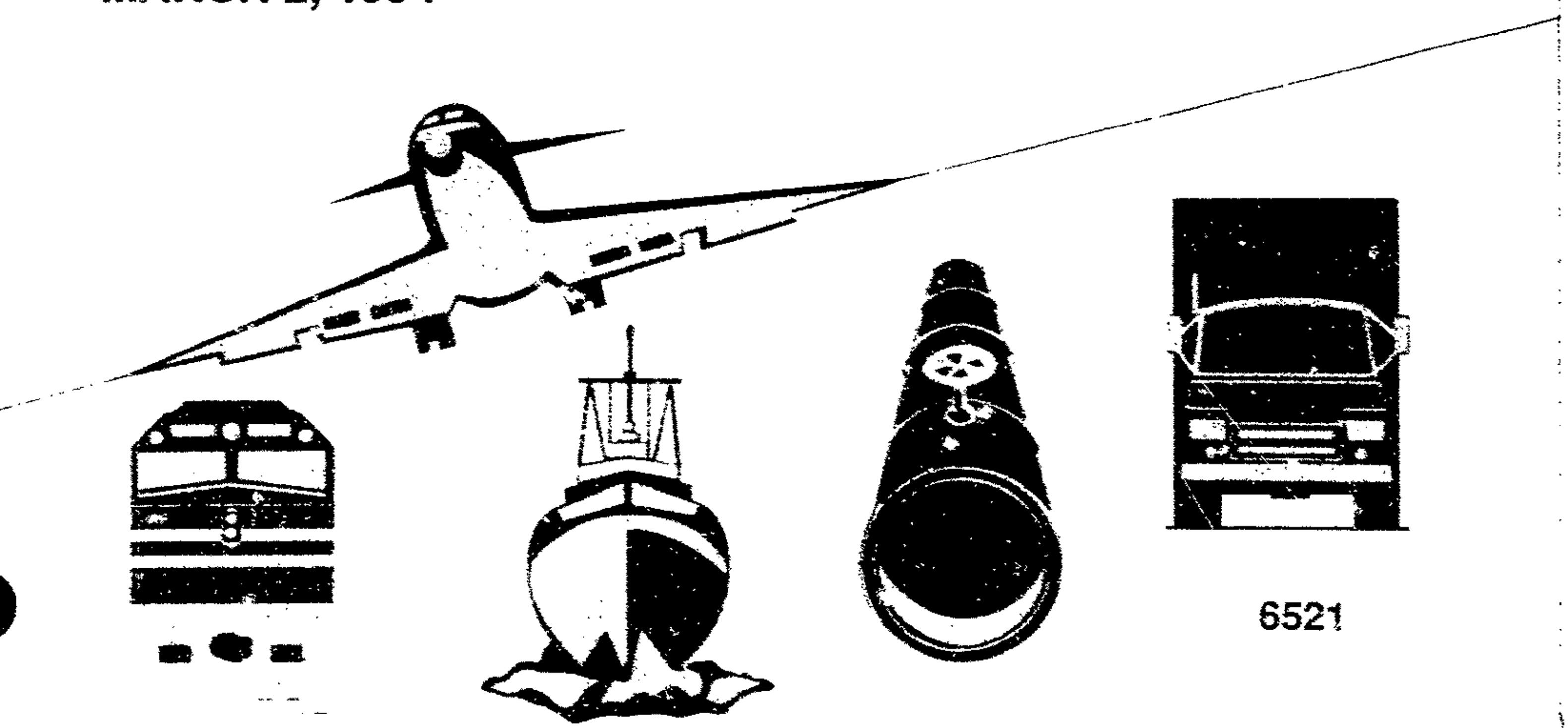
PB95-910401
NTSB/AAR-95/01

NATIONAL TRANSPORTATION SAFETY BOARD

WASHINGTON, D.C. 20594

AIRCRAFT ACCIDENT REPORT

RUNWAY OVERRUN FOLLOWING REJECTED TAKEOFF
CONTINENTAL AIRLINES FLIGHT 795
McDONNELL DOUGLAS MD-82, N18835
LaGUARDIA AIRPORT
FLUSHING, NEW YORK
MARCH 2, 1994



6521

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Adopted: February 14, 1995
Notation 6521

Abstract: This report explains the accident involving Continental Airlines flight 795, an MD-82 airplane, which experienced a runway overrun following a rejected takeoff from runway 13 at LaGuardia Airport, Flushing, New York, on March 2, 1994. Safety issues discussed in the report include the availability of takeoff performance data for flightcrews, the proper functioning of pitot/static heat systems, the duration of cockpit voice recordings, and problems associated with passenger evacuations from airplanes. Safety recommendations concerning these issues were addressed to the Federal Aviation Administration and to Continental Airlines, Inc.

CONTENTS

EXECUTIVE SUMMARY

On March 2, 1994, about 175946 eastern standard time, Continental Airlines flight 795, a McDonnell Douglas MD-82, registration N18835, sustained substantial damage when the captain rejected ?he takeoff from runway 13 at LaGuardia Airport, Flushing, New York. The airplane continued beyond the takeoff end of Runway 13 and came to rest on the main gear wheels with the nose pitched downward, so that the fuselage was balanced on top of a dike. The underside of the nose lay on a tidal mud flat of Flushing Bay. There were 110 passengers, 2 flightcrew members and 4 flight attendants aboard the airplane. There were no fatalities, and no serious injuries were reported. There were 29 minor injuries to passengers, all of which were sustained during the evacuation, and 1 minor injury to a flightcrew member. There was no postcrash fire.

The National Transportation Safety Board determines that the probable causes of this accident were the failure of the flightcrew to comply with checklist procedures to turn on an operable pitot/static heat system, resulting in ice and/or snow blockage of the pitot tubes that produced erroneous airspeed indications, and the flightcrew's untimely response to anomalous airspeed indications with the consequent rejection of takeoff at an actual speed of 5 knots above V1.

Safety issues discussed in the report include the availability of takeoff performance data for flightcrews, the proper functioning of pitot/static heat systems, the duration of cockpit voice recordings, and problems associated with passenger evacuations from airplanes. Safety recommendations concerning these issues were addressed to the Federal Aviation Administration and to Continental Airlines, Inc.

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1. FACTUAL INFORMATION

1.1 History of Flight

On March 2, 1994, about 175946 eastern standard time (est),[1] Continental Airlines flight 795 (COA flight 795), a McDonnell Douglas MD-82, registration N18835, sustained substantial damage when the captain rejected the takeoff from runway 13 at LaGuardia Airport (LGA), Flushing, New York. The airplane continued beyond the takeoff end of runway 13 and came to rest on the main gear wheels with the nose pitched downward, so that the fuselage was balanced on top of a dike.[2] The underside of the nose lay on a tidal mud flat of Flushing Bay. There were 110 passengers, 2 flightcrew members and 4 flight attendants aboard the airplane. There were no fatalities, and no serious injuries were reported. There were 29 minor injuries to passengers, all of which were sustained during the evacuation, and 1 minor injury to a flightcrew member. There was no postcrash fire.

Flight 795 was the return leg of a scheduled trip for both the captain and first officer. Both of them were based in Denver, Colorado. The trip was from Denver Stapleton International Airport (DEN) to LGA, with a return flight to DEN. The leg from DEN departed at 1030 mountain standard time (mst) and arrived at LGA at 1639. The turnaround time at LGA was approximately 44 minutes.

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[1] Unless otherwise indicated, all times are eastern standard time (est) based on a 24-hour clock. Official sunset was 1748.

[2] Also referred to as the "seawall" in this report.

Prior to departing the gate, the first officer performed a preflight walk-around and noted no problems with the airplane, except that it needed to be deiced. The mechanic who performed the clear ice inspection said that the captain came to the COA maintenance area at LGA to personally request deicing. According to an aircraft logbook entry, deicing began at 1712 and ended at 1724. Although he did not observe the entire deicing/anti-icing process, a mechanic performed a tactile inspection of both wings and signed off the procedure as complete in the airplane's logbook. The mechanic characterized the ramp surfaces as "slushy."

Personnel who performed the deicing of flight 795 stated that, prior to engine start, they found light snow on the airplane. The snow was easily removed during the deicing process using glycol/water (Type I) fluid. One of the deicing personnel said that it was not snowing heavily when the deicing was completed, but that the snowfall began to increase when flight 795 was taxiing out. The fluid applications truck driver stated that snow did not appear to be adhering to the airplane's surfaces.

After deicing was completed, the pilots started the left engine and began preparations to taxi for takeoff. The airplane's cockpit voice recorder (CVR) recorded the first officer's call to LGA Ground Control for taxi at 1731:06.[3] (See appendix B for CVR transcript). At 1753:20, the captain asked the first officer, "why don't you go have a look," at the wings for evidence of icing. Between 1753:35 and 1754:42, the first officer was in the cabin. He examined the wings by shining a flashlight through cabin windows. When he returned to the cockpit, the first officer stated to the captain, "Looks okay to me."

At 1756:52, the first officer started the right engine and recited checklist items for "After engine started." LGA Tower cleared the flight to "...taxi into position and hold," on takeoff runway 13 at 1757:02.

The flightcrew stated that the taxiways were slippery. Other flights commented on ground control frequency regarding braking action and snowy conditions. Pilots of airplanes that departed LGA approximately 1/2 hour prior to flight 795 taking off were interviewed. All of them characterized the runways and taxiways as having residual snow cover. Some of the pilots described the residual snow as covering the nmway markings. A B-737 captain described difficulty with

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[3]The CVR transcript begins at 1730:05, with the first officer challenging and the captain responding to items on the "After Start" checklist.

the slippery surface and with directional control while taking off on runway 13, 12 minutes before the accident. The pilots that departed after the B-737, and before flight 795 took the runway, reported that they did not experience the same difficulty with directional control.

At 1757:32, the captain gave a rejected takeoff briefing, stating,

> ...if we have to abort, I'll call the abort and...as soon as I pull the throttles back, I have control of the airplane, you help me get it stopped mainly by makin' sure the spoilers are out, we get it stopped then you tell the flight attendants to remain seated and tell the tower we've aborted, we'll go through the ah checklist.

Both pilots later stated that there was blowing snow on the runway but they could see runway markings and lights. They also stated that they left the auxiliary power unit (APU) running during the takeoff.

Flight 795 received takeoff clearance from LGA tower at 1758:36.[4] The first officer was at the controls. He stated that he advanced the throttles to achieve cockpit indicator readings of 1.2 engine pressure ratio (EPR), and called "autothrottles on." The captain crosschecked the N1 readings and compared them with the EPR readings for both engines to confirm that takeoff power was set. The captain said that the N1 readings were 90 percent and that the EPRs were 1.93.

The first officer released the brakes at 1758:48,[5] and the airplane began to accelerate on the runway for takeoff. The captain said that at 60 knots, the indicated airspeed (KIAS) appeared to stop increasing. He said the airspeed indicator increased once from 60 knots to 80 knots, then returned to 60 knots. He glanced at the first officer's airspeed indicator and noted that it also read about 60 knots. He did not recall checking the airspeed on the standby airspeed indicator.

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[4] The LGA automatic terminal information service (ATIS) reported the following weather conditions for 1650: Ceiling 700 feet, obscured; visibility 3/4 of a mile, light snow and fog, temperature 28 degrees F dew point 26 degrees F, wind 070 degrees at 19 knots, altimeter 30.16 inches of Hg., breaking action advisories in effect for Runway 4, none available for 13.

[5] FDR data show that at 1758:48 (2258:48 UTC), the brake pressure and pedal position values indicated brake release, and the longitudinal acceleration values indicated the start of takeoff roll. The engine thrust values became steady at 1758:54 (EPR approximately 1.94 and N1 approximately 88 percent), and 1 second later the Flight Mode Annunciator (FMA) for autothrottles changed from "Off" to "EPR Limit (Takeoff)." See Section 1.16.2, Aircraft Performance.

The captain said that he was considering rejecting the takeoff and, about this time, saw a red light flicker on the instrument panel, just below the glare shield.

The captain called out the word, "Abort," at 175923. The captain said that, during the rejected takeoff, he applied maximum braking and maximum reverse thrust.[6] He also stated that the brakes were ineffective and the airplane continued to slide down the runway. He said that he thought the airplane slowed to approximately 30 hots. He attempted to turn the airplane at the end of the runway, but was unable to do so. He straightened the airplane so that the nose of the airplane impacted the dike that was beyond the end of runway 13. The first sounds of impact were heard on the CVR at 175946. At that hme, the Aeronautical Radio Inc. (ARINC) Communications, Addressing, and Reporting System (ACARS) sent a message that the airplane was "airborne."[7]

The accident took place about 3 hours before low tide.[8] Crewmembers and passengers reported that upon looking out the cabin windows, they thought that the airplane was going into the water. However, the nose of the airplane did not go below the water surface until after the evacuation when the tide started tu rise.

The captain stated that after the airplane came to rest, he called for the rejected takeoff checklist and the evacuation checklist. The CVR recorded him twice calling for the rejected takeoff checklist. He made a public address (PA) announcement that, "...we see no f i i be careful...go to the rear of the airplane...after you exit the aircraft." Some passengers and flight attendants stated that they heard a public address call to evacuate. Some said the evacuation message was garbled, and some thought they heard that there was no fire and that they should exit via the rear of the airplane. A flight attendant in the rear of the cabin went out on the catwalk in the tailcone and inflated the slide. Seeing that the tail of the airplane was high off the ground and the slide did not reach to the ground, she told passengers to move forward to exit. Some passengers reported confusion during the evacuation and a sense of lack of direction from crew.

A Port Authority of New York & New Jersey (PNY&NJ) lieutenant arrived, by his estimation, about 1 1/2 minute after hearing the alert. He had been in the vicinity, responding to another call. He banged on the first officer's side window

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[6] Braking and reverse thrust were verified by FDR data.

[7] The air/ground switch which provides input to the ACARS is located on the nose landing gear assembly.

[8] Official high tide was 1428. Low tide was 2110.

and told the flightcrew that the right engine was still running. The captain checked the fuel levers and verified that they were selected OFF. The fire handles were pulled and the engines stopped running. The flightcrew also shut down the APU and turned the battery switch to OFF. Passengers began to exit over the right wing and he told them to exit forward, instead, as the wings were near the top of the snow-covered dike. The lieutenant and another PNY&NJ officer observed that the taxiway and road surfaces were "slippery."

The flightcrew was still in the cockpit when the PNY&NJ lieutenant entered the cockpit through the cabin. The lieutenant later stated that he observed the first officer standing near the cockpit door. The first officer looked dazed and said that his back was hurt. The lieutenant observed that the captain was still seated in the left seat and was working on his instrument panel. The lieutenant told the captain to shut off the battery because he smelled electrical smoke and saw sparks. The captain said that he had already turned off the power source.

The PNY&NJ lieutenant said that the captain appeared to be very calm. The captain spoke slowly and was in no rush to leave the cockpit. The captain shut everything down in a deliberate manner. The lieutenant transported the two pilots back to the terminal and he had a police officer take the first officer to a hospital. About 1/2 hour after the accident, an FAA inspector and the captain returned to the airplane. Both stated that the captain retrieved some articles from the cabin and they never reentered the cockpit. They then returned to the terminal.

The accident occurred during nighttime; the airplane came to rest about 40°46.10' north longitude, 73°51.20' west latitude.

1.2 Injuries to Persons

Injuries	Flightcrew	Cabincrew	Passengers	Other	Total
Fatal	0	0	0	0	0
Serious	0	0	0	0	0
Minor	1	0	29	0	30
None	1	4	81	0	86
Total	2	4	110	0	116

1.3 Damage to Aircraft

Damage to the airplane is described in Section 1.12, Wreckage and Impact Information. The cost to repair the airplane was $5.63 million.

1.4 Other Damage

The airplane came to rest on top of the dike beyond the end of LGA runway 13. There was no claim for property damage.

1.5 Personnel Information

1.5.1 Captain

The captain, age 57, was hired by COA in 1965. He holds an airline transport pilot (ATP) certificate, with ratings and limitations for airplane multiengine, and B-727, DC-9/MD-80; and commercial pilot privileges, airplane single-engine land. The captain also possessed a flight engineer certificate with ratings and limitations for turbojet aircraft. At the time of the accident, his total pilot time was about 23,000 hum, with 6,000 hours in the MD-80/82.

Before becoming employed by COA, the captain was a pilot in the U.S. Air Force. His first position with COA was as a second officer in the B-707. He was upgraded to first officer, and, in 1967, was upgraded to captain in the B-727. In 1970, he received the rating of captain in the DC-9/MD-80.

The captain had his most recent 14 CFR Part 121 proficiency check on March 12,1993, and recurrent training on October 24,1993. His last line check took place October 5, 1993. He completed both check flights satisfactorily.

His FAA current first class medical certificate was issued on December 10,1993, with a limitation to wear corrective lenses for near vision. The captain had no record of aircraft accidents, incidents, or flight violations.

Company records indicate that the captain had never been subject to discipline. A COA assistant chief pilot slated that there were no complaints from other pilots about his performance. A first officer, who frequently flew with the captain, described him as "a perfectionist m performing checklists." He added that the captain always emphasized in his briefings any unusual factors, including aircraft weight, weather, and runway conditions. The accident first officer, who had flown with the captain once before during the previous year, described the captain as very thorough. He said that the captain did everything by procedure and explained what he wanted.

The captain had completed an 8-hour class in crew resource management (CRM), about 3 years before the accident. He was scheduled for a refresher CRM class during the week following the accident. The captain described the training as worthwhile. He also indicated that he was familiar with the new RTO procedure, adopted by COA in January 1993, under which only captains were allowed to call for and execute rejected takeoffs.

1.5.1.1 Captain's 72-Hour History Prior to the Accident

On February 27, 1994, the captain flew a trip that departed DEN in the evening. The flight arrived at ORD the following morning, about 0030 cst, landing in what he described as a "terrible snowstorm." The crew checked into the hotel, and he retired to bed about 0115 cst. The captain awoke about 0900 cst and ate breakfast. He departed on a return flight to DEN about 1330 cst. The flight landed in DEN about 1600 mst. He watched television at home that evening and retired to bed about 2300 mst. On March 1, he awoke about 0700 mst and spent a routine day at home. He ate a home-cooked dinner and retired to bed about 2300 mst. On March 2, the captain awoke at 0700 mst, ate breakfast, and departed the house at 0815 mst. He arrived at the airport at 0915 mst. The flight to LGA was scheduled to depart DEN at 1017 mst, but it actually departed at 1030 mst. The captain did not eat a meal on this flight. He indicated that when he was off duty, he normally slept each day from 2300 to 0700.

The captain possessed a valid Colorado driver's license, with no history of moving violations during the past 3 years and no criminal history.

1.5.2 First Officer

The first officer, age 47, was hired by COA in 1985. He holds an ATP certificate, with ratings and limitations for airplane multiengine land, CV-340 and CV-440; and commercial pilot privileges, airplane single-engine land and sea. He also possessed a flight engineer certificate, with rating and limitations for turbojet and turbopropeller powered aircraft. In addition, the first officer possessed advanced ground instructor and flight instructor certificates, with ratings and limitations for airplane single- and multiengine land, and instrument airplane. At the time of the accident, his total pilot time was about 16,000 hours, with 2,400 hours in MD-80 series airplanes.

Before becoming employed by COA, the first officer gained flight experience in civil aviation. He began flying while in his early twenties. Living in Alaska, he worked professionally in the regional airline industry and as an air taxi pilot

Upon becoming employed by COA, the first officer served as a DC-10 second officer, He then upgraded to first officer on the DC-9/MD-80, about 4 years prior to the accident,

The first officer received his most recent 14 CFR Part 121 proficiency check on March 14, 1993, and recurrent training on February 21, 1993. His last line observation flight took place on March 21, 1990, which he completed satisfactorily.

His current FAA first class medical certificate was issued on February 2, 1994, with no limitations. He had no record of accidents, incidents, or flight violations.

Company records indicated that the first officer had never been subject to discipline. An assistant chief pilot reported that there were no complaints from other pilots about his performance. A captain, who was not the accident captain, and had flown with the first officer recently, described him as methodical on checklists. The captain of the accident flight said that one of the first officefs greatest strengths as a pilot was his attention to detail on checklists.

The first officer completed a crew resource management (CRM) training course 6 to 8 months prior to the accident. The course consisted of three phases, taking place over a period of about 4 days. The first officer also received extensive training in rejected takeoff procedures at his most recent ground school training period.

The first officer was married, lived in Seattle, Washington (SEA) and commuted to his crew base in DEN to commence trip assignments.

The first officer holds a valid Alaska driver's license. with no history of moving violations in the past 3 years and no criminal history.

1.5.2.1 First Officer's 72-Hour History Prior to the Accident

On February 27, 1994, the first officer completed a trip that landed at DEN at 1030 mst. He then deadheaded[9] back to SEA, arriving home about 1530 pacific standard time (pst). He spent the evening at home with his family and retired to bed between 2200 and 2300 pst. He was off duty on Monday, February 28. He awoke on that morning between 0700 and 0800 pst. He performed household chores, and retired to bed that evening between 2200 and 2300 pst. He awoke on March 1, about 0700 pst, and ate breakfast. He departed SEA on a deadhead status at 1415 pst, and stayed overnight at a friend's house in the Denver area. He ate a snack on the flight from SEA to DEN, and ate a large dinner that evening. The first officer retired to bed about 2200 mst. He arose on March 2, about 0715 mst, and felt rested. He was driven to the airport for the trip from DEN to LGA. He ate a meal on the flight leg from DEN to LGA. He indicated that his normal sleep schedule, when he was off duty, was from 2200 to 2300 until 0700 to 0800.

1.5.3 Flight Attendants

Three of the four flight attendants on the flight each had more than 30 years of service. The fourth flight attendant had more than 6 years experience.

1.5.3.1 Flight Attendant Training

The initial emergency procedures training for each of the flight attendants varied, depending upon the time of initial training. Three flight attendants began their careers at various airlines that later became part of COA. The most recently hired flight attendant was initially trained by COA at its In-flight Training Center in Houston, Texas.

At the time of the accident, flight attendants were required by COA to complete annual recurrent training at one of four crew bases: Houston, Atlanta, Los Angeles, or Newark. During recurrent training, the flight attendants received classroom instruction on emergency evacuation procedures, as well as in-flight fire fighting, and security. Overwater emergencies were addressed in training; however, three of the four flight attendants stated to investigators that they did not swim. In addition, flight attendants were required to perform hands-on door drills and fire-

[9]Flew in a nonactive crew status.

fighting exercises in recurrent training every 24 months. COA provided joint cockpit and cabincrew coordination training during recurrent training.

On April 7, 1994, part of the investigation team observed the recurrent training program at the COA training facilities in Houston. They observed a flight attendant training class that included hands-on door evacuation drills. During the drills, each flight attendant was required to verbalize evacuation commands to passengers. The drills included opening an emergency exit and simulating the activation of the exit slide pack, and directing the passengers down the slide and away from the airplane. The flight attendants were then critiqued by their instructors, who identified any mistakes and noted appropriate correct commands or procedures. The instructors emphasized proper procedures; however, the flight attendants were not required to shout their commands or conduct a simulated evacuation within a prescribed period of time.

1.6 Aircraft Information

1.6.1 The Aircraft

The airplane was delivered new to COA by Douglas Aircraft Company on December 19,1986, as serial number 49439. The total aircraft time was 23,448 flight hours, with 11,083 cycles. The last "C" check was performed on April 5, 1993, at 20,295 hours. The engines installed on the airplane were Pratt & Whitney model JT8D-217A.

1.6.2 Maintenance History

Honeywell Central Air Data Computer (CADC) No. 1 was repaired and functionally tested by the manufacturer on November 28, 1988. At the time of the accident, total flight time on the No. 1 CADC was 31,804 hours, with 14,458 cycles. Total flight time since overhaul was 24,575 hours, with 11,439 cycles. Time since the unit was installed on the accident airplane was 7,347 hours,

The No. 2 CADC was installed on the accident airplane on April 18, 1989. Historical data does not indicate additional maintenance on this unit. At the time of the accident, the total flight time on the unit was 31,804 hours, with 14,458 cycles.

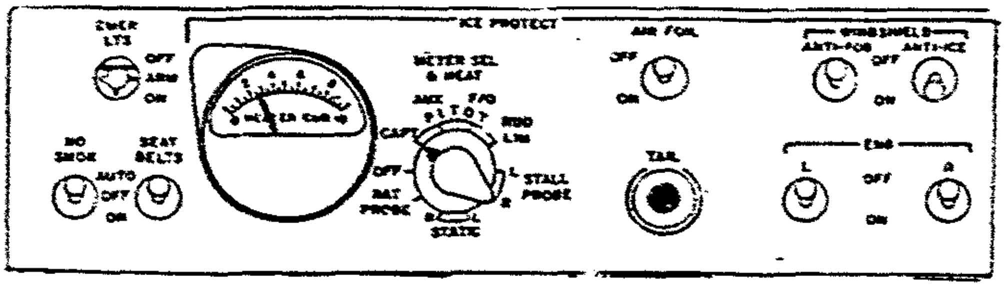
COA Aircraft Maintenance Log (AML) entries for February 3, 1994, stated that the left thrust reverser unlock light stayed on for 30 seconds after the thrust reverser lever was stowed in the cockpit. Maintenance placed a placard on the left thrust reverser unlock indication system, listing it as inoperative, in accordance with minimum equipment list (MEL) item 78-02. This did not affect the operation or use of the thrust reversers. The AML entry for February 28, 1994 (2 days before the accident) indicated that the No. 2 Flight Management Annunciator (FMA) autoland lights were inoperative. Maintenance removed and replaced the FMA and performed an operational check prior to returning the aircraft to service.

On December 13, 1993, and several times thereafter, the captain's flight director and associated subsystems were subjected to pilot and maintenance writeups. At the time of the accident, the No. 1 flight director speed flag was listed as a deferred maintenance item and was placarded inoperative. This would not affect the pilots' display of airspeed.

1.6.3 Pitot/Static/Stall Warning/Ice Protection Systems

Ice protection for the pitot tubes, static ports, ram air temperature probe, and angle-of-attack transducers is provided by electrical heating elements. The anti-icing heating system also includes current transformers, a current converter, control relays, selector switch, direct current (DC) ammeter, and a PITOT/STALL HEATER OFF light.

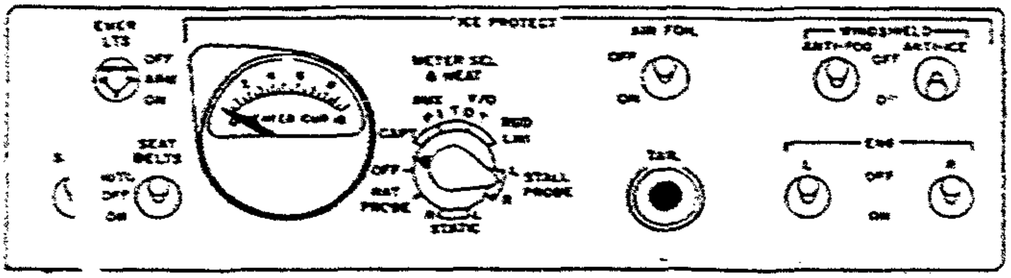
The heating elements consist of fine resistance wire sealed in each assembly. The ice protection rotary meter selector and heat switch, on the overhead switch panel, connects 28 VDC [volts direct current] power to the heating elements of the captain's auxiliary and first officer's pitot tubes, and 115 VAC [volts alternating current] electrical power to the heating elements of the static ports, ram air temperature probe, rudder Q-limiter pitot tube, and angle-of-attack transducers. (See figure 1). When the switch is selected to any position except OFF, electrical power is supplied to all heaters at all times except the ram air temperature (RAT) probe heater, which only receives power when the "air/ground" relay located on the nose landing gear is in the "flight" mode. When selected to the OFF position, power is not applied to any of the heaters. The ammeter indicates current flow in the circuit to the component for which the switch is positioned. The ammeter is located adjacent to the rotary selector switch. The meter scale is calibrated to read from 0 to 10 units for current indication only and does not directly indicate amperes. Individual current transformers located on a relay panel, in the electronics



Upper Illustration-Normal position for system ON and reading CAPT Heater current.

Middle Illustration-Approximate alignment of accident airplane's switch in OFF detent.

Bottom Photo-Photo of accident airplane's METER SEL & HEat switch in OFF position. See arrow: ▷



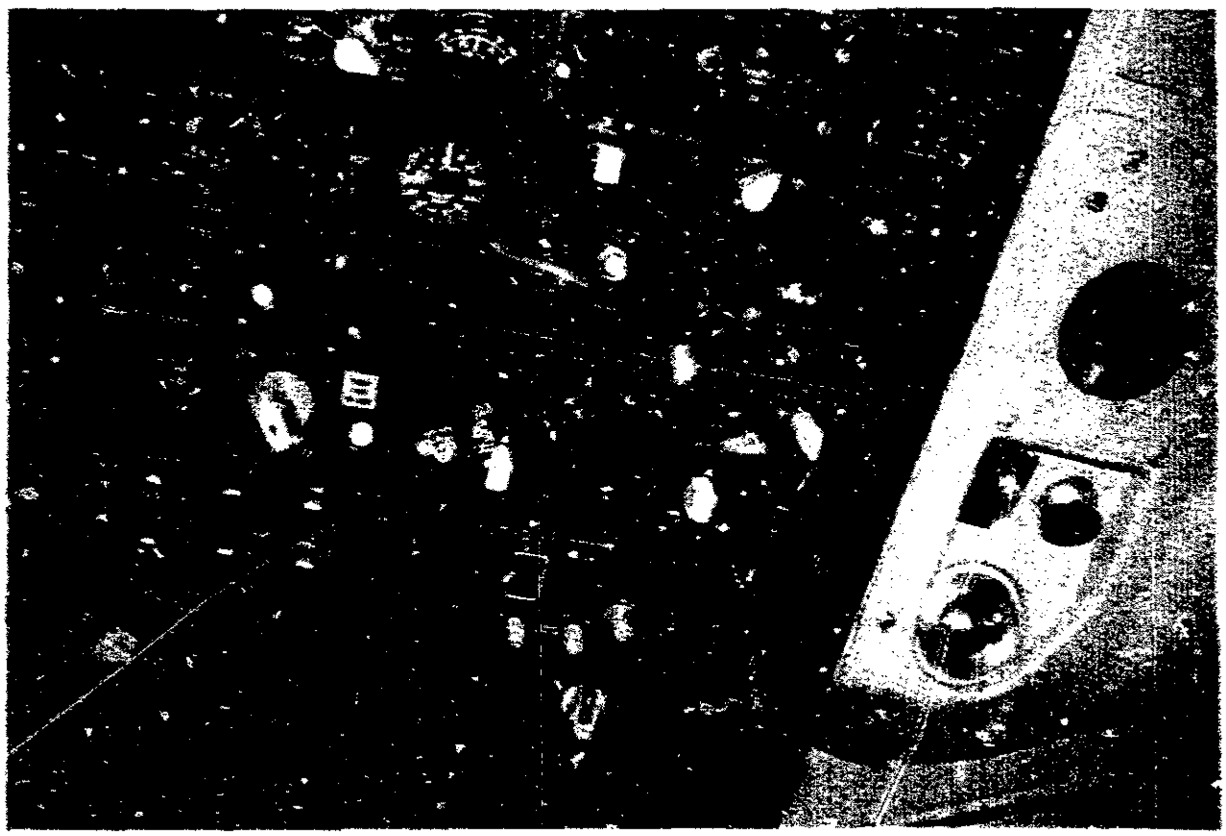


Figure 1.--Pitot/static/stall heater selector switch.

compartment, are in the feeder circuit of each heating element, except the left and right alternate static ports, and provide electrical power to the ammeter through a current converter. The current converter rectifies AC electrical current from the transformers to DC electrical current for the ammeter. Three shunts in the CAPT's, F/O's and AUX pitot tube heaters allow for current monitoring of those circuits.

Six heater caution relays, located in the E/E [electronic equipment] compartment, and a PITOT/STALL HEATER OFF light, located on the cockpit overhead annunciator panel, provide indication of heater operation. A caution relay is connected in series to each of the four pitot tubes and the two angle-of-attack transducer heater circuits. The relays are energized when respective heater current is flowing. When the selector switch is in the OFF position, the amber light will come on. When the selector switch is in any operating position and current ceases to flow (open wiring or defective heater) in one of the heater circuits, the respective caution relay will deenergize and the amber light will come on. When the PITOT/STALL HEATER OFF light comes on, the MASTER CAUTION lights also come on.

1.7 Meteorological Information

1.7.1 Synoptic Weather Information

The National Weather Service (NWS) 1900 surface analysis chart located an intense area of low pressure along the eastern North Carolina-Virginia border. A warm front extended eastward from the low, and a cold front extended southward over the southwest Atlantic Ocean. The chart also showed a ridge of high pressure over northern New England.

Strong easterly to northeasterly surface winds were shown extending from Virginia through central New England. Mostly light to moderate snow was indicated from Pennsylvania through the New York area.

The New York City public forecast issued by the New York Forecast Office at 1510 included the following:

> Winter Storm Warning Tonight and Thursday...
>
> Coastal Flood Warning Thursday Morning for Kings-Queens-Richmond...

Coastal Flood Watch Thursday Morning for Bronx-New York (Manhattan)...

Wind Advisory Tonight and Thursday...

Tonight...Snow...Mixing with sleet and possibly freezing rain by midnight. Accumulations of 3 to 6 inches of snow and ice. Lows of 30 to 35. Wind northeast 15 to 25 mph increasing to 25 to 35 mph with gusts to 40 mph after midnight. Chance of precipitation near 100 percent.

1.7.2 Surface Weather Observations

The weather observations at LGA were taken by Weather Experts, Inc., a private company under the NWS contract.[10] The company's primary assignment was to take and disseminate weather observations. In addition, the contract observers assisted in disseminating local airport advisories prepared by the NWS. The LGA observing facility was located at the Marine Air Terminal Building in the southwestern part of the airport. The NWS reported that the last inspection of the LGA weather office was on June 23, 1992. The inspection found no significant discrepancies in the LGA observations program.

The two weather observations at LGA, taken closest in time to the crash, were at 1750 and 1803 as follows:

Time--1750: Type--Record; indefinite ceiling, sky obscured, vertical visibility 700 feet, visibility 3/4 mile, light snow and fog, temperature 28° F., dew point 26° F., winds 060° at 21 knots gusting 31 knots, altimeter setting 30.13 inches of Hg; Remarks--runway 04 visual range 6,000 feet plus, drifting snow.

Time--1803: Type--Special; indefinite ceiling, sky obscured, vertical visibility 500 feet, visibility 1/2 mile, moderate snow and fog, winds 050° at 23 knots, altimeter setting 30.12 inches of Hg; Remarks--runway 04 visual range 6,000 feet plus, tower visibility 3/4 mile, drifting snow.

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[10] Regarding weather information, all heights are given above mean sea level (msl), unless noted. Heights given in surface weather observations and terminal forecasts are above ground level (agl). All wind directions are given in reference to true north, unless noted. All distances are given in statute miles, unless noted.

The LGA Surface Weather Observations forms for March 2, listed sunset at 1748. The form showed that 2.4 inches of snow fell between 1245 and 1840, and an additional 2.1 inches fell from 1840 to midnight. The 1840 and midnight snow depths were recorded as 3 inches and 5 inches, respectively.

The LGA weather observer, and his assistant, who were on duty at the time of the accident, were interviewed. The observer stated that 1.8 inches of snow was measured on the ground at 1800. He also stated that the average height of snow drifts was around 9 inches. The observer stated that he calculated the ratio of snow to water equivalent to be about 12 to 1, and he characterized the snowfall as dry.

1.7.3 Recorded Weather Measuring Equipment

Wind Gust Recorder.--The NWS anemometer was positioned about 20 feet above ground level (agl), near the FAA centerfield anemometer along runway 04/22. According to the trace from the recorder, about the time of the accident, wind speeds were measured between about 18 and 27 knots during the period between 1755 and 1800. Wind directions were not recorded.

Record of Precipitation.--The rain gauge was located on the roof of the Marine Air Terminal Building. The observer work sheet showed 0.1 inch of snow accumulation between 1740 and 1300. During the same interval, the Record of Precipitation reported 0.01 inch of water equivalent.

Runway Visual Range (RVR).--RVR transmittance readings were recorded at the weather observatory for runways 04 and 22. The minimum transmittance values for the two transmissometers were recorded between 1755 and 1800 to be about 0.80. The light setting during this period is unknown. However, according to the Federal Meteorological Handbook, Number 1, Surface Observations, Table A3-6C, the transmittance value of 0.80 at light setting three corresponded to an RVR of 6,000 feet; and at light settings four and five, the corresponding RVR was 6,000 feet plus.

1.8 Aids to Navigation

There were no known difficulties with aids to navigation.

19 Communications

Other than a garbled evacuation call on the aircraft public address system, from the cockpit to the cabin, there were no known difficulties with communications.

1.10 Aerodrome Information

LGA is owned and operated by the PNY&NJ, Flushing, New York. The airport is located on Long Island's Flushing Bay, about 4 miles east of Manhattan The field elevation is 22 feet above mean sea level (msl). The airport is certificated in accordance with Title 14 Code of Federal Regulation (CFR) Part 139. *(See* figure 2).

The airport is served by two runways. 4/22 and 13/31. At the time of the accident, both runways were 7,000 feet long and 150 feet wide (the runway 31 threshold was displaced 175 feet). Runway 13 was grooved asphalt, except for the first 900 feet, which was constructed of grooved concrete on an elevated deck above the Rikers Channel portion of Flushing Eay. Runway 13 was configured for *Category* I instrument approaches and equipped with high intensity edge lights and centerline lights.

The airport has an FAA-approved emergency plan, and is certificated at Aircraft Rescue and Fire Fighting (ARFF), "Index D," in accordance with 14 CFR 139.[11] LGA has an FAA approved Snow and Ice Control Plan, in accordance with 14 CFR 139.313. The airport has published precision and non-precision instrument, and visual approaches, and published departure routes.

1.10.1 Runway Safety *Area*

The distance from the departure end of runway 13 to the beginning of the slope of the seawall was 200 feet. Title 14 CFR 139.309, "Certification and Operations: Land Airports Serving Certain *Air* Carriers," requires that runways constructed, reconstructed, or significantly expanded on or after January 1, 1988, have safety areas which conform to dimensions set forth in FAA 150 series advisory

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[11] Index D is the FAA ARFF index for air carrier aircraft of at least 126 feet but less than 159 feet in length. 14 CFR 139 requires a minimum of three ARFF vehicles available, carrying an amount of water and commensurate quantity of AFFF so that the total quantity of water for foam production carried by all three vehicles is at least 4,000 gallons.

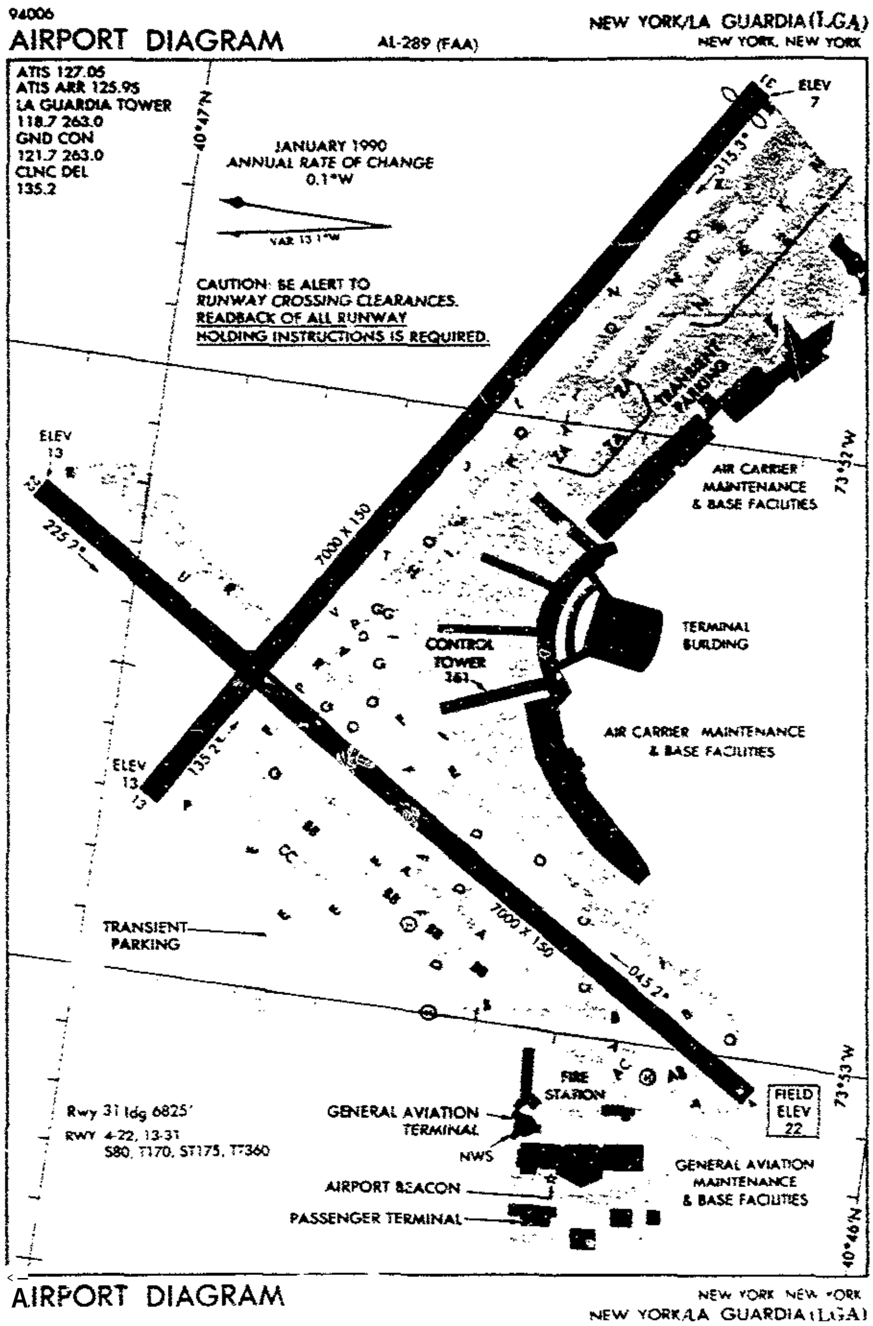

Figure 2.--Airport diagram.

circulars (AC). FAA AC 150/5300-13, "Airport Design," depicts runway safety areas of 1,000 feet beyond each runway end. There was no reconstruction or significant expansion of runways 13/31 after January 1, 1988, that would meet the criteria for extending the safety area. The PNY&NJ has informed the Safety Board that construction of a partial RSA [runway safety area] at runway 31 has begun and that completion is scheduled for late 1995.

1.10.2 Surface Conditions on Runway 13

The PNY&NJ Deputy Chief, LGA, stated that snow treatment activities began about 1430 on March 2, 1994. Both runways received several applications of plowing, brooming, sanding, and spreading of solid chemicals. Runway 13 was being used for takeoffs only, and runway 4 was being used for landings.

At 1710, PNY&NJ Operations received reports of snow building up on the north end of the airport. Runway 13 was plowed, sanded, and chemically treated, over its full length and width. At 1715, NOTAM No. 03/003 was issued. It *stated,* "R/W 13/31 thin covering of wet snow. R/W has been plowed sanded and treated with solid chemical."

At 1730, PNY&NJ Operations received some reports of poor braking action on runway 4/22. Trucks were sent to sand that mway. At 1735, an American Airlines captain requested a predeparture check of runway 13. The check was begun, but before it was completed, the captain stated to the deputy chief that he was satisfied with the apparent condition of the runway, and the check was stopped at Taxiway Tango at 1755.

The deputy chief also recalled that he received a report from a USAir departing flight of slippery takeoff conditions on mway 13. Two trucks were holding short of mway 13 for additional sanding when the accident occurred. The deputy chief stated that although no friction tests had been taken, using the PNY&NJ's Saab Friction Testing Vehicle,[12] he described the braking action as good, using the brakes on his PNY&NJ operations automobile.

The deputy chief explained that friction tests of runway surface conditions are made in accordance with PNY&NJ standard operating procedures,

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[12] Surface friction testing equipment installed in a Saab automobile.

which were developed from FAA AC 150/5200-30A, "Airport Winter Safety and Operations." During ice and snow conditions, tests are initiated upon request, and/or when deemed necessary by the Snow coordinator.

1.10.3 Runway Friction Tests

About 25 minutes after the accident, the PNY&NJ field supervisor performed a Saab friction test on runway 13. During the test, the field supervisor drove the vehicle approximately 10 feet to the right of runway centerline, at 40 miles per hour. The intensity of the snowfall increased during this testing period. He stated that the v i s i i i was poor, and, m his opinion, the depth of the snow and slush was consistent with the readings he received. The readings for coefficient of friction (Mu) were as follows:

Segment A (the first 2,300 feet of runway 13):	0.16
Segment B (the second 2,300 feet of runway 13):	0.22
Segment C (the third 2,300 feet of runway 13).	Incomplete

Due to traffic restrictions, the check began about 300 feet from the beginning and stopped about 1,200 feet from the end of the runway.

On March 4, 1994, investigators oversaw a PNY&NJ friction test of nmway 13. It was a dry test (onboard water m the Saab Friction Test Vehicle was not used). There was no snow on the runway at the time of this test, and the runway was dry. The average M u in the test was 0.72.

1.11 Flight Recorders

An operable CVR and FDR were removed from the airplane after Safety Board investigators arrived at the site of the accident. The two recorders were flown to the Safety Board's laboratories in Washington, D.C. Both cases were intact, and both recorders provided recordings of excellent quality.

1.11.1 Flight Data Recorder (FDR)

The digital FDR was a Sundstrand Model UFDR-HXUS. It contained 25 hours of recorded data from the accident and eight previous flights, all of which were recovered. It contained 87 parameters of recorded information.

1.11.2 Cockpit Voice Recorder (CVR)

The airplane was fitted with a Fairchild Model A100 CVR, which makes an audio recording of the cockpit environment and the captain and copilot radio channels. The recording was stored on a 30 minute endless loop magnetic tape recording medium. The recording commences with the application of AC power to the airplane and runs continuously until the power is removed, recording over the oldest data after 30 minutes.

The CVR recording begins with the crew performing the "After Start" checklist, which should follow the "Before Pushback/Before Start" checklist. The CVR produce a 31 minutes and 29 seconds continuous recording, which ended after the airplane came to rest on the seawall. CVRs normally record for slightly more than the 30 minutes they are now required to record.

Recorder manufacturers have recently introduced CVRs that store 2 hours of audio data and can replace existing 30 minute CVRs with no aircraft modification. These CVRs, which have gone into service on domestic and foreign aircraft, use solid state memory devices as the recording medium. The 2 hour solid state CVR (SSCVR) meet all current Technical Standard Order (TSO) requirements and have demonstrated improved reliability and crash/fire survivability capabilities when compared to 30 minute magnetic tape CVRs. According to industry sources, a 2 hour SSCVR will cost approximately 10 to 15 percent more than a 30 minute SSCVR.

1.12 Wreckage and Impact Information

1.12.1 Fuselage

The airplane came to rest on top of a dike, pitched nose downward, so that the underside of the nose of the airplane rested on a tidal mud flat on the Flushing Bay side of the dike. When investigators arrived at the airplane, the nose and generally the area beneath the cockpit floor, back to the forward cabin, were under water because the tide had risen. Due to strong winds, snow and freezing rain during the early morning hours of March 3, the airplane could not be moved. The airplane was moved from the dike during the afternoon of March 3. By that time, two periods of high tide had allowed salt water to enter the lower forward fuselage area.

Upon initial examination of the airplane, the forward cabin door, left and right aft overwing exits, and the first officer's cockpit windows were open. The flaps were extended in the 40-degree position. The leading edge slats were extended to the midposition. The radome was split vertically along the centerline. Skin, stringers, and frames from the forward fuselage were torn and buckled. The main landing gear remained down, resting near the runway side of the top of the dike. The nose landing gear assembly was fractured and the strut was forced backward into the forward electronic equipment (E/E) bay, and was nearly flush with the underside of the fuselage. The fuselage was buckled circumferentially in compression, forward of the wing roots. The cabin floor was buckled upward about 4.5 inches, at a location just forward of the circumferential fuselage compression from seat rows 5, 6 and 7. Along the bottom centerline of the fuselage, the skin was scraped and deformed upward, for an approximately 10-foot length below the wings, where the airplane had come to rest on top of the dike. Additional fuselage skin deformation was found in the midcabin area, aft of the compression buckle.

There was no damage to the vertical stabilizer, rudder, horizontal stabilizer, or elevators. The only apparent damage to the left wing occurred during recovery, when the outboard wing trailing edge contacted a pile of snow. The retractable landing light at the tip of the left wing was found in the extended position, with the lamp housing crushed and the lamp shattered.

The airplane was lifted from the dike by two heavy cranes and placed on a flatbed truck trailer. The airplane was moved to an enclosed maintenance hangar at LGA, where a systematic documentation of the airplane and its systems began on March 4, 1994.

1.12.2 Powerplants

There was no damage to either engine's nacelle cowl doors, thrust reverser, or engine cases and plumbing. The thrust reversers for both engines were found in the stowed position. There was no oil or metal present in the mixer, exhaust duct, or fan duct of either engine. The fourth stage turbine blades and vanes of both engines appeared in good condition, with no heat or mechanical damage apparent. Borescope examination of compressor and turbine section stages of both engines found no damage.

On the left engine, there were two small dents on the underside of the inlet cowl lip. All fan blades were found undamaged. The fan case rub strip showed no evidence of blade tip rub, and the inlet acoustic panels were undamaged. The low pressure rotor could not be easily rotated by hand, and when rotated, a heavy rub could be heard and felt. The high pressure rotor could be rotated easily by hand, by means of the starter. Subsequent disassembly of the engine revealed that some of the low pressure compressor first stage stator vanes were displaced rearward at the inner support and contacting the first stage rotor blades.[13]

On the right engine, the low pressure rotor could be rotated easily by hand. The high pressure rotor could also be rotated easily by hand through the starter gear. Fifteen fan blades had leading edge nicks, the most severe of which was about 1/4 inch by 1/4 inch, with a small tear from the corner of one blade. There were three small dents in the inlet acoustical panels. Subsequent disassembly of the engine disclosed no internal damage.

Because witnesses stated that the right engine continued to run after the flightcrew had attempted to shut down the engines, using the fuel shut-off levers, and that the fire handle had to be used, an additional examination of this system was made. The right engine fire handle in the cockpit was found in the extended position. It could be easily rotated to the agent No. 1 and agent No. 2 discharge positions, and would return by spring load to the neutral position. The right engine squib on the No. 1 full extinguisher agent container had been fired, and the container was found empty. The left engine fire handle was in the extended position and in the No. 1 agent discharge position. The handle would not return by spring torque to neutral, but it could be turned by hand with some difficulty. It could not be rotated from neutral to the No. 2 agent discharge position. Neither of the left engine squibs on the agent containers had been fired, and the No. 2 container had not been discharged. An electrical continuity check was made and confirmed that the fire handles were wired correctly to the agent discharge squibs.

After the airplane was recovered to the hangar, both fuel shut-off levers were functionally checked. Both levers moved easily through full travel and operated the shutoffs at the engine fuel controls.

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[13]Service experience with this model engine has shown that this condition can occur when the engine experiences compressor stalls.

1.12.3 Aircraft Systems

All flight control surfaces were found intact and undamaged. There were no observations of failure of any flight control surface or actuation mechanism. The rudder and aileron trim surfaces were found at the 0-degree position.

The horizontal stabilizer was found with the leading edge down. The cockpit indicator for horizontal stabilizer position indicated that the horizontal stabilizer was set at 6.5 units, airplane nose up (ANU). Measurement of the horizontal stabilizer jackscrew confirmed that the stabilizer was set at 6.5 units ANU.

The integrity and operation of the floor track, exit, and overhead emergency lighting systems were verified.

After the airplane was moved to the hangar, a visual examination of the pitot probes, ram air temperature (RAT) probe, and static pressure ports, revealed no anomalies. Each of the three pitot probes was found discolored; and the discoloration was characterized as normal. All three pitot probes appeared unobstructed. The RAT probe opening was filled with dirt and mud. All static ports were found clean and unobstructed.

All accessible pitot/static system plumbing was found intact. There was no accident-related damage to this system. The system drains at the forward cabin were clean and no fluid was present. The spring/ball mechanisms in the system indicated that there was no fluid in the system.

The static source selectors for the captain and first officer positions were found in their normal positions. Both primary airspeed indicators were undamaged, intact, and all failure warning flags were in view. The standby altimeter/airspeed indicator was undamaged and intact. Testing of the airspeed indication system is described in Section 1.16.1 of this report.

1.13 Medical and Pathological Information

All of the injuries sustained by the passengers were incurred while they were evacuating the airplane. Injuries were sustained as passengers jumped from the trailing edge of the wings onto the snow-covered ground, a distance of about 15 feet. The first officer sustained a back injury when the airplane impacted the dike, The most seriously injured passenger sustained a dislocated shoulder after falling from the wing.

1.13.1 Toxicological Testing

The captain and first officer submitted blood and urine samples on the evening of March 2,1994, in accordance with COA's drug testing program. The samples were tested at an independent laboratory for alcohol, as well as for amphetamines, phencyclidine, cocaine, cannabinoids, and opiates. The results of the examinations were negative for both pilots. The COA 'flight load planner at LGA also submitted a urine sample. His sample was negative for the above tests.

1-14 Fire

There was no fire.

1.15 survival Aspects

1.15.1 Aircraft Configuration

The two-member flightcrew were seated in the standard configuration The cabin was configured in two sections: First Class and Main Cabin. There were four rows. each containing four first class seats, and two seats were on each side of the single-center aisle. In the main cabin, there were 22 rows containing 5 seats in each row, 2 on the left side of the aisle and 3 on the right side. Aft of these 22 rows were 6 rows containing 3 seats each, all located on the right side of the aisle. In the rear of the cabin, the galley and lavatories were located on the left and right sides of the aisle. There were 110 passengers aboard the airplane, which included 1 infant (18 months old). There were no handicapped persons aboard. The passengers were distributed throughout the cabin. The seating capacity was 147. For the takeoff, the four flight attendants were seated m jump seats near the forward cabin doors and aft tailcone exits. No deficiencies were found in any of the seats or restraint systems. (The seating configuration is depicted in figure 3).

1.15.2 Flight Attendant and Passenger Interviews

COA provided sufficient information to contact 95 passengers by telephone or mail. There was also an 18-month-old infant listed, the only child on board. All of the adult passengers on the list were interviewed by Safety Board investigators. Safety Board investigators told on-site COA management that they wished to interview flight and cabin crewmembers on site. COA agreed to provide the flight attendants for interviews beginning at 1000 on March 3, 1994. However, due to internal COA miscommunications, the airline released the fight attendants on March 2, 1994, to return to DEN. Safety Board investigators subsequently took formal depositions in DEN, 6 days after the accident.

1.15.3 The Emergency Evacuation

When the airplane came to rest, a portion of the forward cabin floor was deformed upward and the cabin interior ceiling and side walls were separated m the same area, in the vicinity of rows 5, 6 and 7. Overhead bins were also displaced downward about 6 inches on both sides of the forward cabin. Other than in the area of the displaced cabin floor, the seats remained in place. Passengers did not describe cabin damage as a problem during egress. Some passengers stated that there was a lack of guidance from the crew, with some reporting a sense of abandonment or similar words to describe their feelings prior to egress. Several passengers said that after the airplane came to rest, they did not hear commands from flight attendants. A male passenger reportedly stood up and yelled "stay calm, don't panic," which had a calming effect. some passengers recalled hearing a flight attendant state, "come forward." Some passengers stated that they heard the captain announce over the public address system "no fire, exit aft," which they interpreted as a directive to exit through the tailcone. Several passengers indicated that they thought the airplane was going to go or had gone into the water.

A flight attendant seated in the rear of the cabin stated that after the airplane came to rest, the captain made an announcement that she heard as "exit aft." She designated a male passenger to hold other passengers back until she checked to ensure that the tailcone exit slide had deployed. She entered the tailcone, walking uphill, and saw the slide pack lying in its normal stowed position on the end of the catwalk. She sat down due to the heavy wind blowing in the exit, and kicked the slide off the end of the catwalk. After she pulled the inflation handle a number of times, the slide inflated. However, the bottom of the slide was hanging about 20 feet above the ground. She reentered the cabin and directed the passengers to go forward and out the next exit. With the aid of her personal flashlight (penlight), she moved forward to the first class section where she met the senior flight attendant who asked her if any people were in the aft lavatories. She returned and checked both lavatories. Finding no passengers in the cabin, she returned to the first class cabin and exited the R-1 galley door.

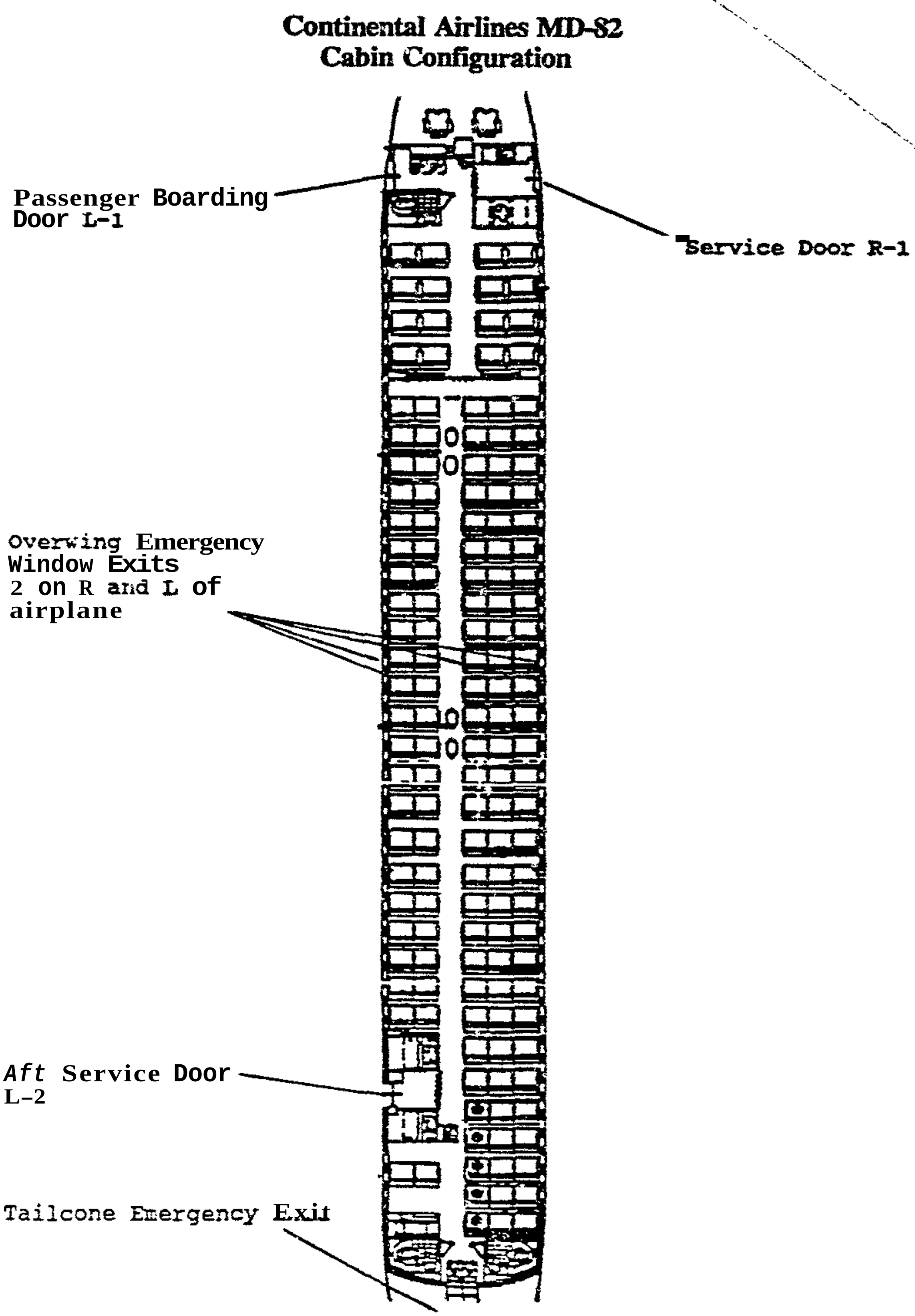

Figure 3.--Seating configuration.

Some passengers reported that the emergency cabin lights went out shortly after the airplane came to rest. Most of the passengers exited the airplane by way of the overwing emergency exits, Other passengers exited through either the forward left or forward right cabin exits (L-1 or R-1).

1.15.4 Airport Emergency Response

About 1758, LGA FAA Air Traffic control Tower transmitted a "Call 44,"[14] the emergency conference line to the PNY&NJ Police Emergency Garage (PEG). PNY&NJ responded with four ARFF trucks, carrying 9,100 gallons of aqueous film-forming foam (AFFF) and water, and eight fire-rescue personnel. Additional personnel responded m patrol units. The ARFF crew chief reported that ARFF trucks responded from the PEG on taxiway A via taxiway P. He then experienced sow. "fishtailing" of his vehicle as he crossed a nondesignated paved area, which was permanently closed to aircraft traffic. The units then proceeded down runway 13, arriving at the accident airplane about 2 minutes after the first alert.

Upon arriving at the airplane, the ARFF crew chief conferred with the incident commander. The incident commander established a temporary command post at the departure end of runway 13. The crew chief and ARFF officers then assisted with passenger evacuation and provided fire protection.

The incident commander was among the first of the PNY&NJ officers to arrive at the accident airplane, arriving about 1 1/2 minutes after the first alert. Immediately after he arrived, he entered the airplane through the R-1 door and talked to the cockpit crew. He told the pilots that the engines were still running. He then entered the cabin and instructed fight attendants and passengers to discontinue using the over-wing exits, and to exit through the R-1 door.

The incident commander then went to the temporary command post to coordinate mutual aid and medical services. Mutual aid units were staged at the preplanned staging area at Guard Post No. 3. The New York City Emergency Medical Service (EMS) then established a triage area at the Delta Air Lines passenger terminal.

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[14] A "Call 44" is defined in the LGA Airport Certification Manual as: "An actual or impending crash. Major aircraft accident or fire. Aircraft in dire emergency. Full response as indicated in the aircraft emergency plan will go into effect."

1.16 Tests and Research

1.16.1 Testing of Airspeed System Components

The METER SEL & HEAT, which controls heat to the pitot tubes/static ports, RAT probe, and AOA [angle of attack] was found to be slightly misaligned. When the switch was set to the OFF position, the switch "pointer" indication was approximately 1/3 of the distance toward the CAPT position. The misalignment of the switch existed as it was rotated throughout each position. Each position was clearly identified by a detent. The switch rotated freely without apparent binding or malfunction.

All Pitot-static system-related electrical circuit breakers were found closed. The nose landing gear was bent aft into the E/E [electronic equipment] bay and had to be forcibly removed so that the compartment could be entered. Evidence of salt water immersion was evident in the E/E bay. Mud, dirt, and weeds were removed from the opening of the compartment. All components inside the compartment remained in their installed positions.

Both CADCs and DFGCs exhibited evidence of immersion m salt water. All plumbing to both CADCs was found intact and undamaged. The No. 2 CADC (first officer's side) had minor impact damage to the function test selector switch,

All electrical connectors to the air data system components were mtact and undamaged.

After the CADCs were removed, all drains for the system were opened. Approximately 100 milliliters (ml) of clear fluid were collected from the alternate static system drain tire. All other drain lines were found either dry or contaminated with less than 1 ml of fluid.

A Pitot-static system test was connected to the three Pitot-static systems: captain's, first officer's, and standby. A leakdown test was performed, and each system passed Douglas Aircraft Company maintenance manual requirements for leakage.

With the CADCs removed, the captains and first officer's pitot systems were flow checked. No obstruction was found in either system When air flowed through them, no additional fluid or particles came from the systems.

The standby airspeed/altimeter system was functionally tested. The indicator and the system operated correctly.

When electrical power was connected to the airplane, the METER SEL & HEAT switch in the cockpit was selected to the CAPT position. At that time, all pitot probes, static ports, and the RAT probe were touched and were described as hot or warm. The ammeter on the ice protection panel indicated current flow m each position of the switch. When the switch was selected to OFF, an amber PITOT/STALL CAUTION warning also appeared concurrent with the selection. Rotating the selector switch to the CAPT position extinguished the annunciator light warning.

On March 5, 1993, the CADCs and DFGCs were examined and functionally tested at Honeywell. The tests revealed that they were functional with only non-critical failures noted that resulted from the damage caused by the accident and immersion m salt water. Also, tests of the Mach/airspeed and thrust rating indicators revealed minor tolerance anomalies that would not have prevented them from operating properly during the accident flight,

On March 17,1994, the airspeed and ram air temperature probes from the accident airplane were tested at the Douglas facilities, Long Beach, California.

Since the FDR data showed that the recorded airspeed from the first officer's airspeed system (No. 1 CADC) increased to 54 knots and returned to zero while the airplane was accelerating, tests were performed to determine whether a blockage of the pitot probe, followed by a bleed of total pressure through the pitot head drain hole on the bottom of the tube behind the inlet port, could have resulted in the indication apparent on the FDR. For the tests, an unplugged first officer's pitot was accelerated to a simulated 50 knots, and the pitot system drain can, the "Whitey" valve, was closed to trap pressure within the system. After allowing the airspeed to stabilize, the system was opened, and the pressure was allowed to bleed to ambient. The test was repeated in order to simulate the FDR airspeed trace.

However, test results indicated that the pressure bleed resulted in recorded airspeeds dropping from about 50 knots to zero within 1 to 2 seconds after the opening of the system. The tests were unable to replicate the FDR airspeed trace.

Additional tests were conducted to determine whether ram air temperature probe temperature increases immediately after nose strut extension (when the air/ground switch goes to the "air" mode) in the absence of air flow over the probe.

To begin both tests, the probe heat select switch was positioned to RAT. Ambient temperature readings were recorded. The left-hand ground control relay (BI-23) was then pulled, and the RAT probe was energized and allowed to heat. Temperature data was subsequently recorded.

In the first heat test, the RAT probe was allowed to heat in ambient air. After being energized, the RAT probe indicated an immediate temperature increase, both on the cockpit gauge and FDR-recorded temperature. The maximum recorded temperature was 104 degrees C.

For the second test, the RAT probe was immersed in a bucket of ice water to simulate the accident weather conditions. Once the temperature of the probe reached an ambient temperature (about 0 degrees C), the probe was again energized and allowed to heat. The recorded temperature during the test remained about 0 degrees C for the first 30 seconds of the test, then rose steadily over the next 30 seconds to about 20 degrees C. After the next 60 seconds, the RAT probe temperature had risen to about 30 degrees C, and remained at around 30 degrees for nearly 3 minutes. Finally, the RAT probe was disconnected and removed from the airplane. Probe removal recorded 535 degrees C on the FDR and flagged the cockpit indicator.

1.16.2 Aircraft Performance

The FDR indicated airspeed data were determined to be erroneous. Therefore, an airplane performance study was accomplished to determine groundspeed and time-distance histories of the airplane. Additionally, various takeoff/stop scenarios were examined. FDR longitudinal acceleration data, FDR pitch data, and prevailing winds were used to calculate indicated airspeed and distance traveled during the takeoff roll. (See figure 4).

The performance calculations were based on a takeoff on LGA runway 13, with a temperature of 28 degrees F. The wind that was used for the computation was from 050 degrees at 18 knots. This produced a headwind component of 6 knots. The dispatch performance calculations included engine anti-ice protection selected ON for the JT8D-217A engines.

The performance calculations produced takeoff speeds of V1 - 138 KIAS, Vr - 143 KIAS, V2 - 151 KIAS, flap retract speed - 156 KIAS, slat retract speed - 1% KIAS, and clean maneuvering speed - 244 KIAS. These calculations resulted in a takeoff flap setting of 11 degrees. The runway performance limit weight was 144,100 pounds.

The COA MD-80 series flight manual provided airplane limits and operational data, which listed the maximum allowable depth of standing water, slush, or wet snow for takeoff as 1/2 of an inch. The maximum allowable crosswind on takeoff was listed as 25 knots. COA restricted crosswind limitations to 15 knots if the runway was considered wet/slippery.

The data show that:

1. The accelerations and decelerations were consistent with expected airplane performance for the conditions present.

2. The takeoff was rejected at a computed indicated airspeed of 143 KIAS. (See figure 5).

3. The maximum computed indicated airspeed during the takeoff was 145.5 KIAS.

4. The airplane departed the end of runway 13 at a computed indicated airspeed of 53 KIAS.

5. The airplane struck the dike at a computed 39 KIAS.

6. The time between 60 KIAS and the start of the abort (as determined by the performance evaluation, not the cockpit indicators) was 19.25 seconds.

In addition, two takeoff/stop scenarios were evaluated to determine the stopping distances (1) if the rejected takeoff had been initiated at V1 (138 KIAS), or (2) if the dike had not been present (infinite length runway) for the actual speed of the rejected takeoff. These calculations assumed one second reaction time and used longitudinal acceleration from the FDR. Mu was not necessary for these calculations. The calculations revealed that:

1. If the takeoff had been rejected at, or about, V1 (138 KIAS), the airplane should have stopped 6,935 feet down the runway, about 65 feet from the runway end (about 265 feet from the dike). (See figure 6, scenario 1).

2. For the airspeed of the actual rejected takeoff (computed as 143 KIAS), the airplane would have stopped 159 feet past the dike, (about 358 feet beyond the end of the runway), if the dike were not present. (The computed maximum airspeed was 145.5 KIAS). (See figure 6, scenario 2).

The airplane performance study also revealed that the airplane should have been able to stop 1,320 feet from the end of the runway, if the runway surface were dry. (See figure 6, scenario 3). These computations assumed weight, thrust, and environmental conditions for the accident flight. The study also determined that the acceleration of the airplane, as compared to the nominal performance data for the airplane, was consistent with that for an uncontaminated runway, and the deceleration values were consistent with a slippery runway. (A Mu of 0.2 was used in these calculations).

1.17 Organizational and Management Information

COA was founded in 1935. At the time of the accident, it operated 360 aircraft, on both domestic and international flights. It had 45,000 employees, of whom 4,700 were pilots. It had 67 MD-80 series airplanes, flown by 600 MD-80 pilots. The certificate holding office (headquarters) is located in Houston, Texas.

The former Texas International, Peoples Express, New York Air, and Frontier Airlines have been become part of COA. COA also acquired assets from former airlines, Muse, Transtar, and Eastern.

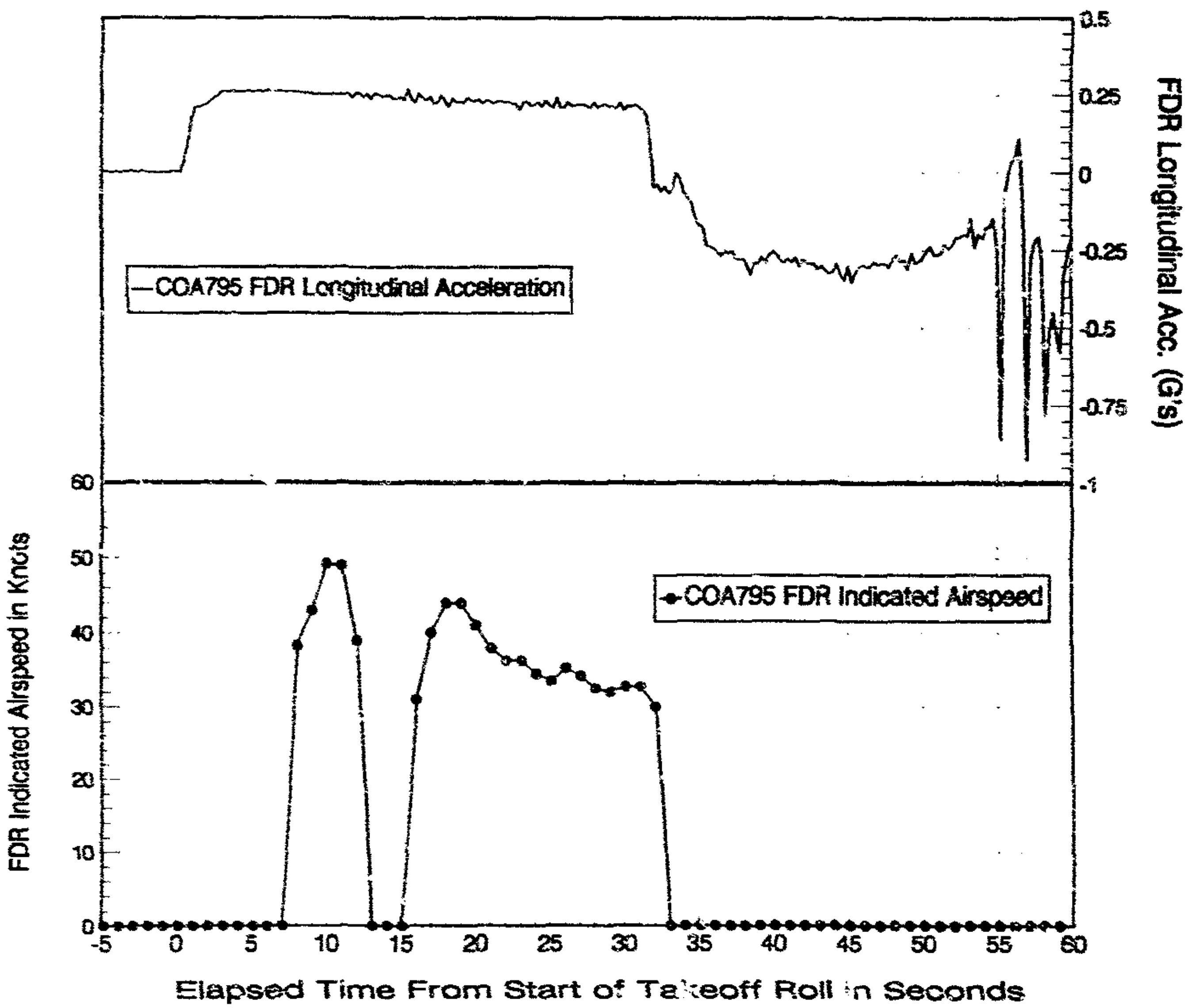

Figure 4.--FDR data.

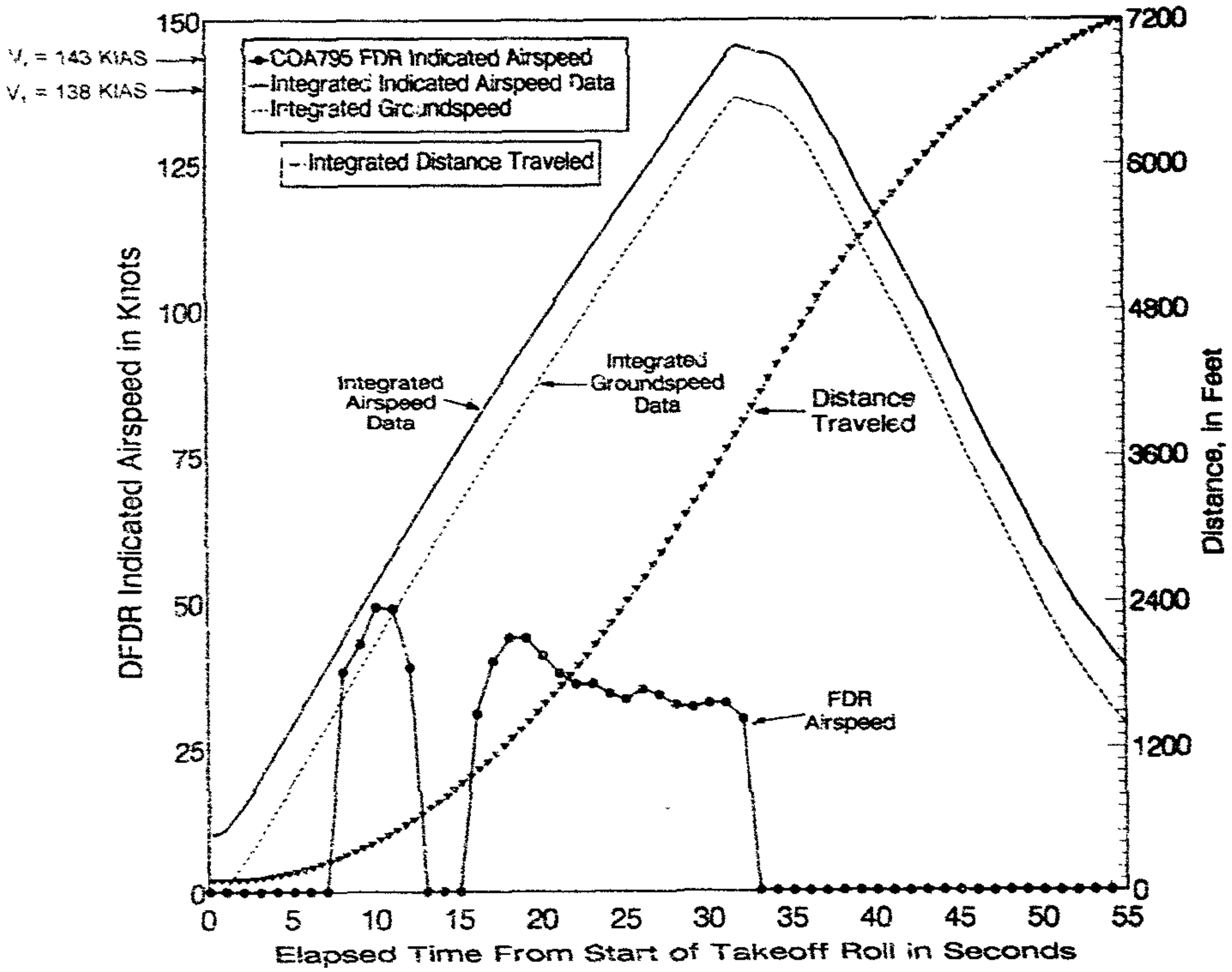

Figure 5.--Comparison of FDR airspeed and integrated airspeed.

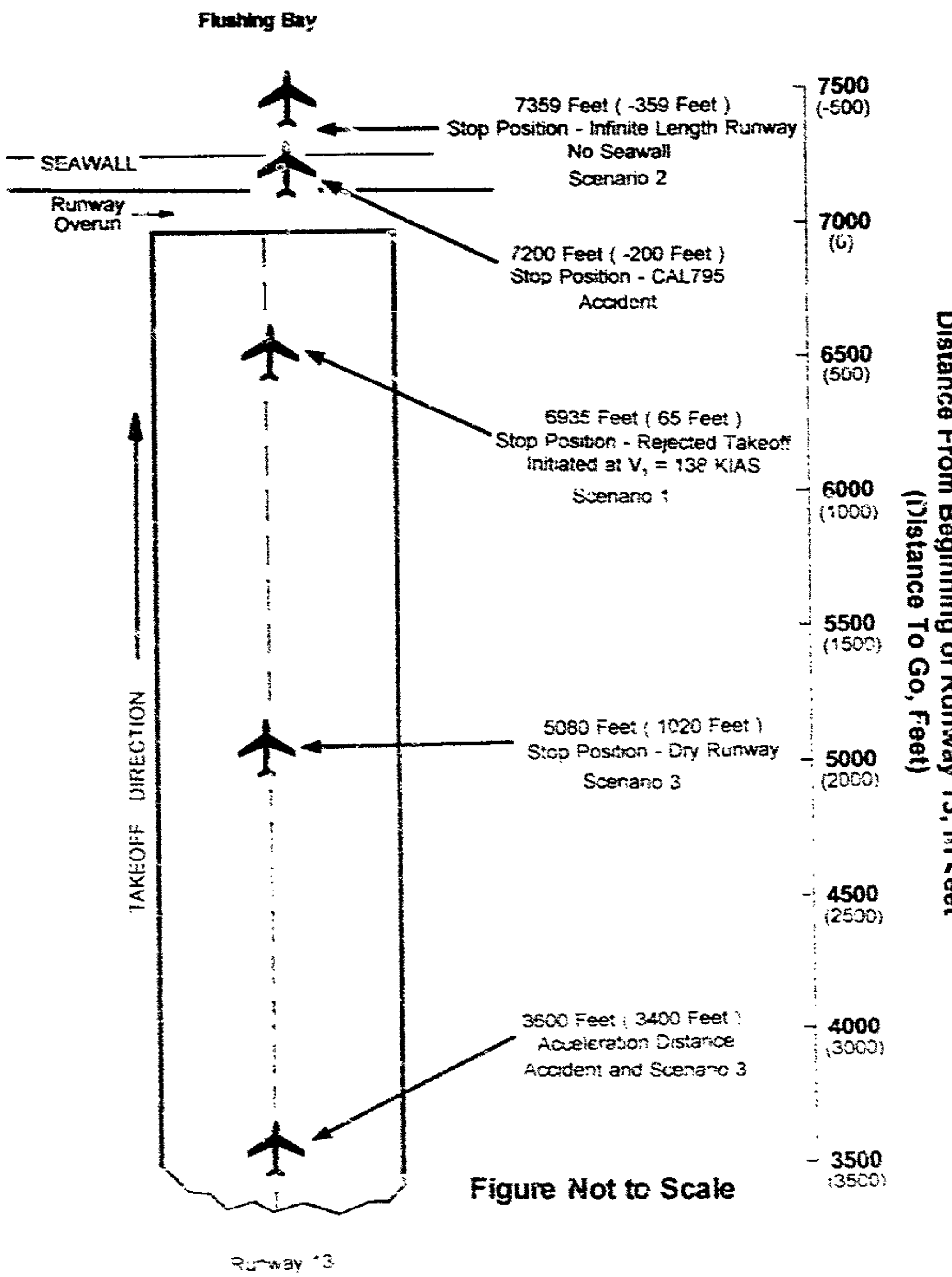

Figure 6.--Results of takeoff/stop scenarios.

COA uses a computerized recordkeeping system to track flightcrew training and evaluation. This system, which has been in place since 1986, recorded both unsatisfactory and satisfactory pilot training and evaluation performances. The system can be used to examine pilot records historically.

The COA MD-80 series Fleet Manager indicated that the COA operations manual was being completely revised. Flight manual quotations are from the revision current at the time of the accident.

COA's FAA Principal Operations Inspector (POI) became the POI on July 1, 1991, following an assignment as an Air Carrier Operations Specialist in the FAA's Southwest Regional Office. He described COA managers as conscientious. He said that his office had disagreed with COA management personnel regarding some issues, but that COA management had responded to him in a timely manner.

The POI for COA stated that the DC-9/MD-80 Aircrew Program Manager (APM) evaluated the RTO training and checklists before the POI approved them. The APM was qualified on the DC-9/MD-80 having had prior air carrier experience as a captain.

The POI stated that he could use more help in operations, but inspectors in his office were able to accomplish their work plan. He said that the FAA geographic inspectors in the other offices were covering his other requirements adequately.

Inspectors from the POI's office performed a focused inspection of COA operations during a 3-week period in January and February 1994. Inspectors observed from 40 to 55 en route flight inspections. The stated results were that some pilots were not following the checklists and standard operating procedures. The POI debriefed COA management regarding these results, and the company was reportedly committed to initiating remedial action.

1.18 Additional Information

1.18.1 Flight 795 Dispatch Information

Flight 795 was dispatch released at 1750 for the return leg or flight from LGA to DEN. The release fuel was reported as 32,400 pounds, with a planned taxi and en route fuel consumption of 800 pounds and 23,700 pounds, respectively.

The weather at DEN for the flight's planned arrival time was forecast to be clear, with the wind from 210 degrees at 8 knots. No alternate airport or alternate fuel consumption was listed in the dispatch release.

In addition to 110 passengers and a crew of 6, the flight was released with a cargo and baggage weight of 4,912 pounds. The aircraft's operating empty weight was 82,794 pounds, payload was 23, 613 pounds, fuel was 32,400 pounds, and the gross takeoff weight was calculated as 138,807 pounds, with a center of gravity (CG) of 13.8 percent of the airplane's mean aerodynamic chord.

1.18.2 COA Checklist Procedures

COA provided MD-80 series pilots with checklist guidance in Section 4 of the MD-80 Flight Manual. Checklist items that were to be accomplished prior to takeoff were "Before Pushback/Before Start," "After Start," "Taxi," and "Before Takeoff." COA normal checklists, up to but not including the "After Takeoff" checklists, were to be executed as follows:

> Receiving Aircraft [is] to be conducted on each originating flight and crew change. The procedure should be conducted in the designated order, however, minor variations in order are acceptable. The "Receiving Aircraft" shall be read after the checks outlined in the procedure have been accomplished and at a time when there are no distractions in the cockpit. Asterisks (*) define "Through Flight" procedures and checklist items.

The expanded checklist did not indicate whether the captain or first officer calls for this checklist; however, it was to be conducted by "First Officer Challenge - Captain Respond."

The "Through Flight" checklist, designated by the items having asterisks on the "Receiving Aircraft" checklis ould be accomplished if the following conditions were met:

1. The cockpit has been under the supervision of a flight crewmember.

2. A briefing has been conducted with the departing crew.

3. No maintenance has been performed that would significantly alter the cockpit configuration (switch or lever positions, panels opened, etc.).

4. "First Flight of the Day" checks have been signed off m the logbook.

COA's expanded checklist procedure for the "Before Pushback/Before Start" checklist stated, "The captain will call for the checklist when he is notified that the cabin door is being closed or when aircraft movement is imminent." This checklist was to be conducted by "First officer Challenge - Captain Respond." The first 8 of the 12 items listed were denoted by asterisks. The checklist was foliowed by a note, which st[illegible]with (*) are required prior to aircraft movement."

The expanded procedure regarding the "After Start" checklist indicated that the captain will call for it, after the engines have stabilized at idle *speed* and ground operations personnel on the headset intercom have been cleared to disconnect from the aircraft. It was to be accomplished by "First officer Challenge-Captain Respond."

The expanded procedure stated,

> After the "After Start" checklist is complete, the captain will call the "Taxi" checklist; the first officer will select the required flaps and obtain a taxi clearance. Flap movement on the ground should occur when clear of congested areas. This checklist is to be accomplished by "First Officer Challenge - First officer Respond."

Following the first eight items of the "Taxi" checklist, there was a break in the checklist that contained the "Delayed Engine Start" and "After [Delayed] Engine Started" checklists. These checklists were not labeled as those above, regarding which pilot is to perform the function: Challenge or Response. The expanded procedure stated, "Normaily, engine starts are to be accomplished by a coordinated crew effort, at a full stop with the parking brake set. In unusual circumstances, the captain may delegate the first officer to start the engines."

The expanded procedure for the "Before Takeoff" checklist provided that it was to be accomplished when the airplane was cleared into position for takeoff on the active nmway. It did not indicate whether the captain was to call for it or if it was is to be accomplished without a verbal order. This checklist was lo be accomplished by "Fii Officer Challenge - First Officer Respond."

Safety Board investigators interviewed seven COA pilots who were not part of the flight 795 flightcrew. All of them indicated that their method of performing the checklist was to "flow the panel" and then to read the checklist; that is, the pilots first set up the cockpit and position the switches and then read the checklist to verify settings and positions. Except for the "Receiving Aircraft" checklist's expanded procedure, the COA MD-80 series Flight Manual did not provide direction for pilots to flow then read. In the "Receiving Aircraft" checklist, there was no guidance regarding whether one pilot is to perform the flow or if they were to divide the flow between them.

On the "Taxi" checklist, the sixth item was "Flaps/Slats." The expanded procedure directed the first officer to perform the first five item, interrupt the checklist., and continue after positioning the flaps/slats following arrival at the end of the runway. Of the seven COA pilots interviewed, all but one stated that he would wait to run through the entire "Taxi" checklist at the time of positioning the flaps.

All seven COA pilots interviewed stated that they test the takeoff warning while taxiing by rapidly advancing and retarding the throttles. They indicated that COA's training department encouraged them to perform this test. This procedure did not appear on any of COA's checklists.

On the "Before Takeoff' checklist, the second to last item was "annunciator panel." The expanded procedure stated, "The Rudder Travel Unrestricted blue] light must be on. All other panel lights should be out, except those of an advisory nature." The COA MD-80 series Flight Manual provided guidance on the Annunciator Panel. It defined the colors of the lights as follows:

> Amber light - (Caution) Indicates a condition that requires corrective action.
>
> Blue iight - (Advisory) Indicates that a system is on or in operation.

The expanded procedure for the "Taxi" checklist stated, "If takeoff is to be made in rain or with water or slush on the runway, the APU should remain "On" for takeoff...." With both engines and the APU operating during takeoff, the amber "APU GEN OFF" light would remain illuminated on the annunciator panel. This procedure mandated takeoffs in conditions of water or slush (that is, with APU on) with an annunciator light of a color that was not "advisory in nature." (In the accident takeoff roll, the amber "APU GEN OFF" light should have been illuminated).

1.183 COA Checklist Procedures on the Pitot/Static System

At the time of the accident, COA's "Receiving Aircraft" checklist for the MD-82 airplane tasked the flightcrew with checking the pitot heat position. Although this item was not specified on the "Through Flight" checklist, the company's expanded checklist procedures indicated that it was subsumed under the checklist item "Ice Protection Panel."

COA's 'Before Pushback/Before Start" checklist indicated that the pitot heat was to be selected prior to pushback or engine start. This item was preceded by an asterisk, which indicated that it was required to be ON prior to aircraft movement COA's expanded checklist procedure indicated that the switch should be placed in the CAPT position.

indication that the pitot heat had failed or was selected OFF would be provided by an amber PITOT/STALL HEATER OFF light on the annunciator panel. The light was to come on simultaneously with the Master Caution lights. The COA MD-80 series Flight Manual described the function of the Master Caution lights as, "MASTER CAUTION light (2) - Both lights will come on when certain individual caution lights on the annunciator panel come on. Pushing either light will turn off both MASTER CAUTION lights and reset the system for subsequent indication."

If the pitot heat fails or is selected to the OFF position, the amber PITOT/STALL HEATER OFF light on the annunciator panel will illuminate and remain illuminated, even after the Master Caution lights are reset. When the Master Caution lights are reset, following indication of a caution signal, the system requires another caution signal to re-illuminate the Master Caution lights. During the course of starting the APU, starting an engine at the departure gate, and then starting an engine while taxiing, many amber annunciator panel warning lights will illuminate, resulting in the Master Caution lights illuminating during normal starting or the operation of the triggering system each time, requiring a crewmember to reset the Master Caution lights.

1.18.4 Checklist Items on CVR

Check airmen who had performed the most recent training and evaluations of the captain and first officer were interviewed. The check airmen slated that they could not recall specifics regarding the evaluation flights because they had performed several pilot evaluations subsequently. COA records indicated that both pilots had completed their evaluations satisfactorily.

COA pilots who had flown with the captain and first officer were interviewed. Also, the flightcrew's supervisory pilot was interviewed. The captain was described as using standard operating procedures, adhering to checklists, and having good communications and CRM skills. The first officer was also described in positive terms.

Pilot verification of pitot heat selection is accomplished in the challenge and response method on the COA "Before Pushback/Before Start" checklist. The accident CVR begins with the flightcrew going through the "After Start" checklist. According to COA checklist procedures, verification of pitot heat selection would have been prior to the beginning of the CVR recording.

The checklist is performed by both crewmembers in a challenge and response format. The introduction to COA's "Normal Procedures" stated:

> The checklist is to be read out loud m a loud, clear voice and the answers should be equally loud and clear, answered as printed. The response to checklist items printed "As Required" must state the configuration. (i.e., Exterior Eights, Nav On ,All Others Off). Any answer different from the printed response should mean that something is abnormal.... When completed, he will announce that the appropriate checklist has been completed.

COA procedures defined the flightcrew's duties and responsibilities regarding how some, but not al, checklists were to be initiated and completed. The captain was to initiate the "Before Pushback/Before Start" and "Taxi" checklists. COA did not make either pilot responsible for initiating the "Delayed Engine Start," "After Engine [Delayed] Engine Started," or "Before Takeoff" checklists.

The following are deviations from stated COA checklist procedures noted on the accident CVR:

a. The CVR begins at 1730:05, with the flightcrew going through the "After Start" checklist. Neither pilot called the "After Start" checklist complete.

b. The COA expanded checklist procedure for "Delayed Engine Start" stated, "If the use of the engine anti-ice is required for takeoff, the Belayed engine start procedure is not recommended." Engine anti-ice was used for takeoff. At 173038, the first officer stated the checklist item, "Engine anti-ice." The captain replied, "Ah it's on ah let's see – shall I turn this on now or wait'll after we start. wait'll we start then we'll turn that on." At 1754:53, while taxiing, the captain said, "Start up engine number two."

c. At 1754:53, the first officer started the remaining (right) engine, without calling out the "Delayed Engine Start" checklist. This checklist was not called out at any time by either pilot.

d. COA's single engine taxi procedure stated, "The use of two engines for taxi is also required when the ramps and taxiways are slippery and/or when anti-icing is required for takeoff." The right or No. 2 engine was started about 24 minutes after the first officer of flight 795 called for taxi.[15]

e. The captain did not call for the "Taxi" checklist. The first officer began to call out the items on this checklist about 1 minute before being told by LGA Tower, "...runway 13 taxi into position and hold." The first officer called out the flap/slat position at 1756:31.

f. At 1756:52, the first officer began to call out the challenges and the responses to items listed on the "After Engine [Delayed] Engine Started" checklist. He did not use COA published terminology to respond to "Engine Anti-ice" and

[15] The COA expanded checklist procedure states, "In unusual circumstances, the captain may delegate the first officer to start the engines." COA pilots, when interviewed, stated that it was common practice for the first officer to start the engines.

"Packs." He did not call out or respond to "Hyd [raulic] (Check Rt Pump)." He did not call the checklist complete.

g. As the flight was cleared into position on the takeoff runway at 1757:16, the first officer continued to call out items on the "Taxi" checklist. He did not call out or respond to the items: "Air Cond[ition] Auto Shutoff," or "Fuel Heat."

h. During the "Taxi" checklist, the first officer called out that the "utilities are on." This item was not on any COA MD-80 normal checklist.

i. At 1758:06, the first officer called the "Taxi" checklist "complete." The captain then asked the first officer, "you got the flaps out now don't ya." Flaps appeared as the sixth item on the "Taxi" checklist, and were called out by the first officer at 1756:31. These items were not in a challenge and response, but were stated in a continuous listing by the first officer.

j. At 1758:11, the first officer began the "Before Takeoff" checklist. There was no request to do so stated from the captain. The first officer called out all of the items on the checklist, and was finished at 1758:18. He did not call the checklist "Complete."

k. The sound of a crash occurred at 1759:46. At 1800:00, the first officer asked the captain what he wanted him to do. The captain stated a series of tasks for the first officer, including calling the company, getting out of the cockpit, shutting the engines down, shutting the electrical system down, and getting the speed brake. Most of these tasks appear on the "Emergency Evacuation" checklist. The captain did not call for this checklist. At 1800:34, the captain called for the "Abort" checklist.

1.18.5 COA Rejected Takeoff (RTO) Safety Training

COA modified its RTO procedures in January 1993. The modified training was delineated in a training bulletin and applied to subsequent simulator training. The bulletin listed considerations to be included in deciding whether to reject a takeoff. These conditions were divided into two categories: Below 100 KIAS and Above 100 KIAS. Two of the considerations listed in the "Below 100 KIAS" category were "Abnormal Acceleration" and "System Failure." All of the COA pilots interviewed stated that based on this training, they believed that they could successfully reject a takeoff for almost any reason as long as the airspeed was less than 100 knots. Most of these pilots also expressed the need for runway remaining markers to aid them in determining how the airplane was accelerating. In the new RTO training doctrine, first officers no longer had authority to perform the RTO.

1.19 New Investigative Techniques

None were used in this investigation.

2. ANALYSIS

2.1 General

The two-member flightcrew and four flight attendants were trained and qualified to conduct the flight in accordance with Federal regulations. The flightcrew received sufficient rest before the flight and had no critical life events that should have adversely affected the performance of their duties.

The airplane was properly maintained in accordance with an FAA-approved program. Although airspeed and autopilot-related computer writeups and corrective actions occurred during the 2 months before the accident, no evidence was found that any of the previous discrepancies were factors in this accident. The evidence shows that the only systems-related anomaly was that all pitot/static tubes and ports were not heated, thereby making the pitot inlet tubes susceptible to icing as the airplane accelerated on the runway. The evidence also supports the conclusion that the lack of heat to the pitot/static tubes and ports was the result of the select knob for those systems not being turned from the OFF position to any other position, which would have activated all heating elements. Extensive systems testing on the accident airplane determined that the pitot/static system heating elements were fully capable of producing heat if the select knob had been moved from the OFF position.

The lack of heat to the pitot system was significant in this accident because the captain's decision to reject the takeoff was prompted by his observation of the abnormal airspeed indication and his consequent belief that the airplane was not accelerating properly. He described his airspeed as bouncing once from 60 to 80 knots and returning to 60 knots. The FDR airspeed trace is consistent with the captain's observation. However, the FDR longitudinal acceleration trace showed normal takeoff values. An integration of acceleration values for the 32-second takeoff roll showed that the airplane reached a groundspeed of almost 133 knots. With 10 knots headwind component, indicated airspeed should have been 143 knots, 5 knots above V1.

The weather conditions, freezing temperatures and precipitation were known and were conducive to icing of the aircraft surfaces, pitot inlet tubes, and runway surfaces.

The analysis of this accident considered the reason for the inaccurate airspeed indication, the flightcrew performance before and during the takeoff roll, and the effect of the runway surface conditions on the stopping performance of the airplane. In addition to those factors directly related to the overrun, the Safety Board also considered the following in its analysis:

- The adequacy of the runway overrun and rejected takeoff safety;
- Air traffic control and LGA's implementation of a deicing plan:
- Airplane evacuation and airport emergency response;
- Efforts by industry and government to impose takeoff performance monitoring procedures and the development of related devices.

2.2 Reason for Airspeed Indication Anomaly

As an airplane passes through the air, the pressure at the airplane's nose is increased by an amount that is directly proportional to the square of the airplane's speed. The indicated airspeed system is simply a comparison of the pressure at the nose of the airplane, as measured at the inlet of the pitot tube (total pressure) and the local ambient pressure, as measured at the airplane's static ports (static pressure). If the inlet to the pitot system is closed so that the increase in pressure is no longer measured, the airspeed indication system will no longer function properly. If a static port is similarly clogged, the pressure differential measurement will not be accurate.

The pitot tubes of the MD-82 have a small hole behind the inlet that serves as a drain for water entering the inlet. If the inlet becomes clogged, and the drain hole remains open, the pressure sensed by the pitot system will equalize with the ambient static pressure so that the airspeed indication will return to its resting position.

The FDR acceleration and airspeed traces showed that the airplane accelerated normally and that the airspeed indication was valid when the airplane reached about 60 knots, but that it became sporadic thereafter and returned to its resting position, even though the airplane continued to accelerate. Tests conducted following the accident showed that the measured airspeed was consistent with the airspeed that would be indicated if the pitot inlet had become closed or partially closed at about 60 knots and pitot system pressure had bled off through the water drain hole.

The captain observed that both his and the first officer's airspeed indicators showed similar readings, and the FDR data recorded from the first officer's airspeed indicator confirmed this observation. Because the captain's and first officer's systems are completely independent of one another (different pitot tubes), it is evident that the inlets to both pitot tubes were at least partially closed before runway acceleration, an occurrence consistent with the buildup of ice at the inlets. Also, ambient conditions were conducive to the pitot inlet icing.

Protection against icing of the pitot inlets is provided by electrical heating elements in the pitot probes. The heating elements are energized by rotating the METER SEL & HEAT knob on the overhead panel in the cockpit to any position other than OFF. The positioning of the METER SEL & HEAT knob to provide heat to the pitot tubes, static ports, and ram air temperature (RAT) probe is a prestart checklist item. Because the prestart checklist was conducted before the CVR started recording, there was no positive confirmation that the checklist was properly accomplished. However, the captain stated that he placed the select knob in the CAPT position as part of the checklist.

During the examination of the cockpit following me accident, investigators found the METER SEL & HEAT knob in the detent for the CAPT position, a selection that would normally energize the pitot tube heating element. The Safety Board believes, however, that the captain's recollection of events could be based on his normal routine in checklist conduct rather than on specific activity associated with the accident flight. Further, the evidence of postaccident cockpit documentation of knob position is not considered conclusive since it is known that some levers, knobs and switches were moved in the aftermath of the accident during shutdown.

To the contrary, the Safety Board believes that the most compelling evidence supports the conclusion that the pitot tube heating elements were not energized during the takeoff roll because the METER SEL & HEAT knob was improperly positioned m the OFF detent. The postaccident examination of the ice protection system showed that all components functioned properly and that when energized, the heating elements were effective in providing heat to the pitot tubes and static ports.

The postaccident tests of the RAT probe also supported this conclusion. Activating the pitot/static system also energizes circuits that provide heat to the RAT probe when the weight-on-wheels logic switches to the airborne mode as the nose wheel strut is extended. In this accident, the nose wheel structure was sheared when the airplane hit the dike and the weight-on-wheels logic switched to the airborne mode. This switch was verified by the automated ACARS transmission. Since electrical power remained on in the airplane, the RAT probe heating element should have been energized after the airplane came to rest. Because there was no air flow past the RAT probe, the probe would have sensed the high localized temperature produced by the heating element in the absence of airflow. The temperature indications would have been transmitted to the TAT display on the thrust rating indicator and the TAT parameter on the FDR. Since the TAT system was found to be functional after the accident, and elevated temperatures were not recorded on the FDR, the Safety Board concludes that neither the pitot heat nor RAT heat was energized at the time of the accident.

The Safety Board found that the select knob pointer was positioned about a third of the distance between the OFF and the CAPT position, when the selector was in the OFF position detent. The Safety Board considered the possibility that the crew observed the knob and was misled by its position. However, the prestart checklist response procedure would have required the crew to check the current on the meter adjacent to the knob when selecting or confirming the knob's position. Also, a light on the overhead annunciator panel in the cockpit would have been illuminated, indicating that the pitot heat was off, as would the master caution light on the glareshield. (However, it would be normal for a flightcrew to reset and thus extinguish the master caution light before conducting a prestart checklist.)

The Safety Board believes that the pilots failed to conduct a prestart checklist properly and, subsequently, failed to observe the illuminated light on the annunciator panel. A second opportunity to detect the status of the pitot heat knob was the annunciator panel check just before the takeoff. In this case, the first officer called checklist items without the captain's request and without using normal challenge and response procedures as the airplane was being taxied into position for takeoff. The pilots appeared to be rushed, and there was no evidence that the first officer actually observed the annunciator panel. This failure and the failure to conduct a prestart checklist properly were direct causes of this accident.

The Safety Board believes that the activation of pitot/static and other air data heating systems should be automatic and should not require flightcrew actions. There have been many accidents because of frozen pitot/static systems over the years in various model airplanes, including transport category airplanes. The reasons for these accidents have always involved the lack of proper flightcrew actions. Many modern airplanes have automatic systems to activate the pitot/static (air data) heating systems. The Safety Board believes that current technology could be used to install such automatic systems on transport category airplanes to remove the possibility of flightcrew errors. Similarly, 14 CFR Part 25.1323 (e) should be amended to require such systems on newly certificated airplanes.

2.3 Flightcrew Performance Before and During Takeoff Roll

The flightcrew deviated from standard operating procedures in a number of significant ways that later affected the sequence of events leading up to the accident. Specifically, they delayed starting the second engine contrary to a COA requirement to taxi on two engines during conditions that require the use of engine anti-ice. This deviation contributed to their being rushed during final preparations for takeoff. They failed to use the Delayed Engine Start Checklist, missed items on several other checklists, and did not call checklists complete.

Prior to taking the runway, the first officer conducted a visual inspection of the wing, and the captain conducted an RTO briefing. The flightcrew appears to have initially conducted the takeoff in a proper manner, with the first officer controlling the airplane, and the captain performing the duties of the nonflying pilot, such as setting the power, and monitoring engine instruments and airspeed. The Board believes that had the captain been monitoring the airspeed adequately, he would have noted and reacted to the discrepant airspeed indication sooner.

The normal time to achieve 60 knots would have been 14 seconds with about 600 feet of roll. The rejected takeoff was not initiated until 34 seconds after the start of the takeoff roll after the airplane had traveled nearly 3,600 feet. The airspeed indicator's needle apparently was not moving for nearly 20 seconds before the takeoff was rejected.

The Safety Board was unable to determine positively the reason for the captain's apparent delayed response to abnormal airspeed indications. The captain's command responsibility required him to monitor all aspects of the takeoff roll, with attention to the instrument panel, the view outside the windshield, and the first officer. Considering the flight's operating environment, which included a slippery runway, strong crosswind, reduced visibility, and a junior officer at the controls, it is apparent that the captain experienced an elevated monitoring workload during the takeoff roll. Still, the Safety Board believes that this situation should not have precluded the captain from attending to airspeed indications.

The Safety Board considered the possibility that this accident could have been prevented had the airplane been equipped with a takeoff performance monitoring system or had the flightcrew been required to use takeoff performance monitoring procedures. Although the subject of takeoff performance monitoring techniques and equipment has been of repeated interest, the concept has not been adopted by the air carrier industry.

As a result of previous takeoff accidents and studies, the Safety Board has supported the development of a reliable takeoff acceleration monitoring system. The purpose of the system, as envisioned, is to detect subnormal acceleration that could be caused by such factors as degraded engine performance, dragging wheel brakes, underinflated tires or runway contamination sufficiently early in the takeoff roll that a rejected takeoff could be initiated at a relatively low speed with sufficient runway remaining to bring the airplane to a safe stop. Several such systems have been developed and tested. However, the industry continues to believe that the complexity of design and the many variables involved in takeoff performance could affect system reliability and lead to unnecessary RTOs with their associated risk. Most of the systems that have been developed to date are based on the measurement of the airplane's inertial acceleration and the comparison of these data with theoretical values for the existing conditions. In this accident, flight 795, the airplane accelerated normally during the takeoff roll, albeit the airspeed indication was reading erroneously. Thus, unless the performance monitoring system incorporated airspeed measurement in its alerting logic, it is questionable whether such a system would have been effective in preventing this accident. It is more likely that the flightcrew would have been confused by the abnormal airspeed indication regardless of the status of an on board takeoff performance monitoring system.

The Safety Board believes, however, that a more simple takeoff procedure, similar to that used by some military pilots, would have been effective in prompting an RTO before the airplane accelerated to a speed above V1. This procedure involves a crosscheck of elapsed time and airspeed or a crosscheck of distance traveled and airspeed, the latter being contingent upon the availability of runway distance remaining markers, which are not yet a requirement for airports used by air carrier airplanes. Basically, the flightcrew must use operational data to predetermine the theoretical airspeed that the airplane will reach within a given time or distance for the existing takeoff conditions. The nonflying pilot is then required to ascertain that the airplane has reached the target airspeed at the corresponding time or distance.

The Safety Board is encouraged by recent improvements in RTO safety training that have been made by the aviation industry and implemented by COA and other carriers. However, the Board believes RTO accident experience indicates that a continuing need exists to provide flightcrews with a better means to verify acceleration during takeoff. Moreover, the Safety Board believes that this need could be met through procedural changes that incorporate currently available aircraft performance information.

Manufacturers of turbojet airplanes routinely develop acceleration data as a function of time during the certification process. These data could be reformatted to provide elapsed time values to target speeds, and made available as part of the airplane's performance data for use by flightcrews to verify acceleration during takeoff.

Accordingly, the Safety Board believes that the FAA should require the manufacturers of transport category airplanes to publish and distribute to operators of these airplanes specific elapsed times to target speeds, under normal acceleration, over the range of authorized operational conditions. Moreover, the FAA should require that the use of this information be incorporated as part of the takeoff performance data available to air carrier flightcrews. Finally, the FAA should require that this takeoff performance data be incorporated into all air carrier RTO training programs.

The captain's decision to reject the takeoff is difficult to fault under the circumstances, even though the pilots should have been aware of the airspeed indicator problem sooner. Once the decision to reject the takeoff was announced, the response to transfer control and transition to maximum deceleration was timely. The most significant deficiency in flightcrew performance was the conduct of the checklist, and the outcome of this failure was exacerbated by the captain's inadequate attention to the airspeed indicator early in the takeoff roll. The Safety Board has been unable to determine the source of the red light that the captain reported he saw on the instrument panel just below the glareshield immediately before his decision to reject the takeoff.

2.4 Effect of Runway Surface Conditions

The takeoff limitations for a transport-category airplane are defined in the operating rules of 14 CFR 121.189 and are described in terms of the maximum weight of the airplane that will ensure performance compatible with the runway length. The limitations applicable to a rejected takeoff state that the airplane's accelerate-stop distance must not exceed the length of the runway plus the length of any stopway. The airplane's accelerate-stop distance is in turn established as a part of the airplane's certification as described in the airworthiness standards of 14 CFR 25.109. Basically, the rules require that the airplane be capable of accelerating normally to a speed at which an engine failure or other emergency is recognized that prompts a decision to reject the takeoff so that the flightcrew's initial actions to decelerate are taken as the airplane reaches V1 speed, and the airplane is brought to a full stop within the accelerate-stop distance.

The braking portion of the accelerate-stop distance is demonstrated on a dry runway surface without use of the airplane's thrust reversers. No considerations are given in establishing accelerate-stop distances for reduced runway friction coefficients on wet or icy runway surfaces, and no adjustments to the length of runway are required for takeoff.

The accident airplane was well within the weight limitations, being about 10,000 pounds lighter than the maximum weight permitted, required for takeoff on the 7,000-foot runway.

According to the airplane manufacturer, the V1 speed for the accident airplane, with a gross takeoff weight of 138,807 pounds, using a flap setting of 11° with the existing meteorological conditions, was 138 KIAS. Under dry runway conditions, the airplane should have been able to accelerate normally and stop within a total distance of 5,680 feet, 1,320 feet before the end of the runway if braking was initiated at 138 KIAS. The accelerate-stop distance was calculated based on the use of full reverse thrust and giving some allowance for runway turn on distance.

Even with the reduced friction coefficient, the airplane should have been brought to a complete stop within the confines of the runway, if an RTO were initiated by V1. The combination of the reduced runway braking coefficient and RTO initiation *speed* resulted in the overrun.

2.5 Adequacy of Runway Overrun and Consideration of RTO Safety

The location of the dike (seawall), 200 feet beyond the takeoff end of runway 13, provided little room for runway overrun, and this distance is far less than the 1,000-foot safety area mandated in a nonretroactive law effective January 1, 1988. The 1988 requirement did not apply to runway 13. If the captain had rejected the takeoff below the calculated V1, or if he had, based on other input, overruled the indications from his airspeed indicator and allowed the first officer to rotate and take off, the length of the 7,000-foot runway, with its 200-foot safety area, would have been adequate to complete the maneuver successfully. In a rejected takeoff with the existing conditions, at an airspeed just below V1, the airplane may have stopped just on the runway.

The Safety Board supports the PNY&NJ and the FAA's construction of a partial safety area at the LGA runway 31 threshold; however, the Safety Board believes that if some type of deceleration area, such as a foam arrestor system,[18] were constructed over the partial safety area, it would provide an additional safety enhancement for airplanes that overrun runways.

On April 16, 1984, the Safety Board issued Safety Recommendation A-84-37 to the FAA on this issue as follows:

> Initiate research and development activities to establish the feasibility of soft-ground aircraft arresting systems and promulgate design standards if the systems are found to be practical.

The latest reply from the FAA concerning this recommendation was dated January 24, 1994, in which it described the ongoing tests. The Safety Board has classified this recommendation "Open--Acceptable Response."

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[18] A foam arrestor system is an area at the end of a runway that consists of layered panels of foam material; when an airplane encounters the material, the weight of the airplane causes the landing gear to partially settle into the panels, thereby decelerating the airplane. These systems are currently being tested by the FAA.

2.6 Air Traffic Control and LGA's Deicing Plan

Air traffic control and airport operations were not causal factors in the accident. However, a metering program for outbound traffic from the gates at LGA, resulting in a measured releasing of flights to taxi for takeoff, was not in effect before or during the accident. The LGA "Snow Desk" officer stated that he did not believe it was necessary to effect the airport's deicing plan because there were more departure slots than departure aircraft. No reasonable evidence exists that metered gate releases or other operational measures external to the accident flight would have prevented this accident. None of the external factors contributed specifically to the pilots' failure to monitor the checklist items. Since this accident, the procedure for implementing the deicing plan at LGA has changed. The plan is now put into effect as soon as any snow begins to fall.

2.7 Airplane Evacuation and Airport Emergency Response

The Safety Board found some disturbing aspects about the emergency evacuation. For example, the flightcrew failed to shut down the engines before the captain issued instructions to evacuate. His instructions were perceived by flight attendants and passengers as being ambiguous and confusing. The flightcrew performed the shutdown procedures when told to do so by a firefighter who had entered the cabin at the L-1 exit. Unfortunately, during the shutdown procedure, the crew turned off the emergency lighting system which prevented the cabin emergency lights and the floor proximity lights from illuminating when the engines were shut down.

The flight attendants did not demonstrate assertiveness prior to and during the evacuation. For example, the cockpit was never queried on the extent of the situation before the captain ordered the evacuation some 55 seconds after the airplane came to rest. The flight attendants did not climb onto passenger seats and shout commands to direct passengers to useable exits to maximize the egress process known as "flow control." While these procedures are contained in the COA flight attendant emergency procedures manual, they are not practiced during recurrent training sessions. Therefore, it is not surprising that they were not followed during this evacuation.

The Safety Board's special investigation of flight attendant training programs at 12 air carriers examined the ability of flight attendants to perform appropriately during in-flight emergencies and during postaccident emergency evacuations.[19] Several flaws, inconsistencies, and shortcomings were found with both initial and recurrent FAA-approved training programs that affected flight attendants behavior during emergency situations, some of which were found in this accident.

The Safety Board's special investigation resulted in 13 safety recommendations to the FAA which addressed such diverse topics as: the lack of guidance given to principal operations inspectors regarding flight attendant training programs; the ability of flight attendants to retain information about the emergency equipment and procedures for the several airplanes in which they must be qualified; the fidelity of training devices; the need for cockpit and cabincrews to train together to develop the skills to communicate and coordinate effectively during emergency situations; and the need for realistic and interactive scenarios to practice emergency procedures.

In that special investigation, the Board found:

> Emergency situations typically require quick, assertive, and decisive action with little time for analysis of the situation. For most flight attendants, the only opportunity to practice skills needed in an emergency is during initial and recurrent training. These skills are perishable, and continuing and effective training is essential for maintaining them.

Safety Recommendation A-92-74 asked the FAA to require an evacuation and/or wet ditching drill group exercise during recurrent training. The Board believed that exercises having participation by both cockpit and cabincrews would be especially beneficial for crewmembers who operate airplanes with two-person cockpit crews.

The FAA did not agree that the Federal Aviation Regulations need to be amended because it believes that current training is adequate. Nonetheless, it requested that the Aviation Regulation Advisory Committee (ARAC), Subcommittee on Training and Qualifications, examine the possibility of improving training. The Safety Board classified the FAA's response to this safety

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[19]See "Special Investigation Report. Flight Attendant Training and Performance During Emergency Situations," NTSB/SIR-92/02, June 9, 1992.

recommendation "Open--Acceptable Alternate Response" on June 8, 1993. No further correspondence has been received from the FAA on this recommendation.

Safety Recommendation A-92-77 asked the FAA to require that flight attendants receive crew resource management (CRM) training that includes group exercises to improve flightcrew and cabincrew coordination and communication.

The FAA agreed with the intent of the recommendation and asked the ARAC's Subcommittee on Training and Qualifications to develop an Advisory Circular (AC) on CRM that includes flight attendants. The Safety Board classified the FAA's response to this safety recommendation "Open--Acceptable Response" on June 8, 1993. No further correspondence has been received from the FAA on this recommendation.

Nevertheless, the Board is aware that on December 8, 1994, the FAA issued a Notice of Proposed Rulemaking (NPRM) that proposes to revise the training and qualification requirements for certain air carriers and commercial operators. If this NPRM becomes a final rule, these operators will be required to provide approved CRM training not only to flight crewmembers but to their flight attendants, as well as to aircraft dispatchers.

Rescue equipment began to arrive at the crash site about 2 minutes after the airplane came to rest. The airport emergency response was timely and effective.

2.8 FAA Checklist Approval

The COA normal checklists that were used by the accident flightcrew were approved by the FAA October 24, 1991. These checklists do not reflect guidance contained in the Air Transportation Inspector's Handbook, FAA Order 8400.10, Volume 3, Section 5, dated June 30, 1991. In summary, the COA normal checklist policies for managing checklists do not consistently specify which crewmember is responsible for initiating or accomplishing each item on the checklist, do not define crewmember responsibilities for bringing to the attention of the pilot in command any observed deviation from prescribed procedures, do not include a policy for management of interrupted checklists, and do not specify that in the taxi and pretakeoff phases, specific aircraft configuration items, such as flaps, should be confirmed and responded to by both crewmembers.

The Safety Board believes that the FAA should require COA to meet the standards for flightcrew checklists and that it should ensure that specific checklist callouts and responses are addressed logically and expeditiously.

The Safety Board has addressed the issue of inadequate checklist procedures by airline pilots several times over the years. Most recently, in a letter dated February 3, 1994, to the FAA Administrator, the Safety Board issued two safety recommendations that addressed the issue of flightcrew checklists. The safety recommendations resulted from a safety study of 37 flightcrew-involved major accidents of U.S. airlines from the years 1978 through 1990.[20] In that study, the Safety Board found that six of the eight takeoff accidents studied involved procedural checklist failures on the part of the flightcrews during the taxi phase of operation. The recommendations were:

> <u>A-94-001</u>
> Apply the results of research conducted to date on the design and use of checklists to improve the error-tolerance of air carrier checklist procedures for taxi operations by enhancing flightcrew monitoring/challenging of checklist execution, providing cues for initiating checklists, and considering technological or procedural methods to minimize the omission of any items on a checklist. Provide specific guidance to air carriers for implementing these procedures.
>
> <u>A-94-003</u>
> Require U.S. carriers operating under 14 Code of Federal Regulations (CFR) Part 121 to provide, for flightcrews not covered by the advanced qualification program, line operational simulation training during each initial or upgrade qualification into the flight engineer, first officer, and captain position that: (1) allows flightcrews to practice, under realistic conditions, nonflying pilot functions, including monitoring and challenging errors made by other crewmembers; (2) attunes flightcrews to the hazards of tactical decision errors that are errors of omission, especially when those errors are not challenged; and (3) includes practice in monitoring and challenging errors during taxi operations,

[20] See "Safety Study, A Review of Flightcrew-Involved, Major Accidents of U. S. Air Carriers, 1978 through 1990." (NTSB/SS-94/01).

specifically with respect to minimizing procedural errors involving inadequately performed checklists.

On April 26, 1994, the FAA responded to the recommendations stating that it agreed with both recommendations and that it plans to issue an Advisory Circular addressing the issues cited in Safety Recommendations A-94-001 and 94-003. On July 6, 1994, the Safety Board classified the FAA's actions "Open--Acceptable Alternate Response." The Safety Board is awaiting final action by the FAA on this important matter that has been a factor in many previous airline accidents, including the accident that led to this report.

The checklist deviations and other pilot procedural deficiencies noted by the FAA during a special inspection, which included numerous en route inspections about 1 month before the accident, suggest that the problems identified in this accident regarding improper checklist procedures were systemic at COA. If pilots fail to adhere to procedures during en route inspections by FAA inspectors, they most likely behave in a similar manner when no inspector is present. Despite the COA POI's efforts to correct this situation with COA management, the actions recommended in A-94-001 and -003 appear to be appropriate for COA.

2.9 Adequacy of CVR Recording Duration

The investigation was hampered by the lack of CVR information covering the time the flightcrew would have been expected to perform the "Before Pushback/Before Start" checklist. Investigators had no documented evidence concerning how or if the flightcrew performed the "Before Pushback/Before Start" checklist, and they had to rely entirely on the flightcrew's recollection.

The FDR and CVR information, in conjunction with other physical evidence and extensive postaccident testing, proved conclusively that the pitot/static heat system was serviceable but that it was not turned "on" prior to the start of the takeoff roll. However, there was no recorded evidence as to why the pitot/static heat was not selected.

The Safety Board has investigated several other accidents and incidents in which vital CVR information has been written over and lost because of the 30 minute recording limitation. For example, on February 19, 1985, China Airlines, flight 006, a B-747, departed controlled flight while cruising at 41,000 feet. The airplane descended to 9,500 feet before control was regained. One flight attendant was injured, and the airplane sustained substantial damage during the descent and recovery. A successful landing was made at San Francisco more than 1 hour after the incident. All of the discussions and other audio information in the cockpit during the event were lost because of the insufficient duration of the recording. On September 8, 1989, USAir flight 105, a B-737, descended below the minimum descent altitude and struck four electrical transmission wires located approximately 75 feet above the ground and 7,000 feet east of the runway threshold, while on approach to Kansas City International Airport. The approach was abandoned, and the flight diverted to Salina, Kansas, where a successful landing was made more than 1 hour after the incident. Again, the important discussions and other audio information that occurred during the event were not available to the Safety Board in its investigation of the occurrence.

The Safety Board has recognized the advantages of an extended duration CVR in certain accidents and especially in incidents. However, until recently, the costs and technical difficulties precluded the feasibility of such recorders.

The availability of low cost, high density memory devices has made it possible for flight recorder manufacturers to offer 2 hour solid state CVRs (SSCVRs) that cost only 10 to 15 percent more than comparable 30 minute SSCVRs. Thus, 2 hour CVRs are now technically and economically feasible.

The international community has also recognized the need for 2 hour CVRs. The International Civil Aviation Organization (ICAO) and the European Joint Aviation Authorities (JAA) have both taken positions favoring 2 hour CVRs. In April 1992, the JAA issued a draft revision to require the forward fit of 2 hour CVRs. The draft is scheduled to be adopted in March of 1995. ICAO Annex 6 Part 1 recommends a 2 hour CVR for airplanes over 5,700 kilograms with an individual certificate of airworthiness issued after January 1, 1990.

The Safety Board believes that after December 31, 1995, all newly manufactured airplanes, and all airplanes brought into compliance with operating rules that require a CVR, should be required to have a 2 hour CVR. In addition, 30 minute CVRs that have reached the end of their service life should be replaced with 2 hour CVRs.

3 CONCLUSIONS

3.1 Findings

1. The flightcrew and flight attendants were trained and qualified to conduct the flight in accordance with FAA regulations.

2. The airplane was certified and maintained in accordance with COA and FAA requirements.

3. Both engines functioned normally.

4. Airplane performance was not a factor in the accident.

5. The computed maximum airspeed was 145.5 KIAS, 7.5 knots above V1.

6. Nineteen seconds elapsed between the time that the airplane actually accelerated though 60 KIAS (the first mark on the airspeed indicator) and the start of the rejected takeoff.

7. Total air temperature data recorded on the FDR indicated that the airplane's ram air temperature probe heating was not initiated after flight 795's air/ground system switched from "ground" to "air," when the nose landing gear collapsed at the end of the runway. This confirms that the pitot heat was not selected "on" by the flightcrew.

8. Extensive postaccident systems testing of the airplane found that the pitot/static heating and related airspeed indication systems were capable of fully functioning, if activated.

9. A buildup of snow and/or ice in the pitot/static system tubes and ports resulted in erroneous airspeed readings for the captain's and first officer's airspeed indicators during the takeoff/abort sequence.

10. There were substantial deviations from checklist procedures recorded on the CVR.

11. The 30 minute CVR on the airplane did not have a sufficient recording capacity to retain audio information for the time period in which the "Before Pushback/Before Start" checklist should have been accomplished.

12. Air traffic control was not a factor in the accident. However, the amount of time flight 795 waited at the runway for clearance to depart could have been reduced if the controllers, having monitored the traffic situation, had advised the "Snow Desk" at LGA of possible delays, and requested that the deicing plan be initiated.

13. Although the weather provided the ambient conditions for the accident, including freezing temperatures, snowfall, and diminished runway breaking conditions, weather was not a causal factor in the accident

14. Runway surface conditions were adequate for takeoff operations.

15. The airport emergency response was timely and effective.

16. The emergency evacuation was not conducted effectively due to insufficient and garbled cockpit and cabincrew communications, as well as failure of the cabincrew to take command of the evacuation process.

17. The flightcrew started the right engine shortly before taking the takeoff runway. This was in noncompliance with printed policy of Continental Airlines, to start both engines prior to leaving the gate in foul weather.

18. All passenger-related injuries were incurred as passengers jumped from the trailing edge of the wing onto the snow-covered ground.

3.2 Probable Cause

The National Transportation Safety Board determines that the probable causes of this accident were the failure of the flightcrew to comply with checklist procedures to turn on an operable pitot/static heat system, resulting in ice and/or snow blockage of the pitot tubes that produced erroneous airspeed indications, and the flightcrew's untimely response to anomalous airspeed indications with the consequent rejection of takeoff at an actual speed of 5 knots above V1.

4. RECOMMENDATIONS

As a result of this investigation, the National Transportation Safety Board makes the following recommendations:

–to the Federal Aviation Administration:

Require manufacturers of airplanes operated by air carriers to publish and distribute to operators specific elapsed times to target speeds (given normal acceleration, the times to given airspeeds). (Class II, Priority) (A-95-18)

Require that the elapsed times to target speeds be incorporated as part of the takeoff performance data available to air carrier flightcrews. (Class II, Priority) (A-95-19)

Require that air carrier rejected takeoff training include elapsed time to target speed takeoff performance data. (Class II, Priority) (A-95-20)

Require the modification of transport category airplanes to incorporate the automatic activation of air data sensor heating systems without flightcrew action. (Class II, Priority) (A-95-21)

Amend the requirements of Part 25.1323 (e) to require that, for newly certificated airplanes, anti-ice protection for the air data sensor heating systems is provided 'automatically (without flightcrew action) following engine start. (Class II, Priority Action) (A-95-22)

Require, after December 31, 1995, that all newly manufactured cockpit voice recorders intended for use on airplanes have a minimum recording duration of 2 hours. (Class II, Priority Action) (A-95-23)

–to Continental Airlines, Inc.:

Conduct a review of recurrent flight attendant training policies and procedures relating to all aspects of emergency evacuation training to determine if improvement or change is needed. (Class II, Priority Action) (A-95-24)

In addition, as a result of this investigation, the Safety Board reiterates the following recommendations to the Federal Aviation Administration:

A-92-74
Amend 14 CFR Part 121.417 to require an evacuation and/or wet ditching drill group exercise during recurrent training. Ensure that all reasonable attempts are made to conduct joint flightcrew/flight attendant drills, especially for crewmembers operating on airplanes with two-person cockpit crews.

A-92-77
Require that flight attendants receive Crew Resource Management training that includes group exercises in order to improve crewmember coordination and communication.

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

James E. Hall
Chairman

Robert T. Francis II
Vice Chairman

John Hammerschmidt
Member

February 14, 1995

5. APPENDIXES

APPENDIX A

INVESTIGATION AND HEARING

1. Investigation

The National Transportation Safety Board was notified of the accident by the FAA about 1845 est on March 2, 1994. Safety Board and FAA investigators arrived at the accident site about 0130 on March 3, 1994. Vice Chairman Susan Coughlin accompanied the investigators to the site.

The following investigation groups were formed on the site:

Aircraft Performance, Aircraft Systems, Aircraft Structures, Airport, Air Traffic Control, Human Performance, Operations, Powerplants, Survival Factors, and Weather.

In addition, investigation groups were formed for the CVR and FDR at the Safety Board's laboratories in Washington, D.C., and a Maintenance Records Group was established at the facilities of COA in Houston, Texas.

The following were parties to the investigation:

Federal Aviation Administration
Continental Airlines, Inc.
Independent Association of Continental Pilots (IACP)
Douglas Aircraft Company
The Port Authority of New York & New Jersey
National Air Traffic Controllers Association
Pratt & Whitney

2. Public Hearing

A public hearing was not held in conjunction with this investigation.

APPENDIX B

COCKPIT VOICE RECORDER TRANSCRIPT

RDO	Radio transmission from accident aircraft
CAM	Cockpit Area sound source
INT	Flight Intercom sound source
PA	Aircraft Public Address sound source
-1	Voice identified as Captain
-2	Voice identified as First Officer
-3	Voice identified as Male Ground Mechanic
-4	Voice identified as Female Flight Attendant
-?	Voice unidentified
GND	LaGuardia Ground Controller
TWR	LaGuardia Local Controller (tower)
UNK	Unknown source
CAWS	Central Aural Warning System
*	Unintelligible word
@	Nonpertinent word
#	Expletive deleted
%	Break in continuity
()	Questionable text
(())	Editorial insertion
-	Pause

Notes: All times are expressed in eastern standard time. Only radio transmissions involving the accident aircraft were transcribed.

INTRA-COCKPIT COMMUNICATION | AIR-GROUND COMMUNICATION

TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
1730:05	start of recording.		
1730:09 CAM-2	that looks good. okay start valve light?		
1730:13 INT-3	you're clear on two clear on two.		
1730:15 INT-I	clear to start.		
1730:17 CAM-1	okay start valve light is out.		
1730:18 CAM-2	you want ah go on two or just one?		
1730:21 CAM-1	I think just one.		
1730:21 CAM-2	okay.		
1730:23 CAM-2	electrical system?		
1730:24 CAM-I	checked.		
1730:25 CAM-2	external power APU?		
1735:26 CAM-1	APU is on.		
1730:28 CAM-2	galley power?		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
1730:30 CAM-1	off - on.		
1730:31 INT-3	cleared to disconnect?		
1730:34 INT-1	cleared to disconnect. thank you good day.		
1730:35 INT-3	yes sir		
1730:37 CAM-2	ignition?		
1730:37 CAM-1	is off.		
1730:38 CAM-2	engine anti-ice.		
1730:39 CAM-1	ah it's on ah let's see -- shall I turn this on now or we'll after we start. wait'll we start then we'll turn that on.		
1730:45 CAM-2	okay.		
1730:46 CAM-1	one is on.		
1730:47 CAM-2	packs?		
1730:47 CAM-1	are on.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
1730:48 CAM-2	door lights?		
1730:49 CAM-1	out.		
1730:50 CAM-2	hydraulics?		
1730:51 CAM-1	are ah checked.		
1730:53 CAM-2	cockpit sterile cockpit light on?		
1730:54 CAM-1	locked and on.		
		1731:06 RDO-2	Continental seven ninety five taxi.
		1731:10 GND	Continental seven ninety five Laguardia Ground runway one three hold for a US left on the inner and then taxi via inner echo hold short of runway four the US shuttle is comin' up on november now.
		1731:23 RDO-2	inner echo hold short of ah four.
1731:24 CAM-2			

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
1731:29 CAM-2	ah do you think we outta wait on the ah wait on the flaps until we get out there?		
1731:51 CAM-2	probably outta leave the ah APU runnin' huh?		
1731:53 CAM-1	yup.		
1731:56 CAM-2	until we get out of here. hit the wings about eight hundred feet.		
1733:11 CAM-1	boy USAir is sure creepin'		
1735:06 CAM-2	well okay. there's not much we can do 'til we get out there huh.		
1735:09 CAM-1	not much.		
1735:29 CAM-1	did you see runway one three on that weight sheet?		
1735:32 CAM-2	yes, I just looked to make sure if it - is runway one three.		
1735:50 CAM-1	what did they give for the max max gross takeoff weight?		
1735:54 CAM-2	forty four one.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
1735:56 CAM-1	okay.		
1736:12 CAM-2	you've got the zero fuel in?		
1736:14 CAM-1	I do. I put in one oh six five.		
1736:21 CAM-2	yeah yeah that's one three.		
1736:43 CAM-1	alright.		
1736:43 CAM-1	we're gunna get in a mess here snow's start buildin' - collectin' on the wings -- we cannot take -- we just cannot take any chances -- have to play it by the book.		
1737:03 CAM-2	what's this guy waitin' for?		
1737:07 CAM-1	he's holdin' for landing traffic.		
1737:15 CAM-2	oh well ah. is that the hold Line? I just can't see.		
1737:18 CAM-1	that's the runway right in front of him - I don't see this is for runway four then across the mway is right to one three.		
1737:25 CAM-2	yeah.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
1737:26 CAM-2	I just looking out there it looked like ah ---.		
1737:38 CAM	((sound of tape splice))		
1738:00 CAM-1	((sound of laugh))		
1738:06 CAM-1	yeah system breaks down.		
		1739:40 GND	Continental seven ninety five continue down to taxiway delta please via the outer and hold short of runway four on delta.
		1739:45 RDO-2	delta via the outer and we'll hold short of four Continental seven ninety five.
		1741:10 GND	Continental seven ninety five taxiacross runway four on delta turn right on double bravo and follow the American over there.
		1741:16 RDO-2	Continental seven ninety five cleared to cross four on to double bravo.
1741:27 CAM-2	it's clear what I can see.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
1741:59 CAM-2	he didn't say monitor tower did he?		
1742:03 CAM-1	I didn't hear anything about tower.		
1742:34 CAM-2	well what's you best guess, we crank it up or -- we gunna be number five or six here.		
1742:39 CAM-1	um yeah I I give it ah we'll be here at least ten minutes.		
1742:57 CAM-1	if you want to you can go back and ah take a the ah preliminary glance at the wings if its ah you know obvious that the stuff is buildin' up out there well then we just start makin' other plans.		
1743:10 CAM-2	uh huh.		
1343:12 CAM-1	ah let's plan to go back ah when we're number one and take a look at it again - make sure they're clear.		
1743:25 CAM-1	I'm not sayin' that you need to go back there now if you don't want to go back until we get to be number one.		
1743:34 CAM-2	ah.		
1743:40 CAM-1	ah just wait.		

INTRA-COCKPIT COMMUNICATION TIME & SOURCE	INTRA-COCKPIT COMMUNICATION CONTENT	AIR-GROUND COMMUNICATION TIME & SOURCE	AIR-GROUND COMMUNICATION CONTENT
1743:40 CAM-2	hum.		
1743:41 CAM-1	I would just wait if I were you when we get to be number one go back and have a good look at it.		
		1743:55 RDO-2	do you want seven ninety five to go to tower.
		1744:00 GND	Continental neven ninety five you can monitor the tower one one eight point seven.
		1744:04 RDO-2	*.
1744:30 C	((flight switched to tower frequency))		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
1745:34 PA-1	ah folks you can see the ah trucks off to our right there going in the opposite direction. they just finished cl- cleaning the runway one three which is the runway we're going to take off on. You can see off of the left side now airplanes that are also lined up who are waiting for that runway we have one in front of us on this taxiway so it looks like we'll be number three or four here for takeoff probably another ten minutes. and incidentally before we take off you'll see one of the pilots come back in the cabin to inspect the wings there to make sure that they're all clear of ah ice and snow before we make our takeoff roll.		
1747:17 CAM	((sound of two cabin chimes))		
1747:54 CAM-1	tell 'em it's clear go ahead and make it quick.		
1748:00 CAM	((sound of one cabin chime))		
1748:12 CAM-1	hay *.		
1748:37 CAM-1	well we got another Continental over there.		
1749:54 CAM	((sound of cabin chime))		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
1750:07 CAM	((sound of interphone chime))		
1750:10 CAM-2	hello.		
1750:15 CAM-2	thank you.		
1750:16 CAM-2	okay.		
		1753:12 TWR	Continental seven ninety five follow the American MD-80 please.
		1753:14 RDO-2	roger.
1753:17 CAM-1	Okay why don't you go have a look.		
1753:19 CAM-2	what's that?		
1753:20 CAM-1	why don't you go have a look.		
1753:24 CAM	((sound of seat belt being unbuckled))		
1753:35 CAM	((sounds similar to cockpit door opening and closing))		
1754:44 CAM-2	two minutes *		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
1754:42 CAM	((sound of cockpit door opening and closing))		
1754:44 CAM-2	looks okay to me.		
1754:45 CAM-1	good.		
1754:53 CAM-1	start up engine number two.		
1755:19 CAM-2	N-2, oil pressure.		
1755:31 CAM-2	*.		
1755:32 CAM	((sound of momentary power interruption to the cvr))		
1755:41 CAM-2	say let's turn the air off and leave that runnin'.		
1755:44 CAM-1	okay.		
1755:46 CAM-1	what's you pleasure on the lights?		
1755:49 CAM-2	huh.		
1755:50 CAM-1	what's your pleasure on the lighting, the cockpit lighting what do you want would you like it up like it is?		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
1755:55 CAM-2	naw we can turn 'em out if it's alright with you.		
1755:57 CAM-1	okay		
1756:05 CAM-2	oh let's see first you want to takeoff data bugs they're checked and set.		
1756:12 CAM-2	ART set temp zero zero auto, flap takeoff selector set at eleven, takeoff condition display looks like th' .een eight, flaps are eleven, nose trim looks like it's set.		
1756:31 CAM-2	flaps slats eleven and I'm takin' off charlie seven is checked.		
1756:41 CAM-2	let's give it to me.		
1756:43 CAM-2	instruments check we're gunna go right to m e seventy five two DM two and a half DME in a left forty.		
1756:50 CAM-1	correct pretty easy.		
1756:52 CAM-2	start valve Sight was out electrical system was checked galley power is back on see we'll leave those on.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
1757:01 CAM-2	engine ignition is off engine anti-ice is all set packs are closed and auto.		
		1757:02 TWR	Continental seventy ninety five runway one three taxi into position and hold.
		1757:05 RDO-2	seven ninety five one three position and hold.
1757:09 PA-2	we're number one flight attendants please be seated.		
1757:16 CAM-2	** TRI is set APU is gunna be runnin' for electrics.		
1757:24 CAM-2	utilities are on auto brakes are ah we don't have, cross feeds closed, flight guidance and FMA is checked and set, shoulder harness are on.		
1757:31 CAM-2	takeoff briefing.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
1757:32 CAM-1	okay um same briefing that's if we have to abort I I'll call the abort and ah and ah meaning as soon as I pull the throttles back I have control of the airplane you help me get it stopped mainly by makin' sure the spoilers are out we get it stopped then you tell the flight attendants to remain seated and tell the tower we've aborted we'll go through the ah checklist.		
1757:57 CAM-2	oh very well sounds good to me.		
1758:01 CAM-a	brakes are set it's all yours mate.		
1758:03 CAM-2	okay we'll run em up before we move.		
1750:05 CAM-a	alright.		
1758:06 CAM-2	taxi check complete.		
1758:07 CAM-1	you got the €laps out now don't ya?		
1758:08 CAM-2	yes flaps set.		
1758:10 CAWS	((sound of take off warning horn "brakes"))		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
1758:11 CAM-2	Ignition override, brake temps checked, takeoff announcement's all done, annunciator panel checked, exterior light's set. pretty good cross wind left to right.		
1758:19 CAM-1	yes it is. I didn't get you lined up real good.		
1758:22 CAM-2	that's alright.		
		1758:36 TWR	Continental seven ninety five runway one three cleared for takeoff.
1758:38 CAM	((sound similar to parking brake being released))		
		1758:39 RDO-1	cleared for takeoff Continental seven ninety five.
1758:48 CAM	((sound of increasing engine noise))		
1758:54 CAM-2	auto throttles?		
1758:55 CAM-1	auto throttles on.		
1758:59 CAM-1	take off power's set. N-1's are at ah ninety percent.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
1759:23 CAM-1	abort.		
1759:25 CAM-2	okay.		
1759:29 CAM-2	you got full reverse.		
1759:30 CAM	((sound of increasing engine noise)).		
x759:37 CAM-1	tell him we're aborting.		
		1759:43 TWR	Continenta seven ninety five LaGuardia.
		1759:45 RDO-2	Continental seven ninety five's aborting.
1759:46 CAM	((sound of crash)).		
1759:47 CAWS	((sound of take off warning alert "landing gear" and "speed brakes" starts and continues until the end of the recording)).		
		1759:49 TWR	Continental seven ninety five LaGuardia.
		1759:54 TWR	Continental seven ninety five LaGuardia.

INTRA-COCKPIT COMMUNICATION

TIME & SOURCE	CONTENT
1759:55 CAM	((sound of decreasing engine noise))
1800:00 CAM-2	okay what do you want me to do?
1800:01 CAM-1	call company.
1800:10 CAM-I	*go* on out.
1800:12 CAM-?	take it easy now take it easy.
1800:24 CAM-1	alright lets shut the eng- shut all the electrical down.
1800:28 CAM-1	get the ah - spd brake.
1800:34 CAM-1	where's the checklist?
1800:35 CAM-1	the abort checklist.
1800:38 CAM	((sound similar to slide inflating))
1800:41 PA-I	easy victor easy victor and be careful we *see* no fire we set? no fire be careful easy victor and go to the rear of the airplane go to the rear of the airplane after you after you exit the aircraft.
1800:59 CAM-I	okay.

AIR-GROUND COMMUNICATION

TIME & SOURCE	CONTENT

INTRA-COCKPIT COMMUNICATION | AIR-GROUND COMMUNICATION

TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
1801:08 CAM-1	where's the abort checklist.		
1801:15 CAM-4	((sound of female voice)) cane this way cane this way leave your stuff came thls way.		
1801:24 PA-1	Easy victor.		
1801:25 CAM-?	cut the engines cut the engines cut the engines cut the engines.		
1801:27 CAM-1	the engines are off the engines are down.		
1801:31 CAM-2	naw they weren't.		
1801:33 CAM-2	did you pull the Eire handle.		
1801:33 CAM-1	now there down		
1801:34	((end of recording))		