still operating at the prescribed takeoff power settings. The manufacturer's test data disclosed that a pitch angle of 11.6" to 11.8° was required to achieve and maintain an aerodynamic actuation of the warning system in the airspeed regimes of this takeoff. These angles were never achieved. Had angles approaching these pitch angles been reached during the takeoff roll, the aircraft would have become airborne. The first officer indicated that he saw 149 KIAS (V_2) before aircraft rotation was begun, and the performance data disclosed that with both engines operating and at 150 KEAS, the aircraft would have lifted off at a pitch angle of 6.8'.

Once it began, the stall warning was steady and lasted about 6.5 to 7 seconds. The testimony of the captain and the first officer tend to rule out the possibility of a rapid rotation leaving only wind gusts or vortices as possibilities for an aerodynamic activation of the stall warning system. During the 6.5 to 7 seconds that the stickshaker was activated, the aircraft's average indicated airspeed was about 154 KIAS, its pitch angle varied from 1° to perhaps as high as 7°, and it traversed about 1,645 to 1,772 feet of runway. Based on these data, incremental vertical wind velocities of from 20 feet/second at a 7° pitch angle to 47.5 feet/second at a 1° pitch angle would have been required to aerodynamically trigger the stall warning. The vertical velocity components would have had to remain steady for 6.5 to 7 seconds in a forward and upward direction to keep the lift transducers displaced to an angle sufficient to sustain the stall warning. With ambient surface winds of 6 kns, the possibility that vertical velocities of this magnitude or that a wake vortex oriented longitudinally along the runway would maintain the lift transducers in an upward and forward position for 1,645 to 1,772 feet is unlikely.

Based on the evidence, the Safety Board concludes that the stall warning was not activated aerodynamically, but resulted from a system component malfunction. Any one of numerous possible system malfunctions could have activated the stall warning at rotation. Although examination of the stall warning system components which remained intact produced no evidence of malfunction, the left wing transducer and left flap switch were destroyed in the fire and could not be tested.

At a pitch attitude of 10° with both engines operating, the aircraft would have been airborne at 136 KEAS; at 157 KEAS, about the maximum speed recorded on the FDR, the aircraft would have lifted off at a pitch angle of 5.8°. If, in fact, takeoff thrust was maintained while the aircraft was given every chance to fly, the Safety Board must conclude that the fuselage pitch angle never reached 5° with power applied; if the pitch angle ever exceeded 5°, it was after the thrust levers had been retarded to zero thrust and when the aircraft was decelerating. The CVR data substantiated these conclusions.

The movement of the throttles from the takeoff position to the full reverse position has a fixed 2-second delay. This delay is imposed by an interlock at the reverse position which prevents application of reverse thrust until the reversers are unstowed and extended. The consensus of the Douglas Aircraft Company pilots and an FAA test pilot was that 1 second would be a reasonable time interval for moving the throttles from the takeoff to the reverse position; another second would be needed to move them from reverse idle to the full reverse thrust position. Consequently, about 4 seconds would be required to physically move the throttles from the takeoff position to the full reverse thrust position.

The engine response data curve disclosed that the engine will decelerate from 100 percent to 20 percent thrust in 2 seconds after throttle retardation, and from 20 percent to idle in 4 more seconds. About 5 to 7 seconds would be required to reaccelerate the engines to maximum reverse thrust.

The flightcrew stated that they rejected the takeoff after the actuation of the stickshaker. The sound of increasing engine power on the CVR must be reverse thrust, since there is no reason to believe that the sound of increased power heard on the CVR 7 seconds after stickshaker actuation was a reapplication of forward thrust. Power rose simultaneously with the cessation of the stickshaker. Since at least 2 seconds must elapse before reverse thrust can be applied, the engines must have spooled down to some thrust value at or below 20 percent. No estimate has been made of what thrust levels must be attained before the reverse thrust sounds are picked up by the cockpit area microphones, but it is logical to assume that it is some value above 20 percent, and that a delay of 1 to 2 seconds after the application of reverse thrust would have ensued before this value was achieved. Since the physical movement of the throttles from the takeoff to the full reverse thrust position would require about 4 seconds, it seems logical to assume that the time interim from the first movement of the throttles from the takeoff position to the sound of the rising reverse thrust encompassed 5 to 6 seconds, and that the throttles were moved aft within 1 to 2 seconds after the onset of the stall warning. Based on these data, the Safety Board concludes that rotation —ith takeoff thrust applied lasted only 2 to 3 seconds and further concludes that the aircraft never achieved a pitch angle sufficient to permit liftoff.

An FAA test pilot testified that he believed that, because of training, a pilot's response to the stickshaker would, momentarily, be instinctive; and, that the instinctive reaction would be to lower the aircraft's nose, or in this instance, either hold the present attitude or reduce the rate of rotation.

Flightcrew training relative to stall warning response is limited to the in-flight environment. Texas International flightcrews are trained to respond to the stall warning by lowering the nose and applying power and to try to avert the stall. Flightcrews are also trained that the warning is not to be ignored. Flight manuals do not contain any discussions of possible malfunctions that could activate a stall warning. Despite the instances of false stall warnings on takeoffs, there have been no publications or warnings issued.

The Board does not believe that the publication of rigid procedures is feasible because of possible variations in aircraft configurations, or system malfunctions which could activate the stall warning system. Based on runway conditions, runway environment, and other relevant factors, the flightcrew should exercise their best judgment.

Both pilots had experienced nuisance warnings on takeoff on previous occasions. However. in these cases the warnings were of short duration. In the incident case, the warning, once it became activated remained activated without interruption for almost 7 seconds. Both pilots were aware that they were well above V_1 speed and well above stall speed. The steady and persistent nature of the warning convinced them that it was a valid warning, that something serious was wrong, and that the aircraft would not fly. Although, in retrospect, it is evident that the aircraft would have lifted off normally, had rotation to the proper pitch angle been continued, the persistence of the stickshaker caused the crew to perceive this as a valid warning. The Safety Board believes that pilots have a right to rely on mandatory warning systems and are trained to do so. Therefore, their choice was to either accept an inevitable overrun accident or to continue a takeoff in an aircraft that was warning that it was not capable of continued flight.

This was a survivable accident. The occupiable area of the aircraft was totally intact; the only danger to the occupants was during the evacuation. There was no evidence that fire entered the cabin before the evacuation; however, white smoke was present in the cabin but smoke had no effect on passenger survivability.

Several problems were identified in this accident with regard to the DC-9 tail cone exit; specifically, emergency evacuation training, emergency lighting, evacuation slide installation, passenger information, and exit inspection procedures were inadequate.

v

The Texas International Airlines FAA-approved flight attendant manual specifies that the "executive flight attendant" will insure that all emergency equipment and exits are checked. The executive flight attendant on Flight 987 had been with the company for 7 years and had never been in the tail cone area of a DC-9. After the accident, 10 line flight attendants were asked about their knowledge and experience with DC-9 tail cone exit and all indicated that they had never been in the tail cone of a DC-9. Consequently, the tail cone exit may only be checked when required maintenance is performed in the exit area. The exit on this flight was improperly rigged and the deficiency was never detected and may not have been detected until scheduled maintenance operations.

With regard to emergency evacuation training, the flightcrews receive actual "hands on" training. Pilot emergency evacuation training, although conducted by the same training department, is not conducted by the same instructors; therefore, the content varies. The pilots on Flight 987 were more familiar with the proper operation of the exits than were the flight attendants.

Testimony by the training instructor and two flight attendants on board Flight 987 disclosed training deficiencies. With regard to recurrent training, the flight attendants do not receive "hands on" training. In fact, flight attendants interviewed had considerable tenure with the company and had never operated an exit with an emergency evacuation slide attached or been in the tail cone area of the DC-9 and operated the exit. While the flight attendants involved in the accident certified in their training records that they had operated all exits and had the required training to do so, their actual experience and training did not meet practical requirements. With regard to the DC-9 tail cone exit, the most recent recurrent training had included the operation of a mockup of the tail cone release handle. The fact that the mockup was used in a well-lighted classroom and was not accompanied with a visit to the tail cone of an actual aircraft appears to be in conflict with the guidelines contained in Air Carrier Operations Bulletin 76-1. (See Appendix I.) Since flight attendants did not receive recurrent training under realistic conditions, such as under emergency lighting conditions, they may develop unrealistic perceptions of what to expect under actual emergency conditions.

Since the handle was a dark color and was located outside of the illuminated area of the emergency lights, the flight attendant was unable to find the handle quickly. The key element in the tail cone emergency system is the tail cone release handle--nothing works unless the handle is pulled and the tail cone is released. The tail cone release handle should be self-illuminating or an emergency light should be placed close to illuminate the handle. The Safety Board believes that the current configuration of the exit release is inadequate for effective and efficient use of the exit system.

The Safety Board is concerned about the fact that a serious deficiency such as an inaccurate or incomplete passenger information card was identified in an accident involving a DC-9 operator in 1972 and was identified again, almost 5 years later, in this accident. Had critical safety information regarding the North Central accident been properly disseminated by FAA inspectors, many of the evacuation problems encountered in this accident would have been avoided.

3. CONCLUSIONS

3.1 Findings

1. The takeoff operation was normal until the stall warning activated.

2. The stall warning remained activated for more than 6 seconds.

3. The DC-9 stall warning systems had a history of several nuisance warnings.

4. There was no aerodynamic cause for the stall warnings.

5. Aircraft performance was normal.

6. The nose was lowered and the thrust levers were retarded after the stickshaker was activated.

7. Takeoff pitch attitude was not attained and, consequently, the aircraft did not become airborne.

8. Although the crew initiated takeoff rejection within 2 seconds after stickshaker actuation by retarding the power levers, they did not employ maximum braking immediately or deploy ground spoilers.

9. The aircraft had accelerated beyond V_2 speed when the takeoff was rejected.

10. Pilot training did not include the response to stall warnings activation while aircraft are on the ground.

11. Evacuation of passengers was rapid even though cabin crew evacuation training regarding the use of the tail cone exit was inadequate.

12. The aircraft was damaged when it left the runway, traversed terrain depressions, and struck approach light stanchions.

13. Passenger information cards regarding tail cone exit data did not comply with regulations.

3.2 Probable Cause

The National Transportation Safety Board determines that the probable cause of this accident was a malfunction of the stall warning system for undetermined reasons which resulted in a false stall warning and an unsuccessful attempt to reject the takeoff after the aircraft had accelerated beyond refusal and rotation speeds.

The decision to reject the takeoff, although not consistent with standard operating procedures and training, was reasonable in this instant case, based upon the unusual circumstances in which the crew found themselves, the minimal time available for decision, and the crew's judgment concerning a potentially catastrophic situation.

4. SAFETY RECOMMENDATIONS

On May 23, 1977, the National Transportation Safety Board recommended that the Federal Aviation Administration:

> Require that the emergency evacuation training program of all DC-9 operators comply with the intent of 14 CFR 121.417, specifically with regard to training in the operation of the tail cone exit. (A-77-26)
>
> Insure that safety information, which is developed and disseminated as a result of accident experience, receives the proper attention from principal air carrier inspectors and operators of similar equipment and that they comply with directives related to such information. (A-77-27)
>
> Issue an Air Carrier Operations Bulletin clarifying the designation of the DC-9 tail cone exit as a required exit and requiring that principal operations inspectors assigned to DC-9 operators insure that their assigned air carriers provide instructions in their passenger briefings and on their passenger information cards on the availability and operation of the tail cone exit as an emergency exit. (A-77-28)
>
> Issue an Airworthiness Directive to require that an emergency light source be located in close proximity to the DC-9 tail cone release handle or that the handle be self-illuminating. (A-77-29)

Additional recommendations were issued by the Safety Board to improve the level of safety of airports certificated under 14 CFR 139 to:

Amend 14 CFR 139.45 to require, after a reasonable date, that extended runway safety area criteria be applied retroactively to all certificated airports. At those airports which cannot meet the full criteria, the extended runway safety area should be as close to the full 1,000-foot length as possible.

Expedite the retrofit of ALS structures with frangible materials and fittings by allocating additional fundings or by increasing the priority of the existing program so that it can be completed within 3 to 5 years.

On August 10, 1977, the Administrator of the Federal Aviation Administration issued the following responses to our recommendations:

"A-77-26.

"Comment. The third paragraph of the material supporting the recommendations acknowledges that Texas International Airlines (TXI) has been providing its flight attendants with hands-on training in the use of emergency exits during initial training for the past year. It also states that this hands-on training had not been incorporated into the recurrent training program.

"The Federal Aviation Administration Principal Operations Inspector met with TXI management in August 1973 and discussed the NTSB report of the North Central Airlines Accident issued in July and FAA Air Carrier Operations Bulletin (ACOB) 73-1 dated May 7, 1973.

"The flight attendant training program was changed to require hands-on training on all emergency exits including the tail cone exit. Initial training in the operation of the tail cone exit was accomplished using a realistic mockup, a pictorial presentation and actual demonstration on the airplane. Recurrent training included operation of the tail cone exit mockup and observing a pictorial presentation. There was no requirement for observation of an actual demonstration in the airplane since the mockup was considered realistic.

The TXI recurrent training program was revised this year to include hands-on training in emergency lighting conditions on the operation of the tail cone exit in the airplane. This is in addition to training in the mockup and observation of a Douglas Aircraft Company film of the operation of the tail cone exit. All TXI flight attendants had completed the revised recurrent training by May 1977.

"ACOB 8-74-76, Crewmember Emergency Training, provides guidance to our field personnel concerning policy with regard to emergency training as specified in 14 CFR 121.417 (c)(2) and (4).

"Inspections of air carrier flight attendant training programs were conducted in January 1977. All were found in compliance with 14 CFR 121.417.

"Notice of Proposed Rule Making 77-12 was published in the Federal Register on July 21 as a result of the FAA Operations Review Conference. This proposal specifies that initial and recurrent training for each crewmember will be required on each type of aircraft in which they serve. Actual operation of emergency exits, fire extinguishers and oxygen bottles are included as are instructions on the additional forces which will be encountered due to unusual cabin deck angle, high winds and structural deformation."

"A-77-27.

"Comment. The FAA has had an effective procedure for some time for timely issuance of instructions to field and regional offices which relate to safety matters in air carrier operations. Immediate notification is by telegram. Less urgent matters are handled by ACOB's. A followup system to provide regions and headquarters with feedback concerning industry actions is used when appropriate. We have included a requirement for review of accident information in training programs in the proposal noted above."

"A-77-28.

"Comment. FAA regional offices were notified by letter of March 7 that the tail cone exit on all models of the Douglas DC-9 is a required exit. They were requested to ensure assigned carriers include reference to the exit in the oral briefing and on the passenger information cards as required by 14 CFR 121.571."

"A-77-29.

"Comment. We have reviewed the design and consider that the lighting conditions in proximity to the release handle are adequate."

On August 18, 1977, the Federal Aviation Administration issued a Proposed Airworthiness Directive that requires better marking of the tail cone exit area. This proposal was issued in regard to Safety Board Recommendation A-77-29.

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

/s/ KAY BAILEY
Acting Chairman

/s/ FRANCIS H. McADAMS
Member

/s/ PHILIP A. HOGUE
Member

/s/ JAMES B. KING
Member

October 27, 1977

5. APPENDIXES

APPENDIX A

INVESTIGATION AND DEPOSITIONS

1. Investigation

At 1945 e.s.t. on November 16, 1976, the National Transportation Safety Board was notified of the accident by the FAA Communications Center in Washington, D.C.

An investigation team was dispatched immediately to Stapleton International Airport, Denver, Colorado. Working groups were established for operations, airports/crash-rescue, human factors, structures, systems, powerplants, air traffic control, witnesses, weather, aircraft performance, aircraft records, cockpit voice recorder, and flight data recorder.

The Federal Aviation Administration, McDonnell Douglas Aircraft Company, Texas International Airlines, Air Line Pilots Association, Pratt & Whitney Aircraft Group of United Technologies, Association of Flight Attendants, International Association of Machinists, and the City of Denver participated in the investigation.

2. Depositions

Depositions were taken in Denver, Colorado, Los Angeles, California, and Houston, Texas, on January 19 and 20, February 7, 9 and 10, 1977. Parties to the depositions included the FAA, McDonnell Douglas Aircraft Company, Texas International Airlines, the City of Denver, Airline Pilots Association, and the Association of Flight Attendants.

APPENDIX B

PERSONNEL INFORMATION

Captain Robert B. McMurry

Captain Robert B. McMurry, 42, was hired by Texas International Airlines on July 27, 1959. He has an Airline Transport Pilot Certificate No. 1347211 with an airplane multiengine land (AMEL) rating and type ratings in Douglas DC-3, DC-9, Convair CV 240, 340, 440, 600, and 640 aircraft. He also has commercial privileges in aircraft single engine land (ASEL) aircraft. He had a first class medical certificate dated November 4, 1976, with no waivers and had completed recurrent ground training on August 25, 1976, and February 13, 1976. His last two line checks were flown on November 10, and June 14, 1976. His last two proficiency checks were given and passed on May 15, 1976, and December 11, 1975.

Texas International Airlines proficiency checks are given in a flight simulator instead of an aircraft. In order to complete the check a captain must make two landings under supervision of a check airman, and this is generally accomplished on a line check. (First officer landings may be made under the supervision of a qualified captain.) The required line check form which contains the record of the captain's landings during the December 11, 1975, proficiency check was missing from his training folder, as the result of an administrative error. According to the company's training department only the last two line check forms are maintained in an airman's training folder. The captain was scheduled for a proficiency check during November 1976. His line check was given on November 10, 1976, and his simulator check was scheduled for the latter part of November 1976, after the date of the accident.

Captain McMurry had about 15,000 flight hours, of which about 651 hours were in the DC-9. He had flown 140 hours, 50 hours, and about 6 hours 45 minutes during the previous 90 days, 30 days, and 24 hours, respectively.

Captain McMurry had been off duty for 24 hours before reporting for duty at 2015 c.s.t. on November 15, 1976, in Houston, Texas. He departed Houston, Texas, at 2115 c.s.t. and flew to Monterey, Mexico, arriving there at 2222 c.s.t. He had 9 hours 5 minutes off duty time before reporting for duty in Monterey, Mexico, for the sequence of flights leading to the accident. The flight sequence was as follows: Monterey, Mexico, to Houston, Texas: Houston, Texas, to Denver: Denver to Salt Lake City: and Salt Lake City to Denver. At the time of the accident the captain had been on duty about 11 hours, of which about 5 hours 37 minutes were in flight time.

First Officer John E. Howell

First Officer John E. Howell, aged 37, was employed by Texas International December 12, 1965. He has an Airline Transport Certificate No. 1527755 with aircraft multiengine land, and aircraft single-engine land ratings. He has no type ratings. First Officer Howell has a first class medical certificate dated April 22, 1976, with a waiver for hearing loss (Waiver 40 I 77315). He completed recurrent ground training on February 2, and August 23, 1976. His last two proficiency checks were completed May 25, 1976, and April 11, 1975, and his last line check was given on June 18, 1976. The first officer had about 8,400 flight hours, of which about 4,000 hours were in the DC-9. He had flown 200 hours, 66 hours, and 6 hours 45 minutes during the last 90 days, 30 days, and 24 hours, respectively.

First Officer Howell had been off duty about 24 hours before reporting to duty at Houston, Texas, on November 15, 1976, at 2015 c.s.t. His flight, duty, and off duty times thereafter are identical to those of the captain.

Flight Attendant Information

Gayle Blasingame

Mrs. Gayle Blasingame was hired by Texas International Airlines in 1962. She completed her initial training in the DC-9 on July 2, 1968. Her last recurrent training was April 20, 1976. During that training she operated a DC-9 door without a slide attached, a DC-9 window exit in a mockup, and a mockup of the DC-9 tail cone exit release handle.

Ruth Ann Harris

Mrs. Ruth Ann Harris was hired by Texas International Airlines in 1969. She completed her initial training in the DC-9 on May 27, 1969. Her last recurrent training was on June 3, 1976. During her training she operated a DC-9 door without a slide attached, a DC-9 window exit in a mockup, and a mockup of the DC-9 tail cone exit release handle.

Yolanda Coroy

Mrs. Yolanda Coroy was hired by Texas International Airlines in 1971 and completed her initial training in the DC-9 on July 8, 1971. She had previously been a flight attendant with TWA. She completed her last recurrent training on April 2, 1976. During her training she operated a DC-9 door without a slide attached, a DC-9 window exit mockup, and a mockup of the DC-9 tail cone exit release handle.

APPENDIX C

AIRCRAFT INFORMATION

The aircraft, a Douglas DC-9-14, United States Registry N9104, was manufactured by McDonnell Douglas Company at Long Beach, California, on August 19, 1967.

It was accepted by Hughes Airwest on August 23, 1967. The aircraft was purchased from Hughes Airwest by Texas International Airlines on October 24, 1975. The aircraft had accumulated a total of 21,500 hours at the time of purchase.

N9104 had accumulated a total flight time of 24,333 hours at the time of the accident.

Texas International Airlines, Inc., is authorized to utilize the provisions of the maintenance reliability programs which contain the standards for determining time limitations. All checks had been performed according to prescribed maintenance schedules.

N9104 was equipped with a Pratt & Whitney JT8D-7A left engine and a JT8D-7B right engine.

Engine Position	No. 1	No. 2
Serial No.	653523	657078
Total Time	22,091:00 hours	18,626:00 hours
Total Cycles	25,204	25,606
Date Installed	February 5, 1976	October 20, 1975
Time Since Installation	2,198:00 hours	2,838 hours
Cycles Since Installation	2,745	3,644

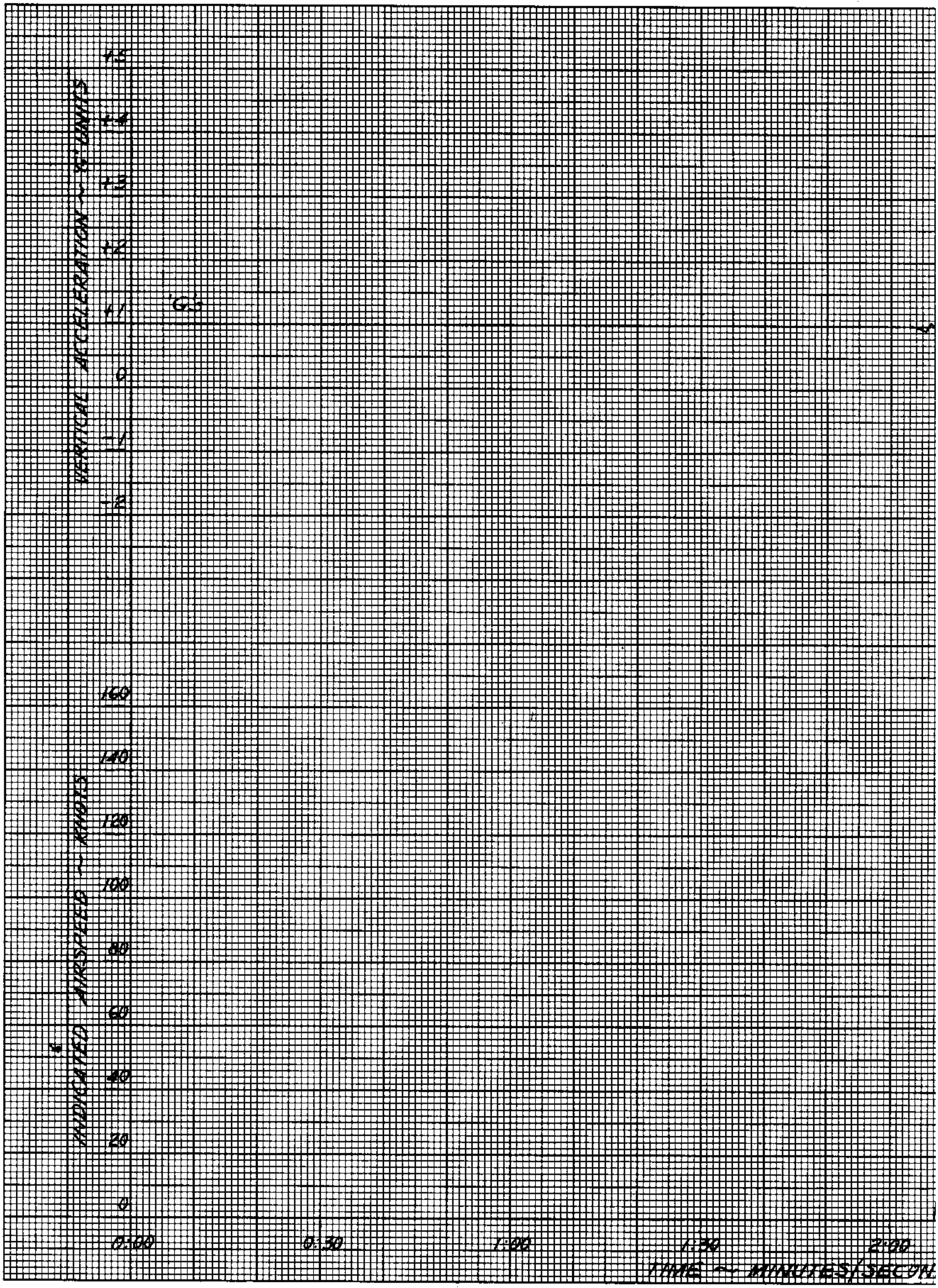
The aircraft was weighed June 6, 1976. The empty weight was 49,784 pounds to which 1,808 pounds of operational items were added. This produced an OEW of 51,592 pounds, and this value was rounded out to 51,590 pounds for use on Form 374-A, the Texas International Airline's Weight and Balance Form.

The baggage, cargo, and carryon luggage were recovered after the accident, segregated by stowage area, and weighed. The following baggage and cargo weights were recorded:

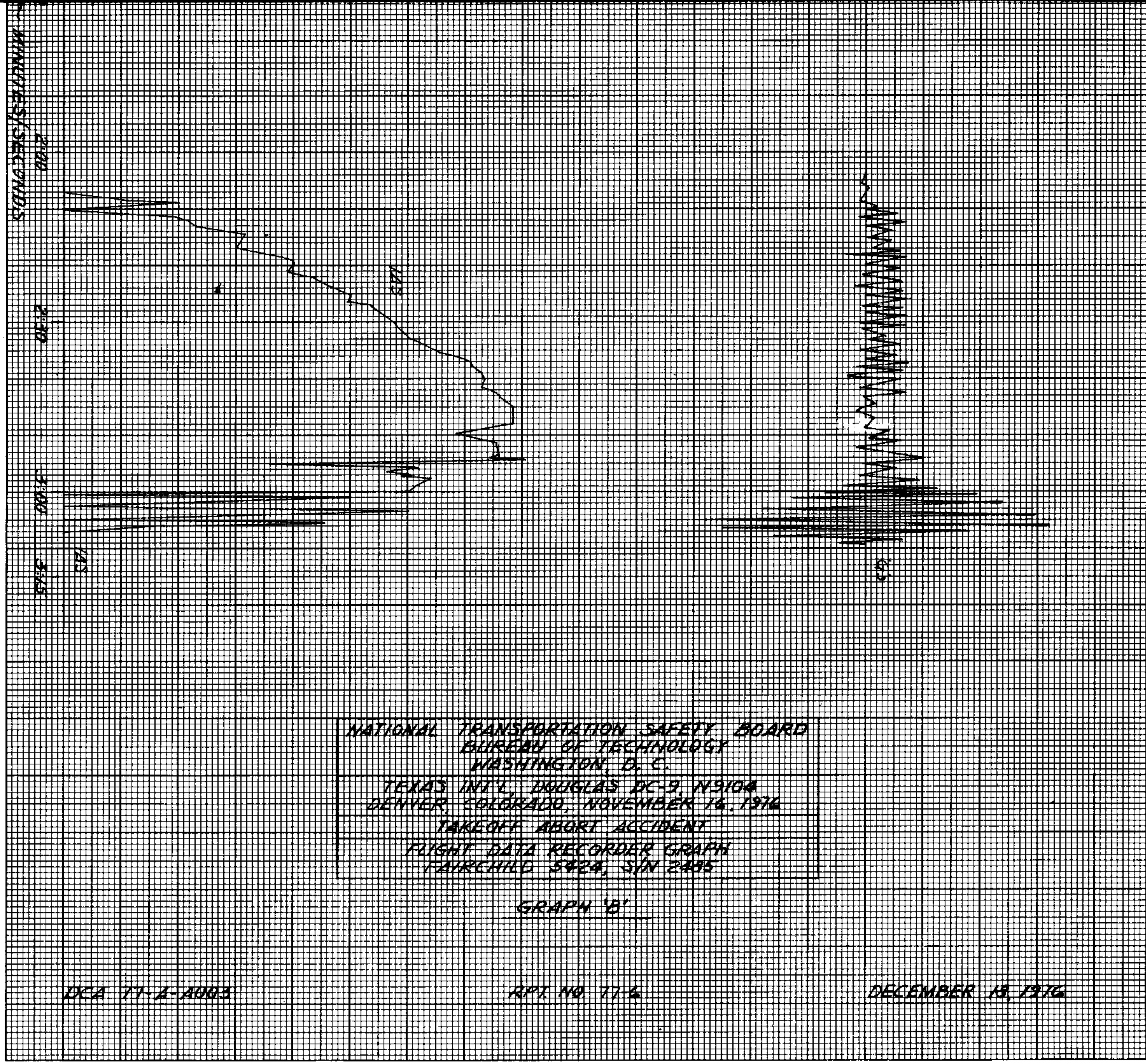
	lbs
Forward cargo bin:	2,447
Aft cargo bin :	1 756
Total	4,203

The actual baggage and cargo weight exceeded the weight noted on the company's weight and balance Form 374-A by **180** lbs.

The aircraft's takeoff gross weight and c.g. were computed three times using the actual arms and moments for the various loads, as well as index numbers. The weights noted on the Form 374-A were used for the first computation, and these values produced a c.g. of 19.24 percent MAC (mean aerodynamic chord). A second computation was made using the actual weights of the recovered cargo and baggage and this produced a c.g. of 20.25 percent MAC.


VERTICAL ACCELERATION ~ 'G' UNITS
+5
+4
+3
+2
+1
0
-1
-2
G-5
INDICATED AIRSPEED ~ KNOTS
160
140
120
100
80
60
40
20
0
0:00
0:30
1:00
1:30
2:00
TIME ~ MINUTES/SECON

APPENDIX D


MINUTES/SECONDS
2:00
2:30
3:00
3:15
IAS
IAS
GS
NATIONAL TRANSPORTATION SAFETY BOARD
BUREAU OF TECHNOLOGY
WASHINGTON, D. C.
TEXAS INT'L DOUGLAS DC-9, N9104
DENVER, COLORADO, NOVEMBER 16, 1976
TAKEOFF ABORT ACCIDENT
FLIGHT DATA RECORDER GRAPH
FAIRCHILD 5424, S/N 2485
GRAPH 'B'
DCA 77-A-A003
RPT NO 77-6
DECEMBER 18, 1976

APPENDIX E

TIME & SOURCE	CONTENT
CAM-1	I mean if we get in a tight, it's not like being, you know, not having a place to go
CAM-?	We are ready
TWR* & C782	((Conversation))
29:13 TWR	Nine eighty-seven cleared for takeoff
29:16 ROO-1	Rolling
29:18 CAM	((Increasing engine noise))
29:23 CAM-1	((Peaking power)) Okay your * stable left and right
29:27 CAM-1	Power checks * *
29:30 TWR	Lear nine lima serria taxi into position and hold
29:33 LS	Lima serria position and hold
CAM-2	Gonna take a lotta runway I'm afraid
29:34 TWR	Nine two tango, are you behind the Lear
29:37 CAM-?	Okay, oil pressure *
29:38 79LS	Seven nine lima serria's a Lear Jet
29:40 CAM-1	Temperatures
29:41 TWR	Seven nine lima serria, I've got you position and hold eight right
29:43 CAM-1	All normal
29:44 CAM-?	So's the airspeed --- normal *

TIME & SOURCE	CONTENT
29:45 79LS	Roger
29:45 TWR	Okay nine two tango, Denver how do you hear?
29:47 CAM-1	Through a hundred
29:48 IJ	One Juliet do you have traffic in front of you there or are you behind the Lear?
29:52 41J	Four one Juliet, we have traffic ahead of us
29:54 2T	Okay, nine two tango Denver how do you hear?
29:56 CAM-1	Okay there's a hundred and thirty
29:59 CAM-1	Vee one
30:00 CAM-1	Vee R
30:02 CAM-1	Vee two
30:04.5 CAM	((Sound of stall warning))
CAM-?	* *
30:08 CAM	((End of stall warning))
30:09 CAM	((Start of stall warning))
30:11 CAM	((End of stall warning))
30:11 CAM	((Sound of roar))
30:18 CAM	((Sound of multiple clicks))

TIME & SOURCE	CONTENT
30:21 CAM	((Sound similar to debris flying around the cockpit and impact with objects))
30:27 CAM-1	Broke the (power)
30:28 CAM-2	Shut it off
CAM-2	Shut it off
CAM-2	Get em off
30:31 CAM	((Sound of engine unspooling))
30:36 CAM-1	Get the doors open and get the emergency exits
30:38 CAM	((End of recording))

APPENDIX F

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

DATE: AB 1

NATIONAL AVIATION FACILITIES
EXPERIMENTAL CENTER
ATLANTIC CITY, NEW JERSEY 08405

IN REPLY REFER TO:

SUBJECT: Analysis of B-727 vortex wake as related to Texas International DC-9 accident, Denver, Colorado, November 16, 1976; NTSB letter dated January 19, 1977

FROM: Director, ANA-I

TO Mr. Charles A. Fluet
Laboratory Services Division
National Transportation Safety Board
800 Independence Avenue, S.W.
Washington, D. C. 20594

Enclosed hereto as Enclosure 1 is an analysis of the Braniff B-727 vortex wake as related to the Texas International DC-9 accident which occurred at Stapleton International Airport on November 16, 1976. We are pleased that we are in a position to respond to your request with data obtained from actual full-scale vortex flight tests performed by NAFEC over the last 9 years. If we can be of any further assistance, please let us know.

ROBERT L. FAITH

Enclosure

ENCLOSURE 1

Analysis of B-727 Vortex Wake as Related to
Texas International DC-9 Accident. Denver, Colorado
November 16, 1976

We have reviewed our full-scale B-727 vortex flight test data and reports and confirmed our earlier opinions. discussed over. the phone with NTSB, that for the accident under consideration, it is concluded that the probability is extremely low for a vortex encounter by the Texas International DC-9-14 during its takeoff roll at Denver. Considered in our review and re-analysis of our data were B-727 vortex characteristics, persistence and movement through space as follows.

The reviewed B-727 data includes over 120 "tower fly-bys" (flying by the NAFEC vortex test tower and the ESSA meteorological tower at the AEC site, Idaho Falls, Idaho), vortex flow visualization photographic and video coverage and in-flight penetrations. Most of our B-727 flight test data was acquired in close proximity to the ground at altitudes less than 300 feet above ground level (AGL).

Vortex Characteristics: In terms of peak tangential velocities (rotational speeds). the Boeing 727 wake is more intense than that of some larger. heavier airplanes of different design configuration, e. g. , Boeing 747. However, the high peak velocities are always associated with a very small core and a rapid drop in velocity external to the core and the core radius is very small, approximately one foot. The net effect of the small core and rapid drop-off in tangential velocity with radial distance is to diminish the field of influence of a vortex and, as a result, the influence of one vortex on the other including descent velocity as discussed in the following sections.

Vortex Persistence: Fortunately for the B-727 airplane we have vortex flight test data acquired at various altitude levels, from sea level to about 12,000 feet pressure altitude, although the majority of our data was acquired at low altitudes. Included are data runs wherein the B-727 was in climbing flight simulating a departure right after takeoff and approaches to a landing or waveoff. For the takeoff configuration, with landing flaps at $\delta_F = 15^\circ$, the vortex "age" was found to be less than 90 seconds for both the tower fly-by data and 700-900 feet AGL flow visualization data. The tower fly-by data persistence determination is based on both recorded data and flow visualization coverage. At higher altitudes, greater than 5.000 feet AGL, it was found that the vortices did persist somewhat longer.

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The predominant mode of decay for the B-727 vortex system was found to be vortex breakdown (or bursting). This is noted as a sudden growth of individual core diameter followed by spiral filament flow around the enlarged core and subsequent rapid core disintegration, the whole event taking about 5 seconds to complete after initiation. (We have numerous still and motion picture coverage depicting this phenomenon which can be made available to you if you so desire, including flyovers by the B-727 at about 800 feet above the ground and in three configurations: landing with $\delta_F = 30^\circ$, takeoff with $\delta_F = 15^\circ$, and holding with $\delta_F = 0^\circ$.)

Vortex Movement: For the operational and meteorological conditions at the time of the accident, we considered both vertical and horizontal vortex movement. It is conceded that the wind speed and direction between the ground and the flight altitude of the B-727 cannot be accurately determined., Accordingly, certain assumptions had to be made in this respect.

Vertical Movement: For the B-727 airplane at G.W. ≈ 137.500 pounds, indicated airspeed = 184 knots, true airspeed ≈ 202 knots (temperature = $2^\circ C$ and density = .0019626 slugs/ft^3, altitude of 6,450 feet msl) the vortex initial descent velocity was calculated to be approximately 4.5 ft/sec using classical potential flow theory which assumes an elliptical lift distribution on the wing. Our flight test data from the tower indicates an initial descent velocity of about 5.3 ft/sec for the takeoff configuratibn. As the vortex becomes "older," the tangential velocities decrease and likewise the descent velocity. The longest recorded time-history for a vortex for the airplane in the 15° configuration, we have the descent velocity averaging 2 ft/sec for its life span. Being conservative and using a vortex life span of 120 seconds, at the most, and an average descent velocity of 4 ft/sec, the B-727 vortex system would, at the most. descend about 480 feet. Flight test data acquired jointly with NASA at the Dryden Flight Research Center, Edwards, California, wherein we tracked the descent path of the B-727 vortex revealed and we concluded: "The vortices from the Boeing 727 tend to settle approximately 300 feet below the flight path of the aircraft and then stop descending."

Lateral Movement: The recorded surface wind for Stapleton at the time of the accident was 140° true at 7 knots. The Denver magnetic variation is noted to be about 13°E. Accordingly, the surface wind at the time of the accident would have been about 127°M at 7 knots. The 6,000-foot msl wind was listed at 150° true (137°M) at one knot based

3

on radiosonde data. Assuming a mean wind direction of. 132°M and speed of 4 knots. between these two altitudes, the component in the direction of the runway being used by the DC-9, Runway 8R-26L would be 2.46 knots, or approximately 2.5 knots (4.2 ft/sec) in the direction of 260°M. Again, assuming a maximum B-727 vortex persistence of 120 seconds for this situation, we have the vortices moving to the west and for a maximum distance of about 504 feet. Accordingly, based on the plan view schematic provided with your letter, it is improbable that the vortices would be in the vicinity of the DC-9 at stick shaker initiation. Even if the vortices persisted, for whatever reason, for the 3-minute 18-second separation time interval cited for the two airplanes, the vortex system would have proceeded 832 feet downwind of the intersection of the B-727 flight path projected on Runway 8R-26L. And for this time interval, the vortex system still would have only descended 792 feet below the B-727's flight path and be 358 feet above the ground.

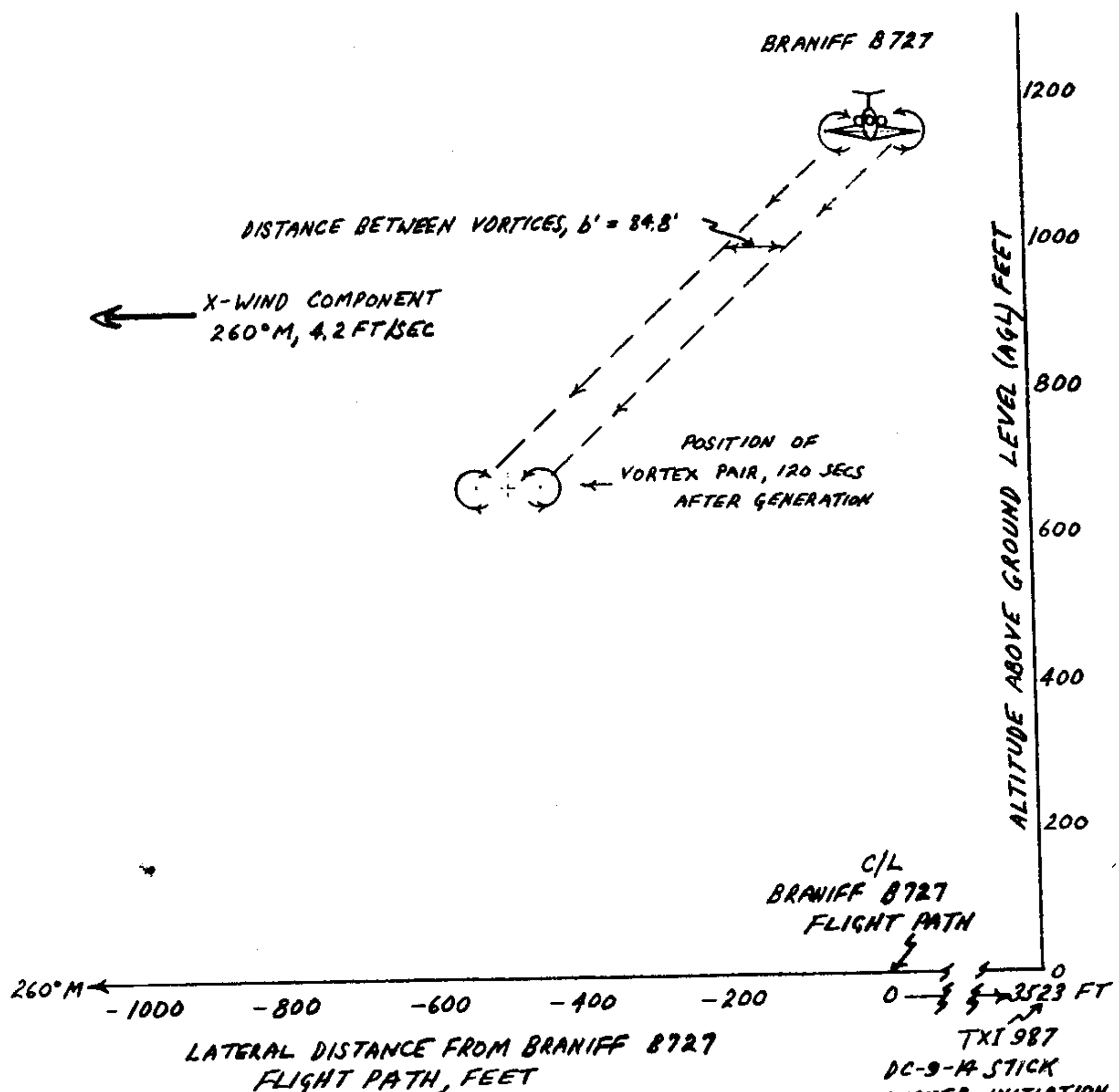
Summary: The probability is extremely low that the Braniff B-727 vortices could have impinged upon the Texas International DC-9 because: (1) based on the best available data to date, it has been found that the B-727 vortices persist at lower altitudes for less than 120 seconds which is less than the separation time between the flight path intersection for the two aircraft; (2) even if they did, for whatever reason. it is extremely unlikely that they would have descended to the level of the DC-9 airplane taking off or create a problem; and (3) regardless of the separation time interval between the two aircraft, assuming valid assumptions on wind speed and direction from the B-727's flight altitude to the surface, the B-727 vortices are drifting downwind of the projected flight path intersection of the two airplanes which is another 3,523 feet downwind of the DC-9 stick shaker initiation position.

References:

Garode, Leo J., Lawrence, D. M., and Miller, N. J., "The Measurement of the Boeing 727 Trailing Vortex System Using the Tower Fly-By Technique," Report No. FAA-RD-74-90, August 1974.

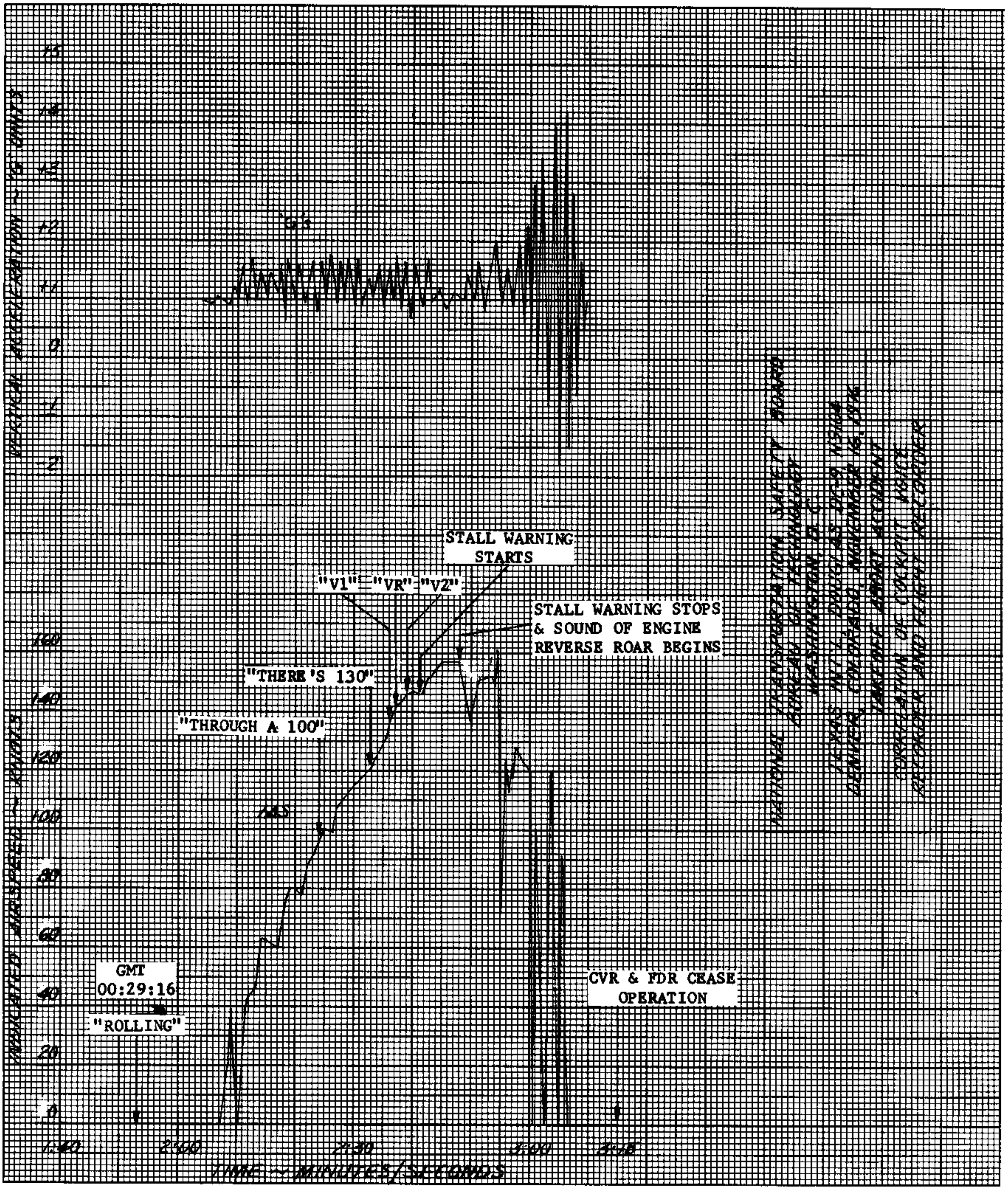
Garode, Leo J. (NAFEC), Barber, M.R. (NASA-FRC), and Kurkowski, R. L. (NASA-ARC), "Flight Test Investigation of the Vortex Wake Characteristics Behind a Boeing 727 During Two-Segment and Normal ILS Approaches," Report No. FAA-NA-25-151. October 1975.

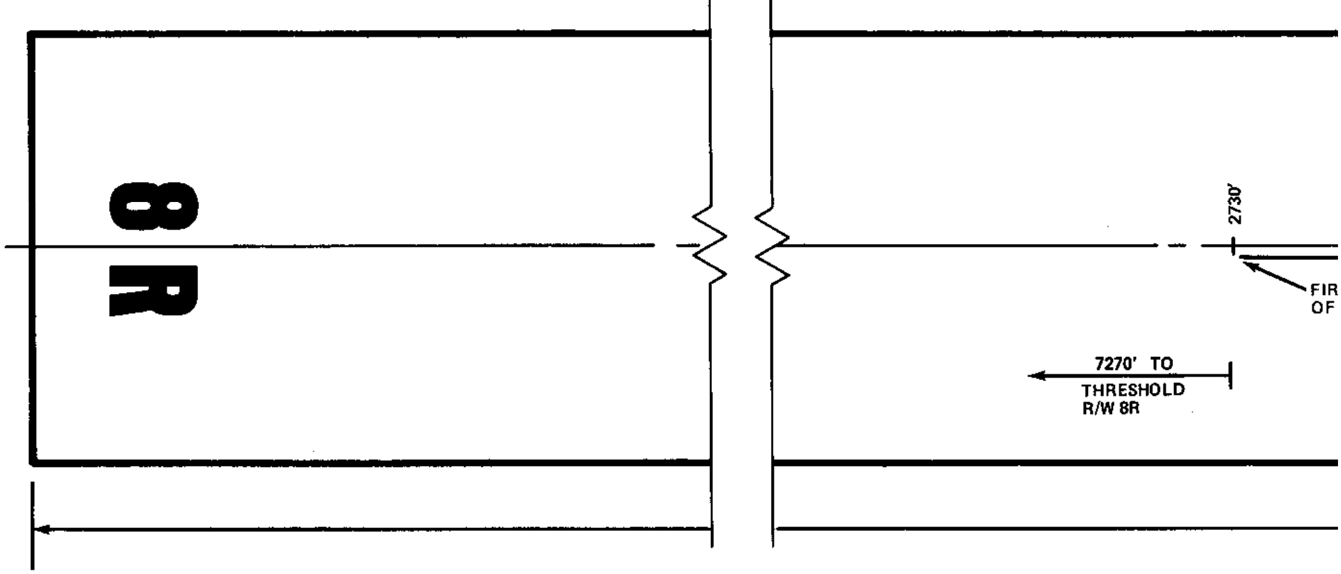
FIGURE 1
BRANIFF FLIGHT 928 - B727-100 - VORTEX TRAJECTORY - NOV 16, 1976
RELATED TO RWY 8R-26L, COMMON FLIGHT PATH POINT
B727 ¢ TXI DC 9-14 (B727 PROJECTED TO GROUND)
STAPLETON INT'L AIRPORT

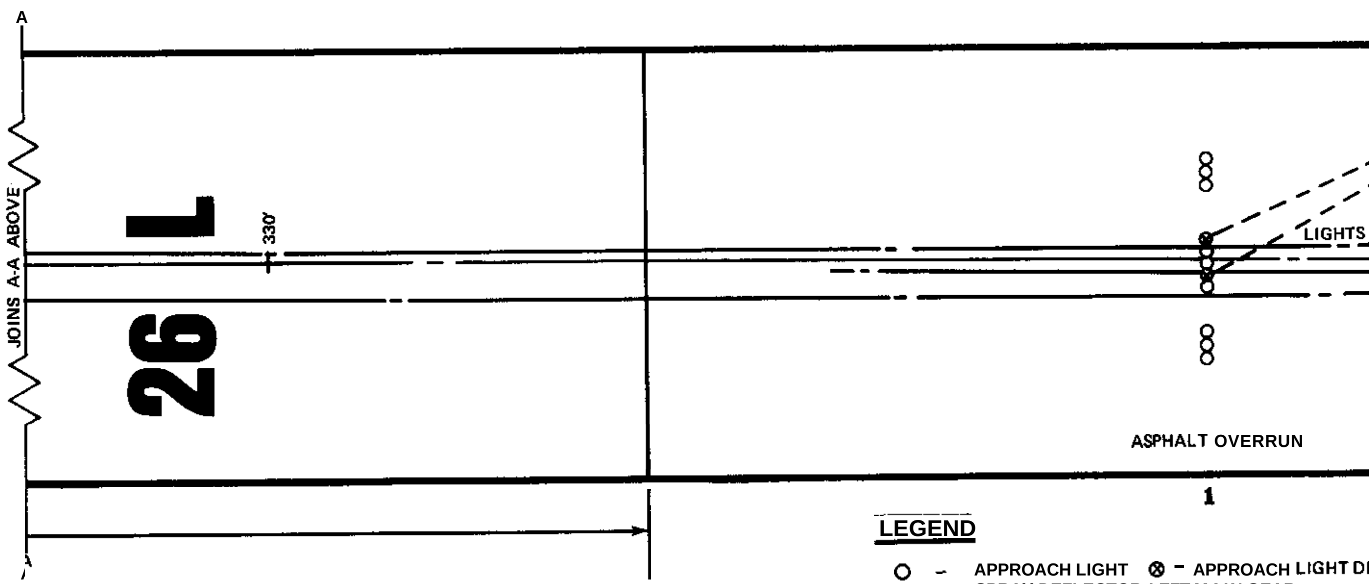


(LEO J. GARODZ, 2/3/77)

APPENDIX G


VERTICAL ACCELERATION ~ 'G' UNITS
'G's
INDICATED AIRSPEED ~ KNOTS
IAS
TIME ~ MINUTES/SECONDS
1:40
2:00
2:30
3:00
3:16
STALL WARNING STARTS
"V1" "VR" "V2"
STALL WARNING STOPS & SOUND OF ENGINE REVERSE ROAR BEGINS
"THERE'S 130"
"THROUGH A 100"
GMT 00:29:16
"ROLLING"
CVR & FDR CEASE OPERATION
NATIONAL TRANSPORTATION SAFETY BOARD
BUREAU OF TECHNOLOGY
WASHINGTON, D.C.
TAKEOFF ABORT ACCIDENT
CORRELATION OF COCKPIT VOICE
RECORDER AND FLIGHT RECORDER



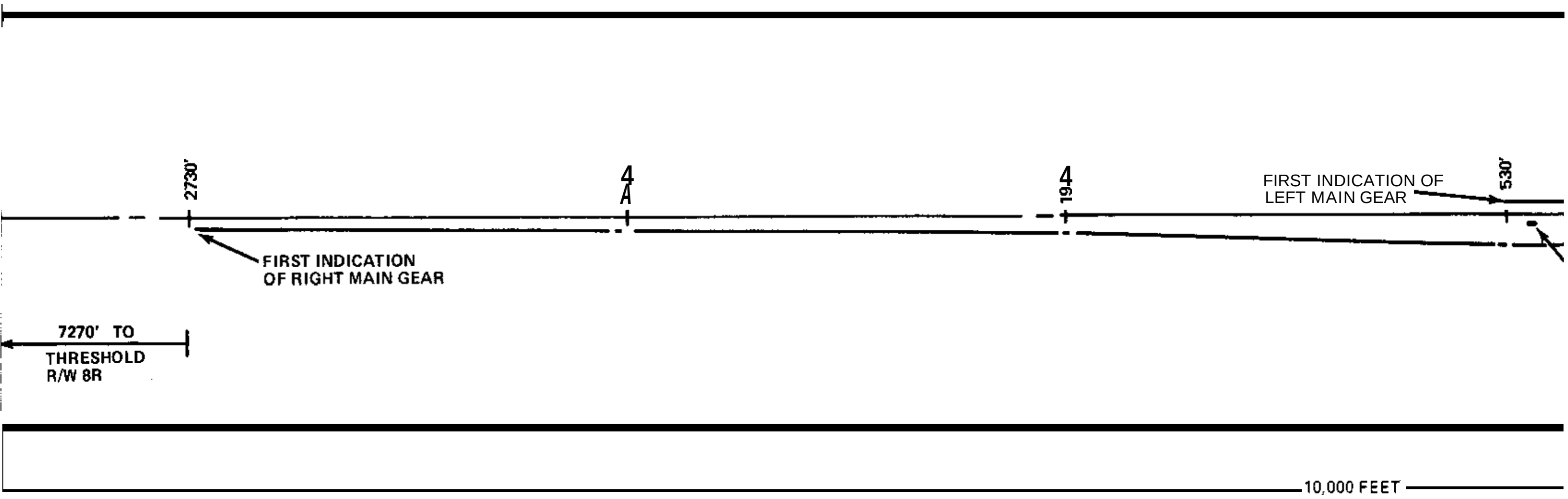


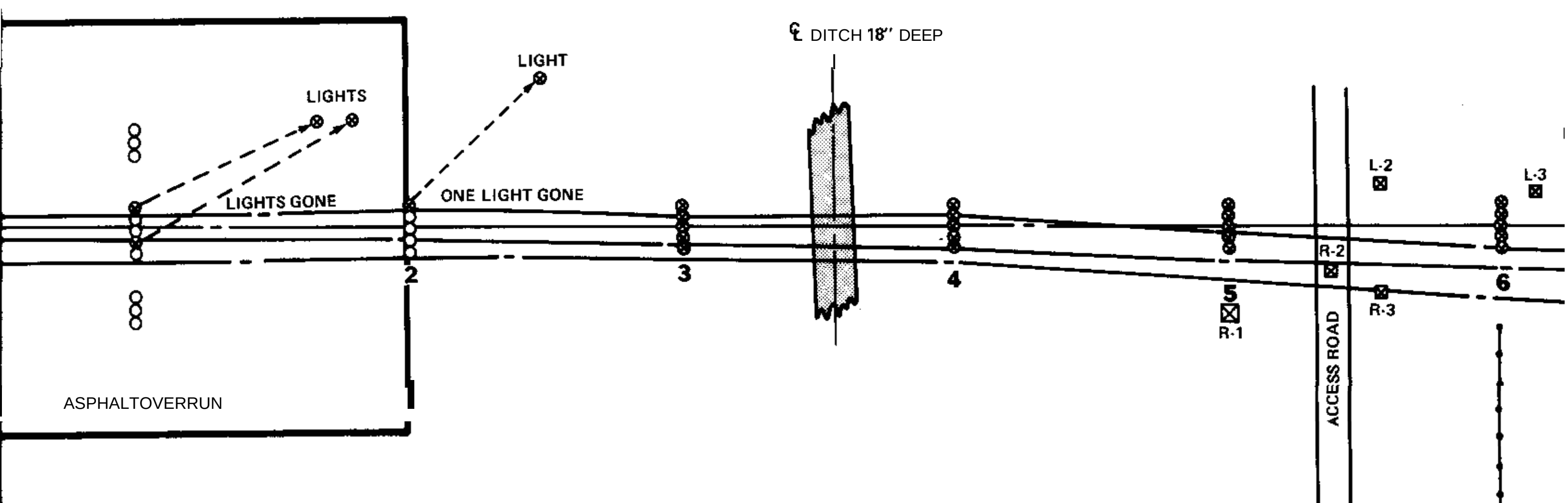
NOTE: SCALE FROM THRESHOLD WEST 1" = 100' (HORT SCALE)
WITH RUNWAY WIDTH 1" = 40' (VERT SCALE)

LEGEND

○ – APPROACH LIGHT ⊗ – APPROACH LIGHT DI
R-1 – SPRAY DEFLECTOR LEFT MAIN GEAR
R-2 – TIRE TREAD (13" x 4" FULL DEPTH)
R-3 – LEFT MAIN LANDING GEAR DOOR
R-4 – TIRE TREAD (14" x 6" FULL DEPTH)
R-5 – NOSE GEAR DOOR
R-5A – LEFT LANDING GEAR BOLT
R-6 – LEFT WING FILLET
R-7 – TIRE TREAD (9" x 6" FULL DEPTH)
R-8 – TAIL CONE

N

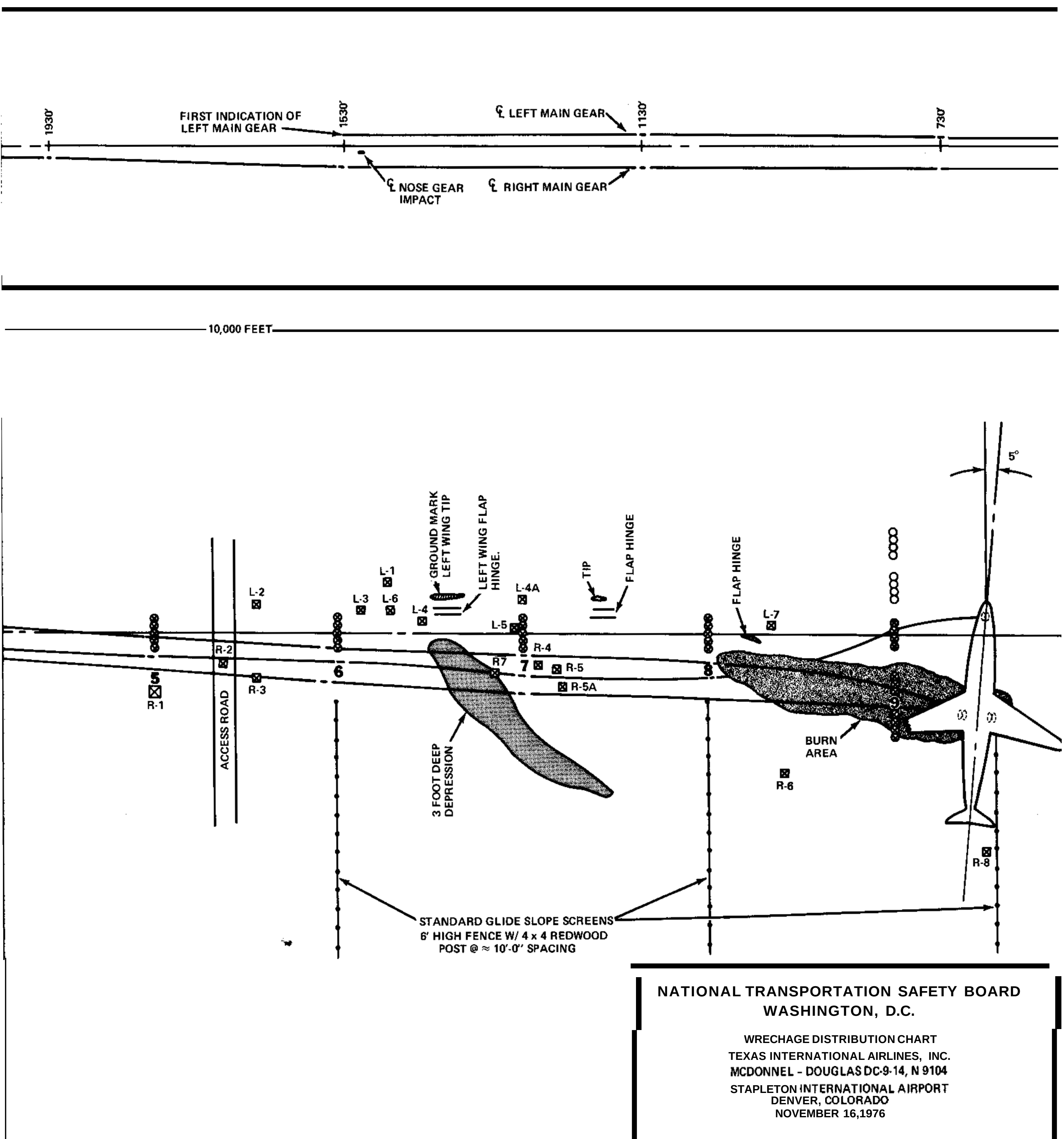




LIGHT ⊗ — APPROACH LIGHT DEMOLISHED
FLECTOR LEFT MAIN GEAR
D (13" x 4" FULL DEPTH)
LANDING GEAR DOOR
D (14" x 6" FULL DEPTH)
R DOOR
DING GEAR BOLT
FILLET
D (9" x 6" FULL DEPTH)

L-1 – LEFT WING LANDING LIGHT SUPPORT RING
L-2 – FLAP ACTUATOR FAIRING
L-3 – LEFT WING FIB. GLASS FENCE
L-4 – LANDING GEAR UPPER DOOR (LEFT GEAR)
L-4A – LEFT LANDING LIGHT
L-5 – LANDING GEAR WHEEL RIM
L-6 – LEFT WING LEADING EDGE
L-7 – LEFT WING TIP (ABOUT 7' SECTION)

N



NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C.

WRECHAGE DISTRIBUTION CHART
TEXAS INTERNATIONAL AIRLINES, INC.
MCDONNEL - DOUGLAS DC-9-14, N 9104
STAPLETON INTERNATIONAL AIRPORT
DENVER, COLORADO
NOVEMBER 16,1976

AIR CARRIER OPERATIONS BULLETIN NO. 73-1

SUBJECT: Reassessment of Crewmember Emergency Training Programs

Recent survivable air carrier accidents have reflected deficiencies in training and performance of crewmembers in regard to emergency evacuation. In one case, some of the crewmembers did not carry out their emergency evacuation assignments and what direction was given to the passengers was given by crewmembers who deplaned ahead of the passengers and were outside the aircraft. There is also evidence that many crewmembers have never physically opened some of the emergency exits, but were trained entirely by the use of pictorial presentations. We do not agree that pictorial presentations alone are adequate, especially during initial training.

We all know the extreme importance of rapid evacuation, especially in the presence of fire. During the period 1962-1971, there were 82 accidents and incidents where an evacuation was attempted. Of these: (1) In 58 the evacuation time was unknown; (2) in 24 the evacuation times ranged from 30 seconds to 5 minutes; (3) 7 of the 82 accidents and incidents accounted for 214 fatalities; and (4) 207 of these fatalities occurred in 4 accidents involving fire after impact, the survivors of these 4 accidents evacuated the aircraft in less than 2 minutes.

A prompt evaluation of an emergency and immediate initiation of the proper action is essential, if lives are to be saved, and should be stressed in training. A well-trained crewmember is subject to less confusion and delay in an emergency, thereby expediting evacuation. Emphasis should be placed on a quality of training which will insure that each crewmember recognizes his responsibility for the safety of his passengers, and understands and is able to perform the duties required to furnish them maximum guidance and assistance in an emergency situation.

The preamble to FAR 121.417 in Amendment 121-55 has been interpreted to imply that visual and audio aids are totally acceptable to satisfy FAR 121.417c(2)(4). Their use is not considered, in some cases, to be an adequate substitute for actual operation of the mechanical device. This is especially true for initial emergency training. It is also true for recurrent training if a high level of proficiency is to be maintained. Therefore, during initial training each crewmember should actually operate each type' of emergency exit, either on an aircraft or a realistic mockup. For those exits where it is impractical for each individual to operate the exit or device, such as the DC-9 tail cone, a group demonstration will suffice provided, it is supported by a detailed visual/pictorial presentation. Actual operation of the exit types during recurrent training need only be repeated at two year intervals.

AIR CARRIER OPERATIONS BULLETIN NO. 76-1

SUBJECT: Crewmember Emergency Training; Use of Mockups

This bulletin updates the philosophy contained in Air Carrier Operations Bulletin No. 73-1. The principal purpose is to require more realistic duplication of emergency conditions in simulator/mockup training.

During a recent emergency evacuation, it was reported that flight attendants had difficulty in opening two main cabin doors. The difficulties with the doors apparently were similar--both flight attendants were able to rotate the handle and partially open the doors but were unable to open the doors further. Eventually, the flight engineer fully opened one door and an off-duty flight attendant helped to open the other door. Examination of the wreckage revealed no evidence of damage to the structure or mechanism of the doors.

The flight attendants had received initial and recurrent emergency training using an actual B-737 aircraft door and a B-737 mockup door; however, neither attendant had ever opened an aircraft door with an evacuation slide engaged for deployment and the mockup door was not designed to realistically duplicate the forces that should be expected in the emergency mode.

In another evacuation, two operable exits were not used. The flight attendants who attempted to open them concluded that they were inoperative because the actions involved in the movement of the handles to activate the door opening cycle were different from those which they had encountered in recurrent training.

FAR 121.417(c), Crewmember Emergency Training, states in part, "each crewmember must perform at least the following emergency drills utilizing the proper equipment and procedures, unless the Administrator finds that with respect to a particular drill, the crewmember can be adequately trained by demonstration:

(2) Emergency evacuations.

(4) Operation and use of emergency exits, including deployment and use of evacuation chutes."

The preamble to FAR 121.417, in Amendment 121-55, has been interpreted to imply that visual and audio aids are totally acceptable to satisfy FAR 121.417(c)(2) and *(4)*. This is not so and their use is not considered to be an adequate substitute for actual operation of the mechanical device in all cases. This is especially true for initial emergency training. It is also true for recurrent training if a maximum level of proficiency is to be maintained. Therefore, during initial training each crewmember should actually operate each type of emergency exit, either on an aircraft or on a realistic mockup. For those exits where it is impractical for each individual to operate the exit or device, such as the DC-9 tail cone, a group demonstration will suffice provided it is supported by a realistic, detailed visual/

pictorial presentation. Actual operation of the exit types during recurrent training should be repeated at two-year intervals.

Assigned air carriers should be encouraged to continue utilizing training mockups, where feasible, in an effort to further augment flight attendant initial and recurrent emergency training programs and facilitate the transfer of learning experience.

To insure a continued high level of performance by flight attendants under emergency evacuation conditions, the following requirements should be incorporated in the individual carrier's emergency training programs:

1. The training mockups utilized to satisfy the requirements of FAR 121.417(c)(2) and (4) be a realistic duplication of the exits on the aircraft and include the actual forces involved in opening exits in the emergency mode.

2. Training procedures should accurately simulate emergency conditions.

3. During initial and recurrent training, flight attendants be instructed in the additional forces that will be encountered when opening exits in the emergency mode with evacuation slide pack attached and under other adverse circumstances such as unusual cabin deck angles, high winds, structural deformation, etc.

Flight attendants should not be required to operate cockpit exits and associated escape devices during recurrent training. Automatic and manual escape chutes need not be deployed each time the associated exit is cycled. Visual presentation of chute deployment is satisfactory for recurrent training. An actual deployment should be provided for each initial training class and each student should be given experience using the device as an escape mechanism.

A well-trained crewmember is subject to less confusion and delay in an emergency, thereby expediting evacuation. Emphasis should be placed on quality of training which will ensure that crewmembers recognize their responsibility for the safety of their passengers and understand and are able to perform the duties required to furnish them maximum guidance and assistance in an emergency situation.

A reasonable period should be allowed for the carrier to purchase or build its training aids. It should be explained that the actions specified herein constitute a statement of FAA policy with regard to emergency training.

Cabin attendants should not be required to operate cockpit exits and associated escape devices during recurrent training. Automatic and manual escape chutes need not be deployed each time the associated exit is cycled. Visual presentation of chute deployment is satisfactory for recurrent training. An actual deployment should be provided for each initial training class and each student should be given experience using the device as an escape mechanism.

A reasonable period should be allowed for the carrier to purchase or build its training aids. It should be explained that the actions specified herein constitute a statement of FAA policy with regard to emergency training.