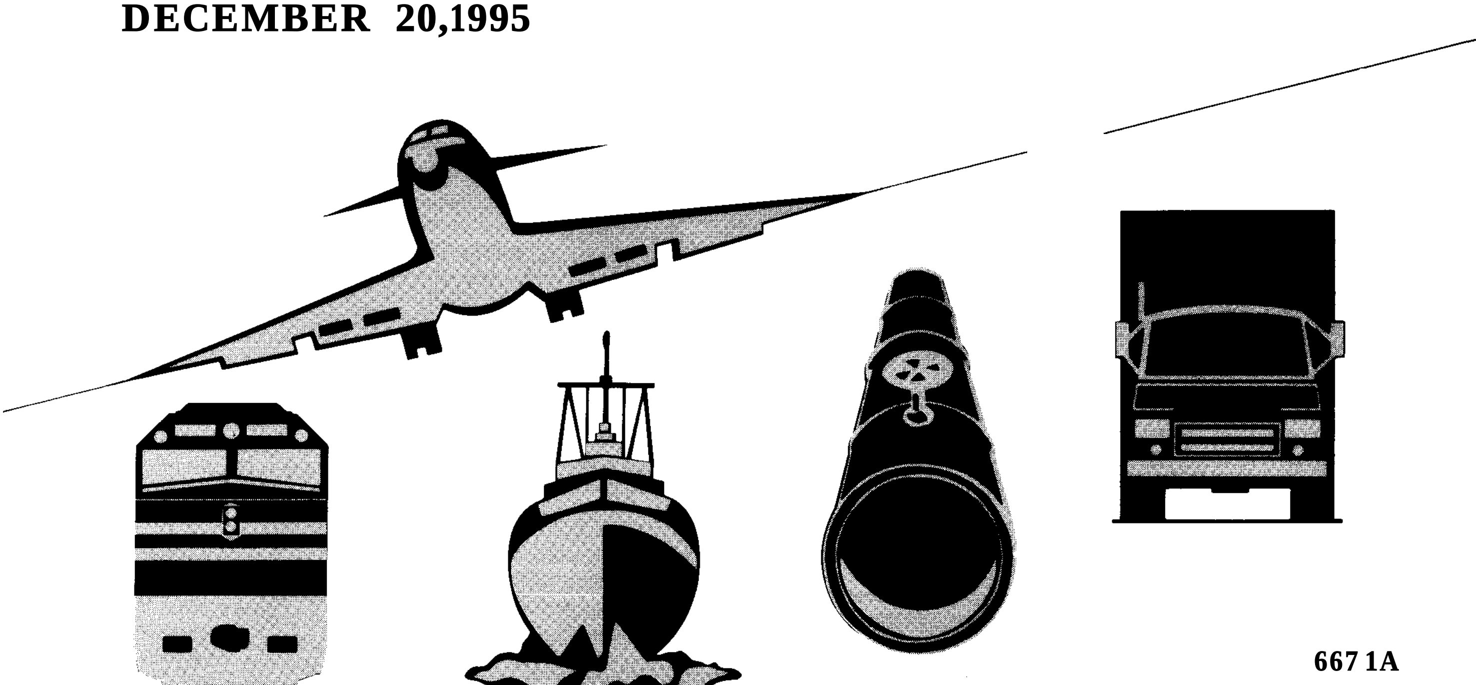
PB96-910404
NTSB/AAR-96/04

NATIONAL TRANSPORTATION SAFETY BOARD

WASHINGTON, D.C. 20594

AIRCRAFT ACCIDENT REPORT

**RUNWAY DEPARTURE DURING ATTEMPTED TAKEOFF
TOWER AIR FLIGHT 41
BOEING 747-136, N605FF
JFK INTERNATIONAL AIRPORT, NEW YORK
DECEMBER 20,1995**



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Adopted: December 2, 1996
Notation 6671A

Abstract: This report explains the runway departure during attempted takeoff of Tower Air flight 41, N605FF, a Boeing 747-136 at John F. Kennedy International Airport, New York, on December 20, 1995. The safety issues discussed in this report include the adequacy of Boeing and air carrier procedures for B-747 operations on slippery runways; adequacy of flight simulators for training B-747 pilots in slippery runway operations; security of galley equipment installed on transport category aircraft; role of communications among flight attendants and between the cabin crew and the flightcrew; adequacy of Tower Air galley security training; compliance of Tower Air's maintenance department with its established procedures; failure of the FDR system to function during the accident; adequacy of the Tower Air operational management structure; adequacy of FAA surveillance and workload imposed on POIs; adequacy of runway friction measurement requirements, including correlation of runway friction measurements with aircraft braking and ground handling performance. Safety recommendations concerning these issues were made to the Federal Aviation Administration (FAA) and Tower Air, Inc.

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EXECUTIVE SUMMARY

On December 20, 1995, at 1136, Tower Air flight 41, a Boeing B-747, veered off the left side of runway 4L during an attempted takeoff at John F. Kennedy International Airport (JFK), Jamaica, New York. The flight was a regularly scheduled passenger/cargo flight conducted under the provisions of Title 14 Code of Federal Regulations (CFR) Part 121. Of the 468 persons aboard (451 passengers, 12 cabin crewmembers, 3 flightcrew members, and 2 cockpit jumpseat occupants), 24 passengers sustained minor injuries, and a flight attendant received serious injuries. The airplane sustained substantial damage. The weather at the time of the accident was partially obscured, with a 700-foot broken cloud ceiling, 1½ mile visibility, light snow, and fog.

The National Transportation Safety Board determines that the probable cause of this accident was the captain's failure to reject the takeoff in a timely manner when excessive nosewheel steering tiller inputs resulted in a loss of directional control on a slippery runway. Inadequate Boeing 747 slippery runway operating procedures developed by Tower Air, Inc., and the Boeing Commercial Airplane Group and the inadequate fidelity of B-747 flight training simulators for slippery runway operations contributed to the cause of this accident. The captain's reapplication of forward thrust before the airplane departed the left side of the runway contributed to the severity of the runway excursion and damage to the airplane.

The safety issues discussed in this report include the adequacy of Boeing and air carrier procedures for B-747 operations on slippery runways; adequacy of flight simulators for training B-747 pilots in slippery runway operations; security of galley equipment installed on transport category aircraft; role of communications among flight attendants and between the cabin crew and the flightcrew; adequacy of Tower Air galley security training; compliance of Tower Air's maintenance department with its established procedures; failure of the FDR system to function during the accident; adequacy of the Tower Air operational management structure; adequacy of FAA surveillance and workload imposed on POIs; adequacy of runway friction measurement requirements, including correlation of runway friction measurements with aircraft braking and ground handling performance.

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AIRCRAFT ACCIDENT REPORT

RUNWAY DEPARTURE DURING ATTEMPTED TAKEOFF

TOWER AIR FLIGHT 41
BOEING B-747-136, N605FF
JOHN F. KENNEDY INTERNATIONAL AIRPORT, NEW YORK
DECEMBER 20, 1995

1. FACTUAL INFORMATION

1.1 History of Flight

On December 20, 1995, at 1136,[1] Tower Air flight 41, a Boeing B-747, veered off the left side of runway 4L during an attempted takeoff at John F. Kennedy International Airport (JFK), Jamaica, New York. The flight was a regularly scheduled passenger/cargo flight conducted under the provisions of Title 14 Code of Federal Regulations (CFR) Part 121. Of the 468 persons aboard (451 passengers, 12 cabin crewmembers, 3 flightcrew members, and 2 cockpit jumpseat occupants), 24 passengers sustained minor injuries, and a flight attendant received serious injuries. The airplane sustained substantial damage. The weather at the time of the accident was partially obscured, with a 700-foot broken cloud ceiling, 1½ mile visibility, light snow, and fog.

N605FF was flown from JFK to Miami, Florida, and back to JFK on December 19, 1995. The captain on those flights reported no problems with the airplane. On December 20, 1995, the airplane was moved to the gate in preparation to depart at 1000 for the first leg of a round trip from JFK to Miami and return for the three flightcrew members. The cabin crew of 12 included a purser, assistant purser, and deadheading flight attendant (in uniform), who was occupying a passenger seat in the cabin.

The captain stated that he met the first officer and flight engineer in company operations before 0830. He received what he described as a thorough weather briefing prepared by Tower Air's dispatch department, which included special weather conditions for JFK. He was aware of reports of compacted snow on the runways and that some of the runways were closed; he was concerned about both the accumulated snow and a forecast storm. He spoke with the Tower Air maintenance controller, who advised him that the airplane had no outstanding

[1] All times herein are eastern standard time, based on a 24-hour clock.

discrepancies, and proceeded to the airplane. The flight engineer had previously completed the external safety inspection and was seated in the cockpit. The first officer joined them shortly, and all preflight checks were completed by 0930.

The captain was the flying pilot for this leg and gave a briefing to the flightcrew. According to the captain, the crew discussed the weather and deicing at the gate. They obtained the holdover times[2] from the Tower Air General Operations Manual. The crew then discussed the amount of snow accumulation, the slippery conditions on the taxiways and runways, [3] the need to taxi slowly, taxi procedures on packed snow and ice, and their plans to use engine anti-ice and wing heat.

The flight was pushed back from the gate at 1036, and the final deicing/anti-icing with both Type I and Type II fluids[4] began at 1100. The flight was cleared to runway 4L and taxied out at 1116.

According to the captain's statements, he taxied forward several hundred feet and made a 90° left turn to join the taxiway. The ramp was covered with packed snow and patches of ice, but some spots were bare. The nosewheel skidded a little in the turn, but the captain taxied slowly (about 3 knots according to the captain's inertial navigation system display), and the braking action was adequate. He stopped the airplane to clear the engine of any ice by increasing power to 45 percent N_1[5] for 10 seconds, but the airplane began to slip as power was advanced, and they could not complete the procedure at that time.

Shortly after this attempt, about 1124, the crew of another flight inquired about the availability of runway 31L, and ground control advised that it was closed, transmitting, "I don't know when it's gonna open—probably be a couple of hours, may want to call the Port Authority." The captain stated that based on this information, he did not consider runway 31L to be a viable option for his flight's takeoff. Several minutes later, flight 41 was instructed, "...cross [runway] three one left. On the other side monitor [frequency one] nineteen one...." As they taxied on the parallel taxiway alongside runway 4L, the flight engineer left the cockpit to visually inspect the wings. He returned and reported, "It's very clean out there." A few seconds later, at 1132:06, the flight was cleared to taxi into position and hold on runway 4L.

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[2] Holdover time is the estimated time the application of deicing or anti-icing fluid will prevent the formation of frost or ice, and the accumulation of snow on the treated surfaces of an aircraft. It begins when the final application of the fluid commences, and it expires when the fluid loses its effectiveness.

[3] In this report, the term "slippery," as it pertains to runways, is defined as runway surface condition when the effective runway coefficient is less than the certificated bare and dry value, i.e., when the runway is not bare and dry.

[4] Type I fluid, primarily used for deicing, contains a high glycol content (minimum 80 percent) and a relatively low viscosity. Type II fluid, normally used for anti-icing, can be operationally defined as fluid containing a minimum glycol content of 50 percent (with 45-50 percent water plus thickeners and inhibitors).

[5] N_1 is the engine fan speed expressed as a percentage of the maximum rpm.

The captain stated that as he taxied into position on the runway, he centered the airplane and moved the nosewheel steering tiller to neutral as the airplane was barely moving. He came to a complete stop, set the parking brake, and did the engine anti-ice runup. The airplane did not move during the runup. The captain said that he could see the runway centerline intermittently. He noted a strip of dark granular material about the width of a dump truck as he looked down the center of the runway. Packed snow was on either side of the strip, and there was some bare pavement. Snow was blowing horizontally from left to right across the runway. The crew completed the "Before Takeoff Checklist" while holding in position.

At about 1136, the local controller transmitted, "Tower forty one heavy, wind three three zero at one one, runway four left RVR's one thousand eight hundred, cleared for takeoff." The captain said that he instructed the first officer to hold left aileron (for the crosswind correction) and forward pressure on the control column. The first officer stated that he held those inputs.

The captain released the parking brake and held the toe brakes while he increased the power to 1.1 EPR.[6] He then released the brakes and advanced the power to 1.43 EPR, and at 1137:04 called, "Set time, takeoff thrust." He said that he scanned the EPR gauges, and all were normal. The flight engineer confirmed that the power was stable at 1.1 EPR, and as power was applied slowly and evenly to 1.43 EPR, he ensured that power was symmetrical and the rpm gauges were matched.

The captain stated that the takeoff began normally, with only minor corrections to maintain the runway centerline. Before receiving the 80-knot call he expected from the first officer, the captain felt the airplane moving to the left. He said he applied right rudder pedal (inputs to the rudder control surface and nosewheel steering) without any effect. He stated that he added more right rudder and then used the nosewheel steering tiller, but both were ineffective. He stated that he had no directional control and that the nose of the airplane continued to turn left. He knew where the runway centerline was, but he was unable to control the direction of movement. The captain said that while the airplane was still on the runway with the veer and drift to the left increasing, he applied full right rudder and nosewheel steering tiller. He said that he then retarded the power levers to idle and applied maximum braking. He said that he intentionally did not use reverse thrust because of the airplane's slow speed at the time of the abort, the long runway, and the possibility that reverse thrust could have worsened directional control. The airplane then departed the left side of the runway.

The first officer stated that shortly after thrust was set and the airplane began moving forward, it appeared to be left of the centerline. He stated that the nose was pointed slightly left of the centerline in a minor deviation. He said that he looked down, noted that the airspeed was less than 70 knots, looked back outside, and observed that the airplane had veered further to the left. He stated that he was able to distinguish the runway edges at this time, and it

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[6] Engine pressure ratio (EPR) is a measure of engine thrust, comparing the total turbine discharge pressure to the total pressure of the air entering the compressor.

was apparent to him that the airplane's veer to the left could not be corrected. He said that he commented on this to the captain and the flight engineer while the captain was attempting to stop the airplane.

The flight engineer stated that after he set takeoff power and cross-checked the engine instruments, he noted that the nose had started to veer to the left. He observed the captain using right rudder and tiller and thought that the airplane would return to the centerline. He recalled that the captain immediately pulled all four thrust levers to idle, and that the captain applied the brakes just before the airplane left the runway.

A deadheading first officer who occupied the aft cockpit jumpseat during the attempted takeoff stated that the captain reduced thrust only seconds after the flight engineer called "power set." He stated that he felt no swerve, and that his first indication of trouble was when the captain retarded the thrust levers. He thought that the airplane was yawed left but tracking straight for a while, and then it started to track to the left off the runway. He thought that about 2 seconds elapsed between the power reduction and the time that the airplane left the runway.

The captain recalled that after the airplane came to a stop off the runway, the first officer called the control tower, and the flight engineer made a public address (PA) announcement for the passengers to remain seated. The captain and flight engineer then performed the memory shutdown items. The crew discussed whether to order an evacuation. Based on the crew's determination that there was no fire, that the airplane was basically intact and not in imminent danger, and that there was a low wind chill factor outside, the captain elected to keep everyone on board.

1.2 Injuries to Persons

Injuries	Flightcrew	Cabin Crew	Passengers	Other	Total
Fatal	0	0	0	0	0
Serious	0	1	0	0	1
Minor	0	0	24	0	24
None	3	11	427	2	443
Total	3	12	451	2	468

1.3 Damage to Airplane

The airplane sustained substantial damage, and it was written off as a constructive total loss.

1.4 Other Damage

A 12-foot double-sided sign and two 8-foot single-sided signs were damaged when the airplane hit them after departing the runway. In addition, an FAA-owned transformer was destroyed.

1.5 Personnel Information

1.5.1 The Captain

The captain, age 53, was hired by Tower Air on May 23, 1992, as a first officer on B-747 airplanes. He was reassigned as captain on the B-747 on April 23, 1994. He held an airline transport pilot (ATP) certificate, with ratings for L-188, DC-9, B-747, and airplane multiengine land. His most recent proficiency check was accomplished on January 11, 1995, and he completed the required recurrent simulator training in lieu of a proficiency check on July 31, 1995. He received his last line check before the accident on May 7, 1995. His Federal Aviation Administration (FAA) first-class medical certificate was issued on July 17, 1995, with the limitation that he must possess corrective lenses. At the time of the accident, company records indicated that he had accumulated approximately 16,455 total flying hours. He had logged 2,905 hours in the B-747, of which 1,102 hours were as pilot-in-command.

The captain flew on active duty in the U.S. Navy from 1967-1971, and in the Naval Air Reserve an additional 15 years in multiengine turboprop airplanes. He flew for Transamerica Airlines from 1978 through 1984, and for Midway Airlines from 1984 through November 1991.

The captain held a reserve bid[7] for December, but he was not assigned any flight duties by Tower Air from December 12-18, 1995. On December 18, 1995, he was notified that he would be performing the accident trip on December 20. He was on reserve on December 19, 1995, but again was not called for duty that day. He napped for about 2 hours in the afternoon and retired about 2200. On December 20, 1995, he awoke at 0400, anticipating bad weather, traffic, and the possible need to shovel snow. He arrived at Tower Air operations at 0645. The company reporting requirement was 1½ hours before departure, which would have been 0830 in this case. He had never flown with the first officer before, but he had flown with the flight engineer five times in the past.

1.5.2 First Officer

The first officer, age 56, was hired by Tower Air on January 16, 1995, as a first officer on B-747 airplanes. He held an ATP certificate, with ratings for LR-JET, N-265, B-747, B-727, airplane multiengine land, and commercial privileges for single-engine land, B-707, B-720, and L-T33. He completed his most recent proficiency check on February 15, 1995, and his

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[7] A pilot on a reserve bid is on stand-by duty for assignment to flights.

recurrent simulator training in lieu of a proficiency check on July 26, 1995. His most recent FAA first-class medical certificate was issued on December 8, 1994, with the limitation that he must possess corrective lenses. Company records indicate that at the time of the accident, he had accumulated 17,734 total flying hours, of which 4,804 hours were in the B-747.

The first officer had been off duty for 17 days before the accident trip. He commuted from his home in Miami, Florida, to a hotel in New York on December 19, 1995. He went to bed about 2230, slept well, and arose at 0600. He reported to operations at 0720. He did not recall having flown with the captain previously, but he had flown with the flight engineer once.

1.5.3 Flight Engineer

The flight engineer, age 34, was hired by Tower Air on March 10, 1995, as a flight engineer on B-747 airplanes. He held a flight engineer certificate with a turbojet powered rating; a mechanic certificate with airframe and powerplant ratings; and a private pilot certificate with ratings for airplane single-engine land. His most recent FAA first-class medical certificate was issued on December 8, 1995, with the limitation that he must possess corrective lenses. He had a Statement of Demonstrated Ability issued on April 2, 1994, for defective color vision demonstrated on a special flight test. His most recent proficiency check was accomplished on March 9, 1995, and his recurrent training was completed on September 19, 1995. Company records indicate that at the time of the accident, he had accumulated a total of 4,609 total flying hours, of which 2,799 hours were as a flight engineer in the B-747.

The flight engineer flew the JFK-Miami-JFK round trip that included flight 41 on December 17, and he was off duty December 18-19, 1995. On December 19, 1995, he left his home in Delaware about 1230 in his car, arrived in New York about 1730, and checked into the hotel about 2000. He went to bed about 2100. He arose at 0500 on December 20, 1995, left the hotel at 0720, and arrived at the operations office at 0730.

1.6 Airplane Information

1.6.1 General

N605FF, a Boeing B-747-136, was delivered new to the British Overseas Airline Corporation in July 1971. Trans World Airlines, Inc. (TWA), acquired it in March 1981, and subsequently sold it to Tower Air in March 1991. At the time of the accident, it had been flown 90,456.7 hours, with 17,726 cycles. It was equipped with four Pratt & Whitney JT9D-7A engines.

The Boeing 747-136 model is equipped with a hydraulic-powered nosewheel steering system to assist pilots with directional control during ground operations. Hydraulic fluid under pressure is used to turn the nosewheel in response to control inputs by the captain and first officer. All B-747s are equipped with a nosewheel steering tiller located at each pilot's side panel. Nosewheel steering through the tiller is capable of 70^{o} of nosewheel deflection, at full tiller input. In addition to the steering capability through the tiller, N605FF (as well as many other B-747s) was equipped with rudder pedal steering that turned the nosewheel in response to control inputs through the rudder pedals at each pilot's foot position. Because of the rudder pedal steering, a pilot's inputs to the rudder pedals would result in coordinated movement of the nosewheel and the rudder control surface at the tail of the airplane. In contrast to the tiller, the rudder pedals were capable of 10^o of nosewheel deflection, at full rudder pedal input.

The flight data recorder (FDR) system on N605FF was an Aeronautical Radio, Incorporated (ARINC) Characteristic Number 563 digital FDR system. This system consisted of a central electronics unit (CEU) and three digital acquisition units (DAU), in addition to the flight data recorder unit. The three DAUs were located in the system's main equipment center, center equipment center, and upper equipment center. Each DAU acquired, converted, and multiplexed inputs from FDR data sensors located near the unit (e.g., DAU #3 handled the vertical and longitudinal acceleration and stabilizer position data). A processed, digital signal was sent from each of the DAUs to the CEU for further conditioning and processing. The CEU, located in the main equipment center, acted as a final signal processor, and sent the signal to the FDR for recording. (Figure 1 shows the location of the FDR system components.)

Following the accident, the baggage and cargo on the airplane were weighed. The actual takeoff gross weight was found to be 566,963 pounds. The maximum allowable takeoff gross weight was 625,609 pounds. The actual center of gravity (CG) was found to be 22 percent mean aerodynamic chord (MAC). According to the Tower Air B-747 Flight Manual, the CG limits for this weight were between 13.8 and 31.5 percent MAC.

1.6.2 Maintenance Records Review

Tower Air maintained N605FF under an FAA-approved continuous maintenance program. All appropriate airworthiness directives (ADs) had been accomplished.

British Airways performed a "C" check[8] on N605FF from December 30, 1993, through January 29, 1994, at its facility in London. Tower Air sent two inspectors to the facility to monitor the work and to ensure that the maintenance was performed in accordance with the Tower Air General Maintenance Manual (GMM). Random inspection of selected work cards by the Safety Board revealed that the individual work cards had been signed off by British Airways personnel. However, the Tower Air inspectors did not complete the "C" check work accountability form that would have attested to the completion of the entire "C" check, as required by the GMM.

[8] The FAA-approved maintenance program for Tower Air includes seven specific checks that must be accomplished at various calendar or operating time intervals. They range from Transit Service, completed at each departure, to "D" checks performed every 72 months. The 15-month service is accomplished at a mid-point (9-15 months) between "C" checks, which are at 24-month intervals.

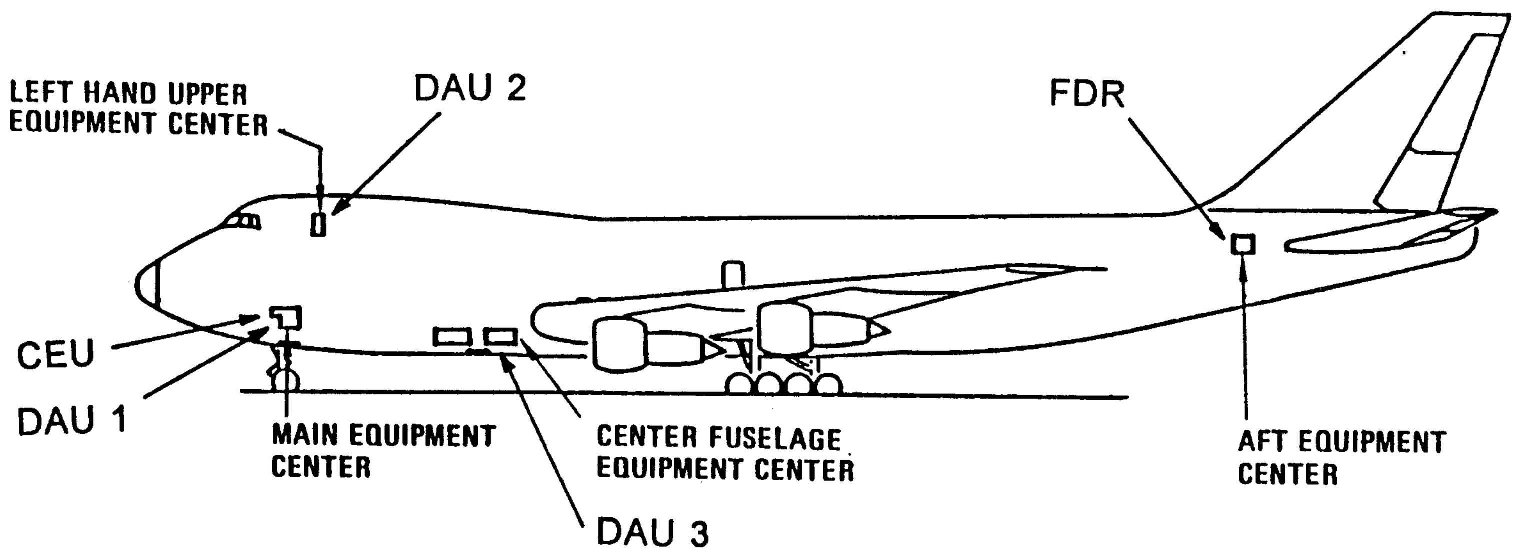

Figure 1—FDR Component Location

A 15-month service check was accomplished on N605FF in March 1995 at the Tower Air facility at JFK. During the service check, all landing gear were removed because of time-in-service limitations. The part numbers of the replacement landing gear (appropriate for the B-747-121 model) were different from those specified in the Tower Air illustrated parts catalogue for the B-747-136. Documentation from Boeing showed that the part numbers of the replacement gear could be substituted on the B-747-136. However, Tower Air maintenance personnel had installed the gear without the documentation from the manufacturer; this documentation was obtained when the issue was raised during the Safety Board's investigation of the accident.

Interviews with the mechanics, maintenance supervisors, inspectors, parts stores personnel, and purchasing personnel involved in the landing gear replacement revealed that no one had cross-checked the part numbers on the landing gear with the carrier's illustrated parts catalog. The Tower Air GMM specified that it was the responsibility of each mechanic and inspector to ensure that all parts being installed were approved in the manual. The GMM also required the receiving inspector to compare the serial number, part number, and quantity with the applicable purchase order or repair order.

On September 28, 1995, FDR S/N 2074 was removed from N605FF for a routine annual check of the airplane's FDR systems. The annual check is performed to determine the validity and accuracy of the mandatory recorded parameters and consists of a readout of the data recorded during recent flights. Nominal data for all recorded parameters would indicate normal functioning of the FDR, CEU, and three DAUs. FDR S/N 2074 was replaced with S/N 2461. The readout was performed by TWA.

On November 3, 1995, after FDR S/N 2074 was read out, TWA issued a memorandum to Tower Air identifying six data parameters that were "suspect." These parameters were (1) elevator position; (2) radio communications; (3) flap outboard position; (4) vertical acceleration; (5) longitudinal acceleration; and (6) No. 2 reverser position.

Aircraft maintenance log page No. 38147 for N605FF, dated December 1, 1995, indicated two specific writeups on the FDR system. The first indicated that the FDR "OFF" light (located on the pilot's overhead panel) flickered in flight. The corrective action shown in the logbook was to replace FDR S/N 2461 with FDR S/N 2152. This action eliminated the flickering light. The second writeup indicated that the FDR system test (located on the flight engineer's panel) was inoperative in flight and on the ground. The corrective action for this item was deferred initially. On December 2, 1995, the CEU was replaced and the system checked satisfactorily. The aircraft was then returned to service.

On December 4, 1995, the six "suspect" FDR system parameters were entered in the aircraft maintenance log, and the discrepancies were transferred to the deferred items log. According to the maintenance log, on December 7, 1995, the last day that the discrepancy could be deferred according to the FAA-approved Master Minimum Equipment List (MMEL), the corrective action taken was to replace DAU #1. There was also the annotation, "Performed functional check as per 31-31-00 [Maintenance Manual]."

According to the mechanic/supervisor who did the work, the required functional check of the FDR on N605FF was not accomplished immediately after DAU #1 was replaced because the “thumb wheel” test equipment was not available during the night shift, when the DAU was replaced. The day shift mechanic/supervisor stated that he performed the required functional check of the FDR after he obtained the tester from TWA. A sales ticket issued by TWA for rental of a “thumb wheel” tester indicated that it was issued to Tower Air at 0800 on December 7, for 4 hours. The mechanic/supervisor could not remember when he obtained the tester or who assisted him, but he stated that the test required about 1½ to 2 hours with another person’s help. He stated that the test could be done at the gate; however, he indicated that any maintenance on the airplane (including the functional test of the FDR system) must be completed 2 hours before the scheduled departure time. Tower Air records indicate that N605FF departed JFK at 0955 on December 7, 1995, and did not return until 2015 that evening.

1.7 Meteorological Information

The National Weather Service (NWS) surface analysis charts for 1000 and 1300 showed a strong area of low pressure located southeast of Nantucket Island moving slowly northeast. Instrument meteorological conditions (IMC), moderate-to-strong northerly surface winds, and light-to-moderate snow were indicated west and southwest of the system over the New England area.

Pertinent surface weather observations at JFK were, in part, as follows:

> 1050--Record--partial obscuration, estimated ceiling 700 feet broken, 2,000 feet overcast, visibility 1 1/2 miles, light snow and fog, temperature 24 ^{o}F, dew point 21 ^{o}F, wind 350^{o} at 13 knots, altimeter setting 29.54 inches of Hg; Remarks--0.5 sky obscured by snow.
>
> 1150--Record--partial obscuration, estimated ceiling 700 feet broken, 2,000 feet overcast, visibility 1 1/2 miles, light snow and fog, temperature 24 ^{o}F, dew point 21 ^{o}F, wind 330^{o} at 11 knots, altimeter setting 29.53 inches Hg; Remarks--0.5 sky obscured by snow.

The JFK Surface Weather Observations Form for December 20, 1995, showed that 1.3 inches of snow had fallen between 0645 and 1245. The form also indicated that the peak wind for the day had been from the north at 24 knots at 1014. No local or special weather observation was made at the time of the accident, as required by NWS directives, because the weather observer was not notified of the accident in time to fulfill this requirement.

The wind direction and speed measurements included in the official weather observations at JFK were obtained from the NWS anemometer located 20 feet above the airport surface, between runways 4L-22R and 4R-22L, about ¾ mile northeast of where the airplane departed off the side of the runway. Given the prevailing northwesterly winds, this location was downwind of the terminal buildings at JFK. Research indicates that no significant sheltering effects exist beyond 20 building-heights downwind of an obstacle. The anemometer was more than 50 building-heights downwind of the terminal buildings.

An NWS Automated Surface Observing System (ASOS) unit that included an anemometer positioned 10 meters above the surface was located about ½ mile further to the northeast. This unit had been calibrated and was operating on the day of the accident, but it had not yet been commissioned by the NWS. Consequently, the weather data that it collected were not included in official observations. The ASOS unit recorded a gust of 22 knots between 1111 and 1121 (15 to 25 minutes before the accident).

1.8 Aids to Navigation

There were no pertinent problems with navigational aids.

1.9 Communications

No external communications difficulties were reported.

1.10 Airport Information

1.10.1 General

JFK Airport is located 13 feet above sea level. It is owned by the City of New York and operated by the Port Authority of New York and New Jersey (PNY&NJ). It was certificated under 14 CFR Part 139, and is an Index E aircraft rescue and fire fighting (ARFF) facility.[9] The runway configuration includes four runways: 4L/22R, 4R/22L, 13L/31R, and 13R/31L. Runway 4L, the accident runway, is 11,351 feet long and 150 feet wide, with an asphalt surface that has transverse grooves the full length. It is configured for Category I instrument landings and is equipped with high intensity runway edge lights and centerline lights.

1.10.2 Runway Conditions

On the morning of the accident, runway 4L had been closed to aircraft operations for snow removal, sanding, and inspection until about 1000. Runway 31L was closed until about 1134, when the airport duty manager informed the control tower that the runway had checked satisfactorily. According to the transcript of radio transmissions on Kennedy Air Traffic Control Tower ground control frequency, at 1131 the ground controller transmitted, "…American fourteen seventy three the word is just now (we're) switching to thirty one left [at taxiway] double kilo for departure so you can plan on that."

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[9] Title 14 CFR Part 139 requires, for scheduled air carrier service with aircraft at least 200 feet in length, that at a minimum the airport be equipped with at least three ARFF vehicles with at least 6,000 gallons of water for foam production.

FAA Advisory Circular (AC) 150/5200-30A advises airport operators to perform friction checks of runway surfaces during ice/snow conditions. The AC does not specify the method of friction measurement to be used, although it provides a list of recommended methods.

The PNY&NJ operations services supervisor stated that she conducted a coefficient of friction measurement survey of runway 4L at 0933, using a Saab friction test vehicle, just after the runway had been sanded. After driving the full length of the runway, 20 feet to the right of centerline, the supervisor estimated that the surface was approximately 60 percent covered with patches of snow and ice. The friction coefficient results from the test, which was completed at 0950, averaged 0.32; with 0.39 in the touchdown zone, 0.26 at the mid-point, and 0.31 in the rollout area. Two additional friction tests were run after the accident at 1147 and 1155 indicating 0.31 and 0.27, respectively, in the touchdown zone area of runway 4L, where the on-runway portion of the accident sequence occurred.

PNY&NJ procedures state, "When [friction] readings are 0.40 and below for any one-third of the runway and taken on <u>acceptable conditions, they should be reported to the tower</u> [emphasis in original]." PNY&NJ Operations Office personnel stated that the 0933 friction results were relayed to the control tower by telephone before runway 4L was reopened at 1000. The control tower had no record that this information was received from PNY&NJ. The 0933 coefficient of friction measurements were entered into the PNY&NJ operations office computer at 1240 (after the accident), with the annotation, "ATCT advised."

The PNY&NJ assistant chief operations supervisor, who was serving as the airport duty manager at the time of the accident, stated that runway 4L had been plowed and sanded full length and width just before the 0933 friction test on December 20, 1995. He stated that he inspected the runway before it was reopened at 1000, and he issued two notices to airmen (NOTAMS), as follows:

1. Runway 4L-22R, patches of one inch-deep compacted snow and ice. Runway sanded.

2. Runway 4L-22R, centerline lights obscured.

Both NOTAMS were valid at the time of the accident.

FAA Order 7110.65J, "Air Traffic Control," paragraph 3-3-4 (d)(1) provides the following procedures for air traffic controllers to use in providing information to pilots about runway friction measurements received from airport management:

> Furnish information as received from the airport management to pilots on the ATIS at locations where friction measurement devices such as…Saab Friction Tester…are in use. Use the Runway followed by the MU number for each of the three runway segments, time of report, and a word describing the cause of the runway friction problem.

1.10.3 Previous Safety Board Recommendations

In 1982, the Safety Board addressed the issue of runway surfaces contaminated[10] by ice or snow in three investigation reports.[11] As a result of these investigations, the Safety Board issued the following safety recommendations to the FAA concerning runway friction measurement technologies and procedures:

> Amend 14 CFR 25.109 and 14 CFR 25.125 to require that manufacturers of transport category airplanes provide data extrapolated from demonstrated dry runway performance regarding the stopping performance of the airplane on surfaces having low friction coefficients representative of wet and icy runways and assure that such data give proper consideration to pilot reaction times and brake antiskid control system performance. (A-82-165)

> In coordination with the National Aeronautics and Space Administration (NASA), expand the current research program to evaluate runway friction measuring devices which correlate friction measurements with airplane stopping performance to examine the use of airplane systems to calculate and display in the cockpit measurements of actual effective braking coefficients attained. (A-82-168)

In a June 19, 1987, response to Safety Recommendation A-82-165, the FAA informed the Safety Board that it had drafted a notice of proposed rulemaking to enable aircraft manufacturers to furnish performance information "for slippery runways in unapproved sections of airplane flight manuals .…" Further, the FAA stated that it had amended its guidance material regarding performance information for operations on slippery runways, AC 91-6, in conjunction with the proposed regulatory changes. However, on April 1, 1988, after reviewing what the Board characterized as "the limited actions taken by the FAA during the [preceding] five years," including the FAA's failure to issue a final rule in this area, the Safety Board classified Safety Recommendation A-82-165 "Closed—Unacceptable Action."

In response to Safety Recommendation A-82-168, the FAA informed the Safety Board on April 1, 1983, that the FAA and NASA were initiating a test program "to develop a means to provide runway braking condition information which has a more quantitative basis than subjective pilot reports." However, on May 5, 1987, the FAA informed the Safety Board of its concerns that such runway friction and aircraft braking measurements could not be made

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[10] In this report, the term "contaminated," as it pertains to runways, is defined as being when the runway is not bare and dry or when the runway surface is altered such that the effective runway friction coefficient is less than the certificated bare and dry value.

[11] (1) National Transportation Safety Board. 1982. Air Florida collision with 14th Street bridge, Washington, D.C., January 13, 1982. Aircraft Accident Report NTSB/AAR-82/8; (2) National Transportation Safety Board. 1982. World Airways, Boston, Massachusetts, January 23, 1982. Aircraft Accident Report NTSB/AAR-82/15; and (3) National Transportation Safety Board. 1982. Large airplane operations on contaminated runways. Special Investigation Report NTSB/SIR-82/15.

meaningful and might encourage operations from a runway with a very low friction coefficient. The Safety Board disagreed and on April 1, 1988, classified Safety Recommendation A-82-168 “Closed—Unacceptable Action.”

1.10.4 Air Carrier Slippery Runway Events

Since 1982, a review of Safety Board accident data for 14 CFR Part 121 and 135 operators showed that 15 accidents occurred during periods of ice and snow contamination. The contamination on the surface was found to be the probable cause in two cases, and a contributing factor in nine others.

According to the FAA Administrator’s Daily Alert Bulletin reports reviewed by the Safety Board, six air carrier operations experienced excursions from runways or high speed taxiways in surface conditions of ice, snow or slush contamination during the winter season of 1995-96.[12] Additionally, air carrier operations experienced five excursions from taxiways under such conditions during the same period.

1.11 Flight Recorders

1.11.1 Flight Data Recorder

The aircraft was equipped with Sundstrand 573 FDR S/N 2152. The FDR was received at the Safety Board laboratory in good condition, with no signs of external or internal damage. However, the readout revealed that all parameters recorded by the FDR, except time and synchronization, lacked orderliness and reflected random values not resembling any type of flight operation. The FDR data were also transcribed at the TWA facility in St. Louis, Missouri, where the system was initially installed, but the data transcription yielded the same results. Finally, the data were provided to a private contractor, who also concluded that no meaningful data were on the tape.

1.11.2 Cockpit Voice Recorder

The aircraft was equipped with Fairchild model A-100 cockpit voice recorder (CVR), S/N 2059. The exterior of the CVR showed no evidence of damage, and the interior of the recorder and tape were also undamaged. The recording from 1106:40 to 1137:21 was of good quality.[13] It began during the preparation to start engines and ended shortly after the aircraft

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[12] Business Express BAE-146, Rifle CO, 2/20/96; Continental Airlines B-737, Kansas City MO, 1/18/96; Delta Airlines B-727, Salt Lake City UT, 1/26/96; Delta Airlines B-757, Portland OR, 2/5/96; American Airlines MD-80, Richmond VA, 2/17/96; USAir B-737, Charlotte NC, 2/3/96.

[13] The Safety Board generally uses the following criteria to assess the quality of a CVR recording: a “poor” recording is one in which a transcription is nearly impossible given that a large portion of the recording is unintelligible; a “fair” recording is one in which a transcription is possible, but the recording is difficult to understand; a “good” recording is one in which few words are unintelligible; and an “excellent” recording is very clear and easily transcribed.

went off the runway. The Safety Board transcribed the complete duration of the tape (see appendix B).

1.12 Wreckage and Impact Information

The first marks on the runway attributed to N605FF consisted of four pairs of black marks located approximately 2,000 feet from the threshold of runway 4L, and centered approximately 40 feet left of the runway centerline (see figure 2). The four pairs of tire marks were consistent with the tires of the airplane left main wing landing gear (LMWLG), left body landing gear (LBLG), right body landing gear (RBLG), and right main wing landing gear (RMWLG). The tire marks on the runway were continuous, and each mark was approximately 8 inches wide. No tire marks were found from the nose landing gear either on the runway or on the ground.

The marks were identified by tracing ground, taxiway, and runway marks back from the airplane using the known dimensions of the airplane's landing gear and tires.[14] When tire marks were correlated with the landing gear that left the marks, it was determined that the LMWLG departed the left edge of the runway (which is 75 feet left of the centerline) 2,100 feet from the threshold, and the RMWLG departed the left edge of the runway 2,300 feet from the threshold.

Both the LBLG and the RBLG tire marks paralleled the other tire tracks. The landing gear made ruts 8-12 inches deep in the soft, snow-covered ground. The RMWLG ruts intersected an area of 8"x12" asphalt blocks about 2,400 feet from the threshold and 105 feet left of the runway centerline. Just beyond this area, the tire marks crossed an asphalt service road connecting the runway and the parallel taxiway. The road sloped away from the runway so that the surface elevation was about 2-3 feet higher at the RMWLG tracks than at the LMWLG tracks. The RMWLG ruts continued to approximately 2,500 feet from the threshold and 240 feet left of the runway centerline, where the ruts began to shallow and then ended about 2,600 feet from the threshold and 290 feet left of the runway centerline. The ruts from the remaining main landing gear continued to where the airplane came to rest. Two new ruts approximately 30 feet apart and to the right of the RMWLG ruts that disappeared were associated with the Nos. 3 and 4 engines. The outboard rut ended at an electric transformer. The transformer and its concrete base were destroyed, and pieces of the nosegear assembly were found approximately 35 feet to the left of the transformer. The No. 4 engine was located about 3,700 feet from the runway threshold and 500 feet left of the runway centerline. The airplane came to rest approximately 4,800 feet from the runway threshold and 600 feet to the left of the runway centerline.

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[14] The distance between the LMWLG strut and the RMWLG strut is 36.1 feet. The distance between the LBLG and the RBLG is 12.6 feet. The distance between the center of an inboard and outboard tire for each landing gear is 4 feet.

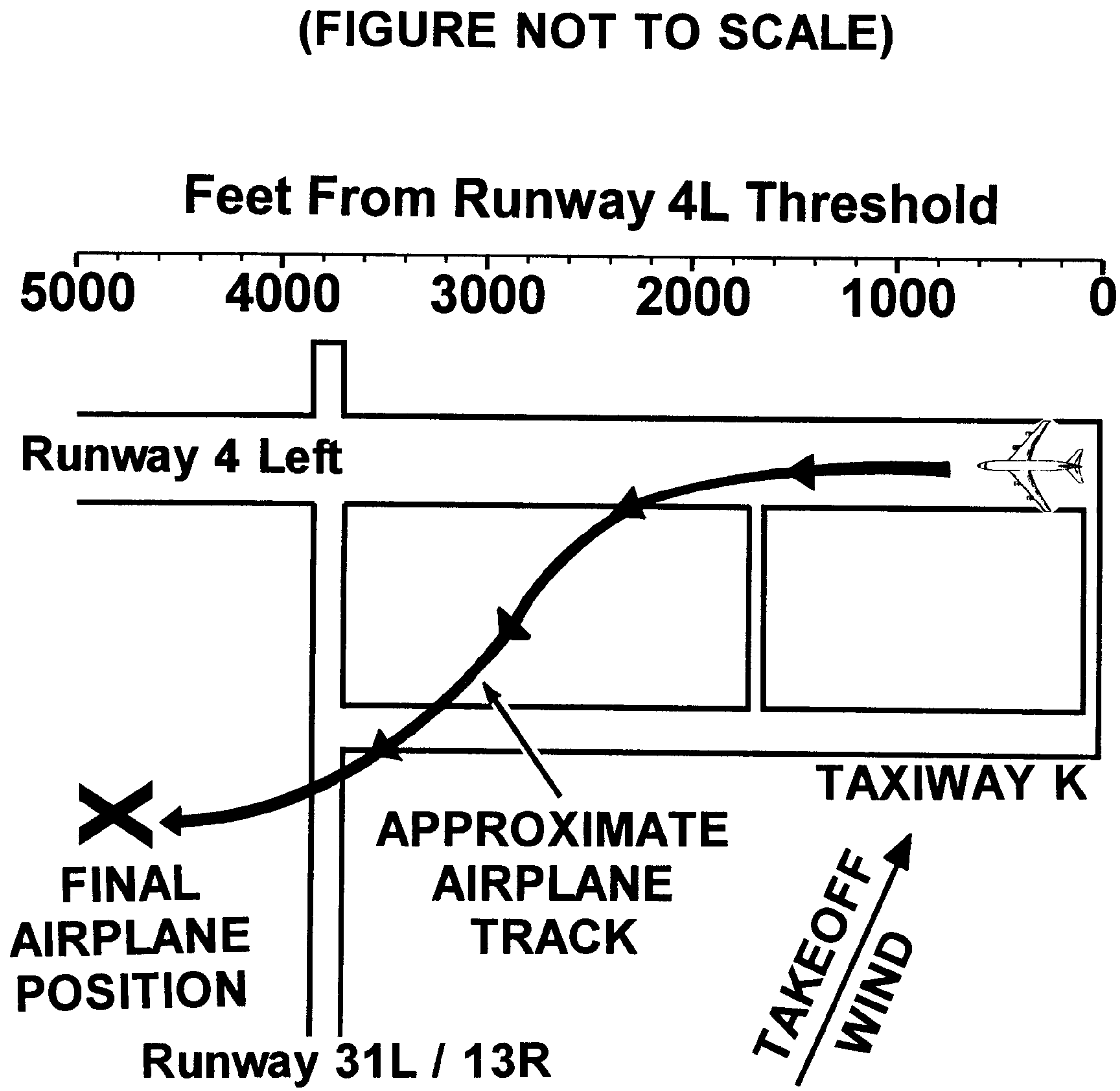

Figure 2—Airplane's Location After Skid

The fuselage forward of the No. 2 main entry door and below the floor level received severe impact damage. It was crushed upward where the nose landing gear had collapsed, still attached, aft into the fuselage. The collapse of the nose landing gear and subsequent crushing of the fuselage lower lobe resulted in significant damage to the electronics bay, and disrupted the normal operation of the PA and interphone systems. There was no impact damage to the fuselage above the floor line, and fuselage damage aft of the No. 2 main entry door was limited to fiberglass fairings.

The left wing, flight controls, and pylons for engine Nos. 1 and 2 were not damaged. The primary structure of the right wing and ailerons was not damaged. The inboard leading edge flaps and the inboard trailing edge mid and aft flaps received impact damage. The No. 3 engine pylon was severely damaged and bent slightly inboard. The No. 4 engine pylon was also severely damaged and separated forward of the rear engine mounts.

1.13 Medical and Pathological Information

In accordance with the requirements of Appendix I of Part 121, each flightcrew member submitted a urine sample at the Kennedy Medical Offices at JFK Airport for the required testing for five drugs of abuse.[15] The samples were analyzed by Labcorp of America, located in Research Triangle Park, North Carolina. The results were negative for all three crewmembers.

In accordance with Appendix J, 14 CFR Part 121, each flightcrew member also submitted to a Breath Alcohol Test. The tests were accomplished between 1416 and 1427 on December 20, 1995. The results were negative for all three crewmembers.

1.14 Fire

There was no fire.

1.15 Survival Aspects

1.15.1 Cabin Interior Layout and Damage

The interior of N605FF was divided into six zones, as shown in figure 3:

- Zone A - Cabin forward of the L1/R1 doors
- Zone B - Cabin between the L1/R1 and L2/R2 doors
- Zone C - Cabin between the L2/R2 and L3/R3 doors
- Zone D - Cabin between the L3/R3 and L4/R4 doors
- Zone E - Cabin aft of the L4/R4 doors
- Upper Deck - Cabin area above the main deck, aft of L1/R1 doors

[15] The five drugs of abuse specified by the regulation for postaccident testing are marijuana, cocaine, opiates, phencyclidine, and amphetamines.

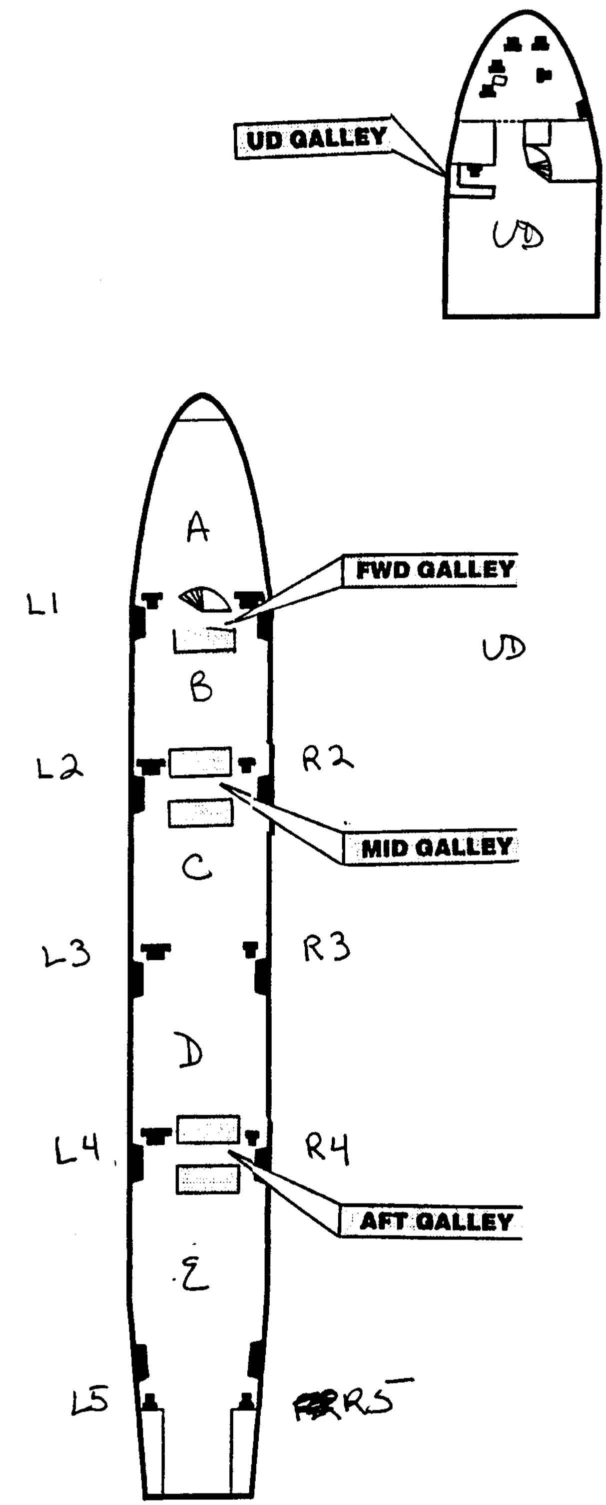

Figure 3—Cabin Layout

The cabin floor sustained substantial damage in Zone A. The floor was displaced upward approximately 2 feet in the center of the cabin at seat rows 6, 7, and 8. At least three of the four attach points for each of the seats in this area remained secured to the seat tracks, and no injuries were reported in this area.

1.15.2 Galley Equipment Description

The cabin of N605FF had three galley complexes, each of which consisted of two galleys facing each other. The forward complex was between the L1/R1 exits; the mid complex was between the L2/R2 exits; and the aft complex was between the L4/R4 exits.

Each galley contained both permanent equipment and removable equipment. Permanent equipment included ovens, coffee makers, and waste bins. Removable equipment included carts (meal or beverage carts used in the aisles), and containers (also referred to as bins, and usually not moved during the flight). Ice carts, slightly larger than the meal and beverage carts, were also part of the removable equipment on the former TWA airplanes in the Tower Air fleet, including N605FF.

According to Tower Air procedures, the ice carts are installed by the caterers before each flight. Flight attendants do not move them from the galley during the in-flight service, but they are responsible for ensuring security of the galley equipment, including the ice carts, based on their training, the Flight Attendants Manual, and the Galley & Service Equipment Training Manual.

Tower Air required that all of the removable equipment, including the ice carts, be secured with both primary and secondary locking devices. Primary latching of meal and beverage carts on N605FF was accomplished by placing each cart over a "mushroom" (a restraining spool mounted on the floor under the galley counter). The carts were secured to the mushrooms by a locking mechanism mounted beneath the cart. A cart could be removed from the mushroom by releasing the cart's brakes, which released the cart from the mushroom.

In contrast to the “mushroom” locking mechanism used to secure meal and beverage carts, the ice cart in each galley area of N605FF locked onto a retaining tongue mounted on the floor of the galley with a lever located on the bottom of the cart. The lever movement inserted a pin through a circular opening in the retaining tongue (see figure 4).

Secondary latches were installed for each cart in the galleys of N605FF. The secondary latches were levers that when rotated, covered a portion of the cart to prevent the cart from moving from its stowage location. In N605FF, some secondary latches were mounted to the galley counter, some were mounted on galley support structures, and some were mounted on trash bin doors. The secondary latch for the ice cart located in the forward-facing portion of the aft galley was mounted on the galley counter.

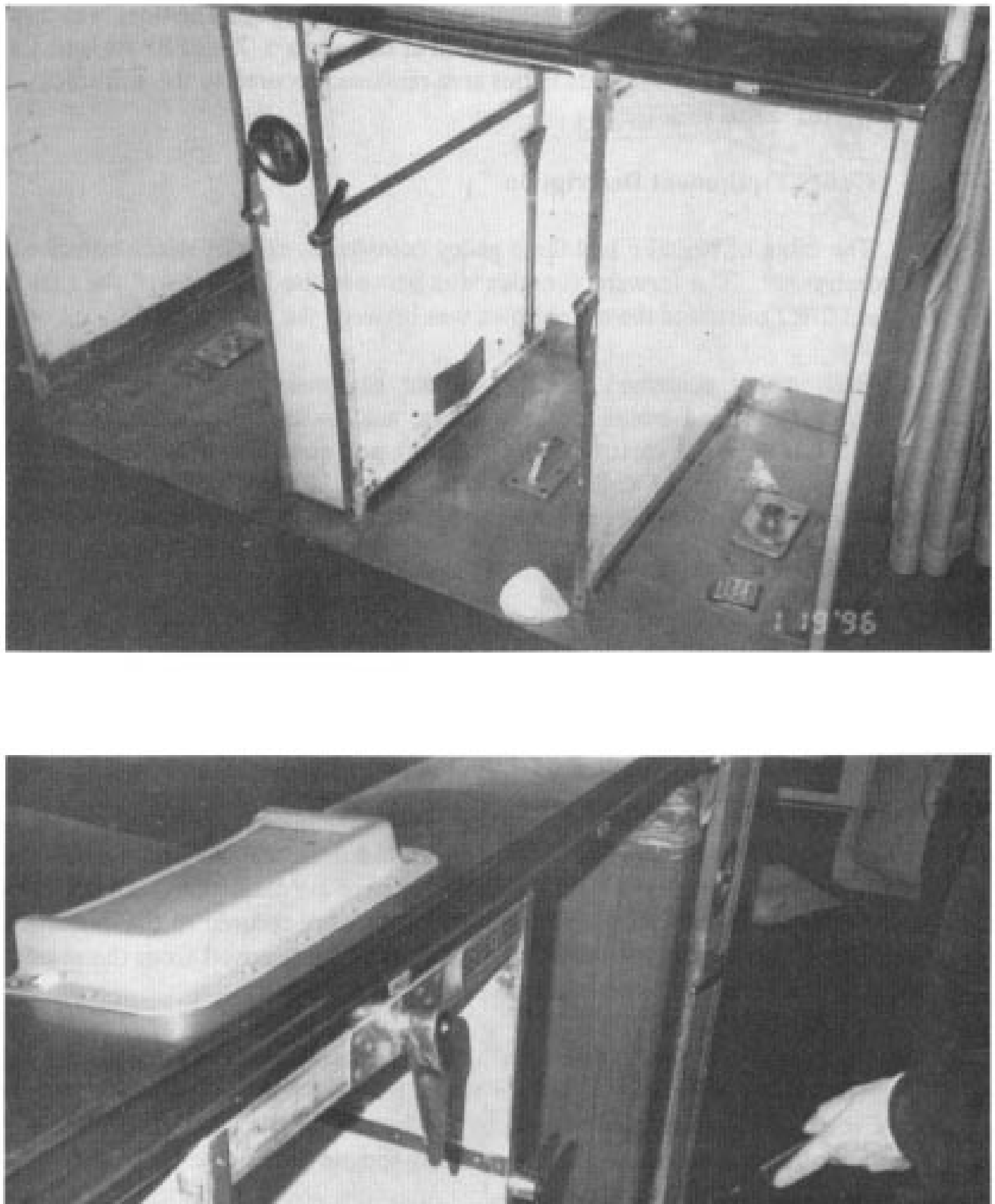

Figure 4—Galley Cart Primary and Secondary Securing Mechanisms

Based on its manufacture date of 1971, according to the FAA, N605FF was subject to type certificate requirements regarding the prevention of items of mass, stowed in a passenger or crew compartment, from becoming a hazard by shifting under the appropriate maximum load factors corresponding to the specified flight and ground load conditions, and to the emergency landing conditions of 14 CFR 25.561(b) and (c).[16]

The airplane was also subject to provisions of 14 CFR Part 25.785(h)(4), which required that each flight attendant seat be "located to minimize the probability that occupants would suffer injury by being struck by items dislodged from service areas, stowage compartments, or service equipment."

TWA had installed secondary latches on N605FF in 1982. The TWA engineering drawings for the installation of those latches included some latches mounted on doors rather than rigid structure. On N605FF, in the galleys where waste bins were installed, secondary latches were mounted on the waste bin doors. Further, the engineering drawings did not include a latch mounted on the galley counter as the secondary latch for the ice cart, as found in the aft galley of N605FF. TWA advised the Safety Board that the latches were installed when decorative, non-structural doors, were removed. The modification order stated that FAA approval was not required; however, a copy of the modification order was provided to the FAA.

On January 6, 1994, the FAA issued AC 25.785-1A, "Flight Attendant Seat and Torso Restraint System Installations." The AC provided the following guidance on secondary latching mechanisms:

> If the primary latching devices fail, the additional restraint devices [secondary latches] should be designed to retain all items of mass under the inertial loads specified as a part of the airplane type certification basis….
>
> ...Service experience with galleys, stowage compartments, and serving carts has shown that some of the presently designed latches or locks, of themselves, may not adequately minimize the probability of items being dislodged under operational and emergency load conditions….
>
> Flight attendant seats that are located within a longitudinal distance equal to three rows of seats measured fore and aft from the center of a galley or

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[16] 14 CFR 25.561 concerns Emergency Landing Conditions. It states, in part, that the airplane must be designed to protect each occupant as follows:...(b) The structure must be designed to give each occupant every reasonable chance of escaping serious injury in a minor crash landing when - (1) Proper use is made of seats, belts, and all other safety design provisions;...(3) The occupant experiences the following ultimate inertia forces acting separately relative to the surrounding structure: (i) Upward, 3.0g, (ii) Forward, 9.0g (iii) Sideward, 3.0g on the airframe; and 4.0g on the seats and their attachments. (iv) Downward, 6.0g (v) Rearward, 1.5g (c) The supporting structure must be designed to restrain, under all loads up to those specified in paragraph (b)(3) of this section, each item of mass that could injure an occupant if it came loose in a minor crash landing.

> stowage compartment area, with the exception of underseat and overhead stowage bins, are not in compliance with para. 25.785(j) [sic (h)(4)] unless additional restraint devices (dual latching devices or equivalent) are incorporated to retain all items of mass in the galley...under the inertia loads specified as part of the airplane type certification basis.

1.15.3 Flight Attendant Galley Preflight Procedures

According to the Tower Air Flight Attendant Manual, all company flight attendants had preflight duties, and four flight attendants on a B-747 were specifically responsible for preflight preparation and inspection of the galleys. The R1 flight attendant[17] was responsible for preflighting the forward galley; L2, the mid galley; L4 (who was designated assistant purser on the flight), the aft galley; and UD, the upper deck galley. These preflight duties included testing cart brakes, primary locking mechanisms, and secondary latches.

Following this accident, Tower Air Inflight Service Department issued a memorandum to all flight attendants on January 31, 1996, describing the operation of the ice module locking mechanism and the flight attendant responsibility to ensure that carts are properly locked.

1.15.4 Flight Attendant Galley Preflight Activities

The R1, L2, L4, and UD flight attendants on the accident flight stated that their galleys were secure for takeoff. These flight attendants stated that they secured the carts by engaging the cart brakes and placing secondary latches over the carts.

The L4 flight attendant was responsible for securing the aft galley. This was her first trip working the galley. She recalled that she was able to secure everything without difficulty. The L4 flight attendant stated that she secured the ice cart module in the aft galley by moving the lever underneath the cart to the secured position.

In contrast to the statements of the L4 flight attendant, the R4 flight attendant recalled that while she was icing down her beverage cart before departure, she noted that the ice cart swing brake was not secured to the retaining tongue. She stated that she tried to lock the cart, but could not. She stated that she advised the L4 flight attendant that the ice cart was not secure and asked the R5 flight attendant if he could secure the cart. The R5 flight attendant did not recall the R4 attendant making this request.

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[17] This report refers to flight attendants according to their emergency exit door assignments (refer back to figure 2 for cabin layout and door labels).

1.15.5 Events in the Cabin During the Accident Sequence

The R4 flight attendant, who was seated in the aft-facing jumpseat at door R4, reported that during the accident sequence, she sensed movement toward the right side of the runway with a skidding sensation. Later she heard “crunching, tearing” noises, and saw the No. 4 engine skidding down the runway before the airplane stopped. She recalled that while the airplane was still moving, many overhead bins opened and spilled their contents. The larger side bins in the cabin nearby also opened and spilled even more debris. During the airplane’s slide, she heard a “metal sound” in the aft galley, and she saw an ice cart and a beverage cart come loose. The ice cart hit her right shoulder, and she suffered a broken right shoulder. The ice cart continued to move forward and stopped upright in front of the empty passenger seats across from her jumpseat. The loose beverage cart hit the ice cart and then came to rest tilted against the seats, blocking the R4 exit. The R4 flight attendant recalled that she and several passengers smelled kerosene after the airplane stopped. She commented that if she had not been injured, she would have evacuated.

The L4 flight attendant stated that when the aircraft stopped abruptly, the overhead bins in Zone E opened, and luggage spilled “all over the place.” After the airplane stopped, the L4 attendant noted that the secondary latch for the ice cart on the forward-facing side of the aft galley was bent upward.

The R2 flight attendant observed that a bin in the mid galley had popped out about 2-3 inches during the accident sequence, and that the L2 flight attendant got out of her seat to secure it while the airplane was still sliding.

The UD flight attendant reported that the doors to several bins opened during the accident sequence. She recalled that various items of personal equipment she had stowed came out of the bins.

Based on the recollections of all flight attendants, the only flight attendants who shouted brace position commands during the accident sequence while the airplane was still moving, as required by Tower Air procedures, were those at the R1, R4, and UD positions.

The purser stated that when the airplane stopped, he tried to call the cockpit on the interphone. Although he heard the interphone tone, he received no answer. He ran upstairs to the cockpit to get instructions from the captain, and was told that because there was no fire or danger, the passengers should be kept on board out of the weather. He recalled that the captain also advised him that the rescue personnel would come to the L1 door. The purser stated that the captain did not inquire about the cabin condition or injuries, and the purser did not report the upward displacement of the floor in the forward cabin (Zone A). The purser returned to the L1 door position and made a PA announcement instructing passengers to remain seated. Flight attendants stated that, following the accident, PA announcements were heard in the front of the airplane, but they were not heard in Zones D and E or the rear part of Zone C. Three flight attendants stated that they attempted to use the interphone to communicate with the purser, and these attempts were unsuccessful. According to their statements, none of the flight attendants attempted to use the megaphones.

The deadheading company flight attendant identified himself to the purser and asked if he needed help. The purser told him, "Just keep the people seated." The deadheading flight attendant then repeated the announcement for the passengers to remain seated using the PA at the L2 station.

The purser stated that he did not think they were going to evacuate at any time. He also thought that the PA announcements were heard throughout the entire cabin, and he did not attempt to make an "All Call"[18] interphone call to communicate with the other flight attendants. According to the flight attendants, both the PA and interphone systems were operating properly before the accident.

1.15.6 Deplanement

When the rescue personnel arrived at the airplane, they proceeded to the L1 exit. The purser was unable to disarm the emergency evacuation slide at the L1 door because the arm-disarm handle would not move to the manual position. He next tried the R1 door, but the girt bar[19] remained engaged even after the arm/disarm handle was moved to the manual position. He next tried the L2 handle, which he was able to place in the manual position, and the L2 door was opened by the rescue personnel. The purser then announced instructions about deplanement over the PA system. Passengers deplaned by rows and boarded buses. The purser stated that he learned about the injured flight attendant during the deplanement.

1.15.7 Flight Attendant Training

Flight attendants at Tower Air were trained in accordance with an FAA-approved program. At the time of the accident, under the provisions of this program, new hires received 40 hours of basic indoctrination covering safety regulations, company policies, procedures, forms, and organizational and administrative practices. They then received 16 hours of initial training (14 hours classroom and 2 hours competency check) on B-747 cabin familiarization (including the aircraft systems they would be operating), authority of the pilot-in-command, and passenger handling. They also received 28 hours of emergency procedures training, including drills that provided instruction and practice in the use of emergency equipment and procedures.

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[18] The communication system includes a "master call indicator panel" and PA and interphone headset at each flight attendant station as well as in the cockpit. The "All Call" signal permits simultaneous interphone communication with all flight attendant stations and the cockpit. When the "All Call" code is used, a chime sounds at every station, and the crew call light on its master call indicator panel will flash (as opposed to a steady light for a normal crew call).

[19] A bar installed through a sleeve in the girt extension of the evacuation slide, which is installed in floor-mounted brackets to enable automatic slide deployment when the slide is in the "armed" position.

Training on operating the serving carts was included in the 16-hour initial training module. This training was conducted in a classroom, and one of the three types of carts in the fleet was brought to the classroom for demonstration purposes. Students were shown how the brakes operated and were given a chance to maneuver the cart. According to routine flight attendant training practices at Tower Air, the cart used for this demonstration could have been any of the meal or beverage carts found on any of the various models of the Tower Air airplanes. Ice carts, which have different primary attachment mechanisms from those of most other carts, were not specifically included in classroom cart demonstrations. At a separate time, students were shown the galleys while performing a "walkaround" on the actual airplane; however, no carts were installed in the galleys during the "walkaround" training session.

Neither slides nor photographs of carts were included in the Tower Air initial flight attendant training program. Students received a "Galley & Service Equipment" handbook during initial training that included a diagram showing an "Atlas"-style cart, which was used on some B-747s in the Tower Air fleet, but not on the former TWA aircraft. The "Atlas" cart had a different primary attachment mechanism from the "TWA" beverage and ice carts installed on N605FF. This handbook also described preflight procedures for the galley, again without specific reference to the "TWA"-type carts.

Flight attendants did not receive crew resource management (CRM) training at Tower Air, nor were they required to at the time of the accident. As part of its 1992 special investigation report[20] on flight attendant training, the Safety Board issued Safety Recommendation A-92-77 to the FAA:

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

Subsequently, the FAA amended 14 CFR 121.421, "Flight Attendants: Initial and Transition Ground Training," and 121.427, "Recurrent Training," to require CRM training for flight attendants. The effective date for the new requirement was March 19, 1996, with all flight attendants to be trained by March 1999.

Also, the FAA completed rulemaking that mandates CRM training for flightcrews and flight attendants and issued Advisory Circular AC 120-51B, Crew Resource Management Training, which recommends initial and recurrent training including communication and coordination exercises. Because of these actions, the Safety Board classified Safety Recommendation A-92-77 "Closed--Acceptable Action" on July 15, 1996. However, based on safety issues previously identified by the Board in its accident investigations, the Board encouraged the FAA to provide additional guidance to air carriers about the importance of group

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[20] National Transportation Safety Board. 1992. Flight attendant training and performance during emergency situations. Washington, DC. June 9, 1992. Special Investigation Report NTSB/SIR-92/02.

exercises involving both cockpit cabin coordination and coordination among the individual members of a flight attendant crew.

At the time of the accident, Tower Air flight attendants qualified for the purser and assistant purser positions[21] after receiving 5 additional days of training. Much of the subject matter was related to customer service functions, but the training also included reviews of emergency procedures, safety regulations, and coordination and communication among flightdeck crew, flight attendants, ground staff, and operations personnel.

Before departure, the flight attendant who had originally been scheduled to serve as purser on the accident flight was replaced by the scheduled assistant purser. This flight attendant had completed a 5-day training course for purser qualification in March 1995. However, he had not served as purser before this flight.

Tower Air procedures assign the assistant purser to the L4 door position. The flight attendant who was assigned the duties of assistant purser at the L4 door, as a result of the last-minute cabin crew change, had not attended the assistant purser training program.

1.16 Tests and Research

1.16.1 Flight Recorder Tests

To determine the operating capability of the FDR components installed on N605FF at the time of the accident, the Safety Board installed and tested the CEU and DAUs in various combinations on a sister ship (N606FF) that had an operative FDR system and components. During the test, individual parameter data sent to the FDR were monitored and recorded by use of an ARINC 563 hand-held tester, which samples the data stream sent to an FDR by the CEU.

When the three DAUs from N605FF were tested with the sister ship's CEU, DAUs #1 and #2 operated normally, but no data were output from DAU #3. In addition, the CEU self-test identified DAU #3 as inoperative.

When the CEU from N605FF was tested with the sister ship's DAUs, only the synchronization and time data were valid, and a valid CEU self-test could not be performed. This data condition was similar to the conditions found on the accident FDR recording.

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[21] The positions of purser and assistant purser are not FAA-mandated; the company uses these positions as part of its cabin crew assignments. According to the Tower Air Flight Attendants Manual, the purser provides “work guidance” to all flight attendants and has complete “responsibility for passenger service and safety requirements of the flight.” The manual states that the assistant purser directs flight attendants in the performance of their duties, ensures accurate provisioning of galleys, and ensures compliance with proper service procedures.

1.16.2 Cockpit Voice Recorder Sound Spectral Study

The area microphone channel of the CVR contained tones that were associated with sounds of the aircraft engines. The recording was examined on a computerized spectrum analyzer that displays and records frequencies. The engine speeds corresponding to the sound signatures were calculated. The engine traces were identifiable above 27 percent N_1 (engine fan speed). During the initial takeoff roll, two distinct traces were audible, but once the engines exceeded 70 percent N_1 only one engine-related sound signature was identified. It could not be determined which engines were creating the identified sound.

After air traffic control's (ATC) issuance of the takeoff clearance to flight 41, as recorded on the CVR, the engines accelerated to approximately 40 percent N_1 and leveled off for approximately 4 seconds. The engine sounds then increased in frequency for 13 seconds, and they stabilized at the equivalent of 87.5 percent N_1 after a brief overshoot to approximately 89 percent. The sounds continued at a constant frequency for approximately 6 seconds (35 seconds after the airplane was cleared for takeoff). After this period, the engine sound began to decrease to a minimum of 72.6 percent N_1. Approximately 42 seconds after takeoff clearance, the engine sound then began to increase again, reaching a maximum of about 91 percent N_1. The engine sound then decreased sharply after 2 seconds and was finally lost in the background noise at approximately 59 percent N_1.

1.17 Organizational and Management Information

Tower Air, Inc., was incorporated in 1982 and obtained an air carrier certificate in 1983. At the time of the accident, the company provided scheduled and charter passenger and cargo service in diverse international and domestic markets. Between 1990 and 1995, the carrier increased its fleet of B-747s from 4 to 17 airplanes. At the time of the accident, Tower was operating 18 B-747s with 132 pilots, 69 flight engineers, and 805 flight attendants.

1.17.1 Reporting Relationships Among Operational Managers

At the time of the accident, the vice president of operations (VPO) exercised daily operational control of Tower Air through the director of operations (DO), the chief pilot, the manager of flight control, and the director of crew scheduling, all of whom reported directly to the VPO.

The Federal Aviation Regulations do not require air carriers to have a VPO; nor do these regulations define the responsibilities or minimum qualifications of the VPO when this management position exists at an air carrier. In contrast, the DO is a required management position for all air carriers, under the provisions of 14 CFR 121.59 and 119.65. Minimum qualifications of the DO are set forth in 14 CFR 121.61 and 119.67. Among other requirements, the DO is required to hold an ATP certificate and have previous experience as a manager or PIC of flight operations conducted under Part 121.

Under 14 CFR 121.133, Tower Air was required to "prepare and keep current a manual for the use and guidance of flight and ground operations personnel in conducting its operations." The Tower Air document that fulfilled this requirement was the company's General Operations Manual (GOM).

Tower Air personnel records indicate that the owner's son, who was not a pilot, was appointed VPO on November 20, 1995. The former VPO became the DO and vice president of training and publications. At that time, the reporting relationships between the new VPO and subordinate personnel also were changed. The DO reported directly to the VPO. The chief pilot, who was managing the daily flight activities, the flightcrew training, and supervision of the pilots, check airmen, and flight instructors of the airline, also reported directly to the VPO.

According to statements of the VPO, the DO, and the chief pilot, these reporting relationships were in effect before the date of the accident. The Tower Air GOM, section 2.2, revision 153, dated February 1, 1996, included descriptions of these revisions to the company's organization structure and management duties and responsibilities. This section of the revised GOM described the duties and responsibilities of the DO, in part, as follows:

> Plans, administers, and directs the overall accomplishment of flight operations in accordance with FAA regulations and company policy and procedures.

Despite these responsibilities given the DO by the GOM, the reporting relationships established by Tower Air before the accident did not provide the DO with the responsibility to supervise the daily operational and training activities, and the operational personnel, that were under the control of the chief pilot.

According to the FAA principal operations inspector (POI), the FAA first received verbal notification of this change in management personnel and reporting relationships on December 20, 1995, before the accident occurred. The POI described the notification he received on that date as one of a planned management change, rather than a management change that had already occurred.

In a letter dated January 25, 1996, the POI assigned to Tower Air requested an updated organizational chart and a list of duties and responsibilities of the VPO, DO, and chief pilot. The company provided the POI with GOM revision 153, dated February 1, 1996. On February 29, 1996, the POI sent a letter rejecting the new organization, stating the following, in part:

> The Vice President of Operations has been assigned several duties and responsibilities for which he lacks the qualifications.
>
> The Operations Organizational Chart shows the chief pilot, Director of Crew Scheduling, and Manager of Flight Control reporting directly to the Vice

> President of Operations and not through the appropriate chain of command, normally associated with aviation experience.

Tower Air's chief executive officer responded on March 20, 1996, in part, that, "Our research of the applicable laws, regulations, and legal precedents reveals no objective basis for your decision. Nevertheless, this is to advise that your position will be addressed in revision 154 of the General Operations Manual." This revision subsequently was issued and reflected the chief pilot reporting through the DO to the VPO.

1.17.2 Director of Flight Safety

In August 1995, Tower Air engaged the part-time services of a consultant to fill the company's newly created position of director of flight safety and evaluation. He served as a "contract employee" with a guarantee of 10 paid days per month, and a daily rate for additional days worked.

To foster the communication of safety information from line crews to managers, the director of flight safety and evaluation established a "CEO's hotline," developed a concern form with drop boxes on company premises, and reviewed crewmembers' trip reports. At the time of the accident, he had developed an internal evaluation program, including provisions for internal and external audits of station, flight operations, cabin, and ramp safety. However, at the time of the accident, Tower Air had not yet formalized the personnel assignments to perform these audits, and none had been performed.

1.18 Additional Information

1.18.1 Operating Procedures - Boeing 747

The Tower Air B-747 Flight Manual (p. 4.30.3) states, "Takeoffs on slippery runways are not recommended if the crosswind exceeds 15 knots…"

The manual describes the following technique for nosewheel steering use during takeoffs (p.4.24.3):

> Rudder pedal steering [nosewheel steering controlled by pilot inputs through the rudder pedals] should be used after the aircraft is aligned on the takeoff runway with the tiller guarded only until 80 knots. If deviations from the runway centerline cannot be controlled during the start of the takeoff prior to rudder effectiveness, immediately reject the takeoff.

It also specifies the following for takeoffs on slippery runways (p.4.30.3 and pp.4.30.3-5):

> Set takeoff thrust slowly and smoothly and correct deviations from the runway centerline with immediate steering and/or rudder action and slight differential

> thrust if required.… During takeoffs on icy runways, the lag in nosewheel steering and the possibility of nosewheel skidding must be realized and corrections must be anticipated. Directional control from nosewheel steering and aerodynamic rudder forces should be optimized during the low speed portions of the takeoff roll by limiting the rudder pedal input to approximately 1/2 of the full rudder pedal travel for airplanes with rudder pedal steering. For airplanes without rudder pedal steering, limit the tiller input to 10^o and use the rudder as required. Rudder effectiveness is less than nosewheel steering effectiveness below approximately 50 knots. Increased directional control may be obtained by the use of the ailerons between 60 and 100 knots.

The manual contains guidance for landing on slippery runways (p.4.30.6), as follows:

> Avoid large, abrupt steering and rudder pedal inputs that may lead to overcontrol and skidding.… The optimum nosewheel steering angle varies with runway condition and airplane speed, and is about $1\text{-}2^o$ for a very slippery runway. Keep forward pressure on the control column to improve nosewheel steering effectiveness.

The manual further amplifies a discussion of the landing rollout that the optimum nosewheel steering angle for a slippery runway is $3\text{-}5^o$, and $1\text{-}2^o$ for a very slippery runway.

A Tower Air 1994 Standards Memo, dated February 11, 1994, provided the following additional guidance in a section entitled, "Steering":

> Use rudder pedal steering for takeoff. Use of the tiller is not recommended unless rudder steering is not sufficient during the early takeoff roll. As the speed increases during takeoff with a crosswind, apply ailerons as required to maintain wings level. Avoid large changes in control inputs. The directional control from the rudder becomes more effective than nosewheel steering at about 50 knots. If directional control cannot be maintained by 50 knots without the use of the tiller, the takeoff should be aborted.

The Boeing 747 Operations Manual states the following (p.4.23.04A):

> On airplanes without rudder pedal steering, limit tiller input to approximately 15^o....The pilot flying should maintain control of the thrust levers until directional control is assured (approximately 50 knots)....If deviations from the runway centerline cannot be controlled during the start of the takeoff roll or until the rudder becomes effective, <u>immediately</u> reject the takeoff.

The Boeing 747 Flight Crew Training Manual contains the following additional information:

> When taxiing on a slick surface at reduced speeds, use of differential outboard engine thrust will assist in maintaining airplane momentum through the turn. Differential braking may be more effective than nose wheel steering on very slick surfaces.
>
> Keep the airplane on the center line with rudder pedal steering and rudder. The rudder becomes more effective than the rudder pedal steering at about 50 knots. Do not use nosewheel tiller during takeoff roll unless required initially due to crosswind.
>
> At aft CG and light weights, nose wheel steering effectiveness is reduced, especially on slick surfaces. Application of takeoff thrust and a sudden brake release will lighten the nose wheel loading. With this condition, a rolling takeoff is preferred with slow, steady thrust application to takeoff thrust during the initial roll. Hold the control column forward to improve nose wheel steering.

1.18.2 Flightcrew Training

At the time of the accident, Tower Air conducted flightcrew training from a base in New York, using leased flight simulators in a variety of locations. The manager of flight training handled administrative aspects of the program and reported to the vice president of training. However, actual training and flight standards activities were managed directly by the chief pilot. The training staff consisted of the chief pilot, classroom instructors, and six simulator instructors. The simulator instructors were line-qualified captains who were current employees or retired captains who served under direct contract with the company. They were also qualified as check airmen.

According to the chief pilot, the company was able to hire pilots already qualified in the B-747 for a period after startup. Later it became more difficult to hire only those pilots who were already qualified in the B-747, and hiring was opened to other applicants. At the time of the accident, the minimum hiring requirement was 3,000 total hours, but the average experience level of new hires was 6,000-8,000 hours with substantial experience in heavy airplanes.

The chief pilot also stated that the training program for new hires provided little training in slippery runway procedures, because the new hires started as first officers, and first officers would not be performing the takeoffs or landings under these conditions (captains would perform all of these operations, according to Tower Air practices).

The chief pilot stated that during upgrade training for captain qualification, adverse weather takeoff procedures were presented in ground school as these procedures were described in the Tower Air B-747 flight manual. The simulator training phase of upgrade training introduced students to a slippery runway condition during landing that rendered the airplane uncontrollable. Tower Air training personnel indicated that the B-747 simulators available for flightcrew training were not capable of adequately simulating the more realistic slippery runway scenarios, in which the airplane would be controllable given proper control technique.

The Tower Air CRM training program for flightcrews included a 1-day ground school on CRM fundamentals. This class was taught by an individual who was experienced in CRM classroom instruction from his work at other air carriers. The CRM instructor worked under contract for Tower Air. Nearly all cockpit personnel, including the three crewmembers involved in the accident, had received this training by the time of the accident. Also, Tower Air integrated CRM elements into recurrent simulator training by including line-oriented challenges for the crew that required coordination among the flightcrew, dispatchers, and maintenance personnel. Recurrent simulator training was conducted with complete crews (the company elected to provide biannual recurrent training for most first officers).

1.18.3 Pilot Techniques for B-747 Takeoffs

The captain stated that his usual takeoff procedure was to hold the tiller with his left hand until the 80-knot callout, at which time he called, “I’ve got it” and transferred his left hand to the yoke. He stated that he used the tiller on every takeoff, and he relied on the 80-knot call to ensure rudder effectiveness. He stated that there was no company-established maximum speed for using the tiller. He was unable to recall the recommended maximum crosswind limit for a slippery runway without referring to the manual.

The first officer stated that his usual takeoff procedure was to use the tiller early in the takeoff roll, until about 80 knots when the rudder becomes effective. He commented that the tiller becomes more sensitive as speed increases. He said that he used the tiller more in crosswind situations. He also pointed out that rudder pedal movement gives some nosewheel steering. He stated that the maximum crosswind component for a slippery runway was 15 knots.

The chief of flight standards described Tower Air’s standard takeoff technique at the time of the accident: During the takeoff roll, the flying pilot should guard the tiller with one hand for possible use during the spoolup phase from 1.1 EPR to takeoff power, in case of asymmetrical thrust. At about 50 knots the rudder becomes controlling. At 80 knots, the flying pilot should release the tiller and take control of the yoke.

The chief of flight standards emphasized that the proper nosewheel steering technique for the takeoff roll should be to use rudder pedal steering, not the tiller. He explained that the Tower Air procedure of guarding the tiller during the takeoff until attaining 80 knots was carried over from an early Pan American procedure. The older model B-747s operated by Pan American were not equipped with rudder pedal steering. During the 1980s, Tower Air had also operated a small number of B-747s that were not equipped with rudder pedal steering. Although at that time instructors encouraged the use of the tiller during the initial takeoff roll, the airline’s policy changed about 1989 with the retirement from the fleet of the last airplane not equipped with rudder pedal steering.

The chief of flight standards stated that proper tiller use, including limitations on the use of the tiller, had been periodically emphasized in training. He added that pilots used the tiller during taxi, and there was sometimes a natural tendency to revert to its use on the runway. He also indicated that instructors emphasized the Boeing training manual language that recommends limiting rudder pedal steering input to ½ full travel to get optimal cornering friction. He indicated that it is clear that if a pilot cannot control the airplane with ½ rudder pedal travel, the takeoff should be rejected.

The chief pilot reported that the tiller should be guarded by the flying pilot, and it should be used for directional control only in the initial alignment with the runway centerline as the transition is made to rudder pedal steering. He stated that the tiller can aggravate directional control at higher speeds. He said that reverse thrust would not be used on slow-speed rejected takeoffs (below 80 knots) and added that reverse thrust presents possible directional control problems on slippery runways.

1.18.4 B-747 Simulator Activity

In a flight simulator study on August 8, 1996, pilots from the Safety Board, FAA, Boeing, Tower Air, and the Tower Air Cockpit Crewmembers Association (TACCA) evaluated various pilot inputs and their effects on directional control. The study was conducted at the Boeing Airplane Systems Laboratory in Seattle, Washington. The simulator employed in the tests was the "747 Cab," a B-747 engineering simulator in the laboratory capable of being systematically modified to reflect selected environmental conditions, aircraft performance characteristics, and aircraft responses to control inputs. It was programmed to reflect the operating weight, CG, flap setting, and outside air temperature applicable to the accident flight.[22] During the simulator sessions, takeoffs were attempted under dry, wet, snowy, and icy runway friction conditions, with crosswind components of 12 and 24 knots (corresponding to the greatest wind velocities reported by ATC to the accident crew and recorded at any time during the morning of the accident, respectively). Gust conditions were simulated by introducing gusts of 12 and 20 knots, with 2-second and 6-second durations. Gusts were introduced at airspeeds varying from 20 to 65 knots.

The evaluation pilots who had actual experience operating the B-747 on slippery runways (those representing the FAA, Boeing, Tower Air, and TACCA) agreed that the Boeing engineering simulator adequately reflected the ground handling characteristics of the actual airplane in slippery conditions. Further, they agreed that the ground handling characteristics of the Boeing engineering simulator were more realistic than those of the simulators used by Tower Air for flightcrew training.

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[22] The simulator was a B-747-400 model, with the simulator modified to reflect the performance of the B-747-136 model involved in the accident. Modifications included engine thrust, stabilizer trim setting, rudder travel, and icy runway friction coefficient.

Operating the simulator under slippery runway conditions, with a left crosswind component of 12 knots, the evaluation pilots were able to reproduce the approximate path of the accident airplane as it deviated from the centerline and departed the runway. In these simulations, the deviations were initiated when tiller inputs were introduced to correct minor heading changes that occurred immediately following brake release, while the simulated airplane was moving at slow speed. The simulator responsiveness to tiller inputs was reduced by the slippery runway conditions. When the pilots reacted to the decreased control responsiveness by adding more tiller, the nosewheel quickly exceeded the critical angle at which the traction available for steering was maximized. This critical angle, which varies as a function of runway slipperiness, airplane ground speed, and airplane slip angle, was one of the parameters recorded during the simulations. Once the critical angle was exceeded, the nosewheel began to skid. Further tiller inputs in either direction were ineffective, and the airplane veered to the left in a weathervaning response to the crosswind.

During most of the simulated takeoffs that reproduced the approximate path of the accident airplane, the airplane did not completely depart the runway surface before it attained sufficient airspeed for the aerodynamic rudder to become effective (50-80 knots). The simulator was capable of responding to right rudder inputs with a corrective, rightward yaw once this airspeed was attained. At that time, pilots were able to arrest the leftward veer with rudder inputs to regain runway heading with some or all of the simulated airplane remaining on the runway surface. The simulator was not programmed to exhibit any additional drag or yaw that may develop when a real airplane landing gear leaves the runway surface. The takeoff attempts during which the left veer could not be arrested with right rudder were those in which the heading deviation was initiated by overcontrol of tiller at the earliest part of the takeoff roll, while airspeed was well below rudder effectiveness.

In contrast to the results obtained with pilot inputs to the tiller, simulated takeoffs could be successfully completed without significant deviation from the runway centerline using control inputs limited to the rudder and the nosewheel steering through the rudder pedals. The takeoffs were controllable in the absence of tiller inputs under all runway surface conditions from dry through icy, and with crosswinds of up to 24 knots. Further, without tiller inputs, takeoffs were controllable under crosswind conditions of 20 knots gusting to 40 knots.

A simulated takeoff during which no aerodynamic rudder or nosewheel steering inputs were made resulted in the simulated airplane initially drifting downwind (to the right) momentarily, then weathervaning into the wind, and departing the left side of the runway.

Takeoffs attempted under slippery runway conditions, with a lower thrust value from the No. 1 engine, resulted in an uncontrollable deviation to the left of centerline. Specifically, when an asymmetric thrust of 0.05 EPR was used at the beginning of the takeoff attempt, the simulator departed immediately from the left side of the runway, at low speed, and before rudder effectiveness was attained. Introduction of asymmetric thrust later in the takeoff roll had varying effects on directional controllability, depending on the airspeed attained and the consequent rudder effectiveness.

During simulated takeoff attempts incorporating use of the tiller under slippery runway conditions, variations in elevator and aileron position did not appear to significantly affect directional controllability at low speeds.

1.18.5 Recent Tower Air Accidents and Incidents

Safety Board records reveal that Tower Air experienced two accidents and three incidents between August 14, 1995, and June 17, 1996. In addition to the accident that is the subject of this report, there were two uncontained engine failures (one of which was an accident), an in-flight engine gearbox fire that had to be extinguished by an ARFF unit, and a landing approach incident.

On August 14, 1995, a B-747-130, N603FF, operated by Tower Air, had an uncontained engine failure in the No. 1 engine during the departure climb from JFK.[23] The crew reported a severe vibration at 14,000 feet, declared an emergency, and returned to JFK. The flight landed safely and taxied to the gate, where the 436 occupants deplaned normally without injury. The JT9D7A engine had been leased to Tower Air and had accumulated 105 cycles since it was installed on July 7, 1995. Examination of the engine revealed that pieces of a turbine shroud had penetrated the turbine exhaust case at the 6 to 9 o'clock position, exited the cowling, and punctured the No. 2 outboard reserve fuel tank. There was a fuel leak, but no fire developed.

On October 23, 1995, N613FF, a B-747-121, had a failure of the No. 4 engine during the takeoff roll at Miami International Airport, Miami, Florida.[24] This was a cargo flight with three crew and two passengers. When the airplane came to a stop, the crew observed a fire in the area of the JT9D7A No. 4 engine. The five occupants evacuated the airplane. There were no injuries, but the airplane was substantially damaged. Examination of the airplane revealed that an uncontained failure of a low pressure turbine hub of the No. 4 engine damaged the cowling, pylon, wing, aileron, flaps, fuselage, and right horizontal stabilizer.

On December 10, 1995, N616FF, a B-747-212B, sustained damage during an instrument landing approach in fog at Schiphol Airport, Amsterdam, Netherlands.[25] The flight executed a missed approach and landed uneventfully following a second approach. A post-landing inspection revealed that the No. 4 engine cowling and right wingtip were damaged. None of the 288 occupants were injured.

On December 20, 1995, this accident occurred at JFK.

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[23] NTSB file number NYC95IA192, B-747, N603FF, JFK Airport, Jamaica, NY, August14, 1995.

[24] NTSB file number MIA96FA013, B-747, N613FF, Miami, FL, October 23, 1995.

[25] NTSB file number DCA96WA018, B-747, N616FF, Amsterdam, Netherlands, December 10, 1995.

On June 17, 1996, N606FF, a B-747-136, experienced a fire warning light in the No. 2 engine at 35,000 feet, during the arrival/descent to JFK.[26] The crew shut down the engine, discharged both engine fire extinguishing bottles, and declared an emergency. The airplane was met by ARFF equipment, which foamed the engine. The 414 occupants deplaned by mobile stairs, without any injuries.

1.18.6 FAA Surveillance

At the time of the accident, the FAA New York Flight Standards District Office (FSDO-EA15), located at Garden City, New York, was responsible for surveillance of Tower Air. The FSDO organization included two Certificate Management Units (CMU): one managing Tower Air and Atlas Air, and the other managing North American Airlines and the USAir Shuttle.

The FAA POI assigned to Tower Air joined the FAA as a geographic operations inspector in 1988. He was assigned to the Tower Air certificate as an assistant POI in 1989 and became the POI in 1991. His previous background included experience in the commuter industry as a director of operations and a chief pilot. He held type ratings in the B-737 and B-747, both of which he received after he was hired by the FAA. His B-747 training was provided by TWA to FAA personnel only, as transition training, and it lasted 1 month in June 1990. As part of that training, he obtained about 2 hours in the airplane. The remainder of his B-747 training and subsequent experience was obtained in the simulator. His most recent B-747 recurrent training was completed in January 1995.

He stated that since 1991, he had always been assigned as the POI of one or more other air carriers in addition to Tower Air. In 1993, he was assigned as the POI of Atlas Air. At the time of the accident, Tower Air was operating 18 B-747s; Atlas was operating 11 B-747s; and both carriers were expanding. He estimated that his time was equally divided between the two carriers. He said that his workload was “near its limits.” At the time of the accident, he was receiving support from an assistant POI, the geographic unit, a navigation specialist, and a cabin safety specialist, all within FSDO-EA15. He stated that he had requested additional geographic inspection support (surveillance of Tower Air operations by inspectors based at other domestic and international FAA flight standards offices).

The POI stated that he obtained feedback from the geographic inspections by reviewing information entered by the geographic inspectors into the FAA Program Tracking and Reporting Subsystem (PTRS) data system. He stated that he attempted to review these entries quarterly, but that his most recent review before the accident was made in June 1995.

A review of FAA PTRS records for Tower Air indicated that the POI had performed one cockpit en route inspection from October 1, 1994, through December 31, 1995. That inspection was performed on January 27, 1995.

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[26] NTSB file number IAD96IA098, B-747, N606FF, JFK Airport, Jamaica, NY, June 17, 1996.

The assistant POI for Tower Air was hired in 1991 as a geographic inspector. He was appointed as an assistant POI for both Tower Air and Atlas in 1993. He had been a pilot for TWA for 34 years and retired as a B-747 captain. He commented that he and the POI assigned to Tower Air and Atlas were not overloaded, but whereas each carrier had been expanding at different times previously, the two airlines were both expanding simultaneously at the time of the accident. He stated that this had resulted in a backlog for check rides and insufficient time for the POI and him to conduct routine en route checks. He stated that he visited the Tower Air corporate offices about once per week, and said that he conducted en route inspections for certification and initial operating experience (IOE).

The assistant POI said that Tower Air flightcrew training was conducted by line pilots. He was not able to describe the company's CRM training program for flightcrews. He was aware that Tower Air had established a safety department about 2 months before the accident, but he did not know whether the safety officer was a full-time employee.

A review of PTRS records revealed that the assistant POI did not perform any en route inspections at Tower Air that were not certification related from October 1, 1994, through December 31, 1995.

The manager of FSDO-EA15 had held that position since October 1994. Previously, he was the assistant manager of the Eastern Region Flight Standards Division. He stated that at the time of the accident, maintenance and avionics inspector staffing at FSDO-EA-15 were at the authorized levels. He said, however, that the operations inspector staff was nine short, including an Aircraft Program Manager (APM) position that he did not expect would be filled. He stated that he had received authorization to fill five of the operations inspector positions in FY 1996. He stated that he hoped to fill the remaining three positions during FY 1997. He commented that a single international en route inspection required 32 hours of an operations inspector's 40-hour week. He stated that FSDO-EA-15 needed more geographic inspection support from other FAA flight standards offices.

According to the FSDO manager, as a result of an internal staffing review, it was his intention to reorganize the office to create three CMUs. The Tower Air certificate would be managed by one of these CMUs, with a dedicated POI and assistant POI. In September 1996, the Safety Board was informed through informal staff communications with the FAA that these changes had not yet occurred, but were impending.

A review of the PTRS records for Tower Air revealed that 160 operations inspections were completed from October 1, 1994, through December 31, 1995. Most of the inspections focused on ramp, en route cockpit and cabin, training records, check airmen, and facilities. Also, one line station and two in-depth inspections were conducted in FY 1995. About half of the operations inspections were conducted by geographic inspectors from the FAA's Eastern Region, which included FSDO-EA-15. Despite the worldwide operations of Tower Air, no cockpit en route surveillance had been performed by inspectors from the Frankfurt, Brussels, or London offices, and no operational inspections of any type had been performed by the Miami International Field Office.

The FAA conducted a national aviation safety inspection program (NASIP) inspection at Tower Air from September 11-20, 1995. The inspection resulted in 34 findings, of which 23 were maintenance related and 11 were operational.

The 23 maintenance discrepancies discovered in the NASIP inspection included 11 items in which procedures were either not found in the maintenance manual or were not being followed. Ten items related to discrepancies in maintenance logbooks, and two items related to maintenance training. All maintenance items were closed either through Tower Air action or a note of explanation provided by FSDO-EA-15.

The 11 operational findings included four related to flight, duty, and rest time recordkeeping; four involved training records of flightcrew members and dispatchers; two related to manuals; and one related to aircraft differences in emergency egress equipment that were not reflected in safety briefings by flight attendants and in passenger briefing cards. One of the training record discrepancies credited a captain with training in New York while he was flying a line trip to the Far East. All 11 findings were closed by the time of the accident. Two findings, including this pilot training record discrepancy, resulted in enforcement action by the FAA.

The executive summary of the NASIP inspection stated:

> Findings documented during the inspection that are being investigated for possible non-compliance with [Federal Aviation Regulations] are: manuals and procedures, training records, passenger briefing cards, [Minimum Equipment List] usage, and life limited parts records.

A review of the FAA enforcement records for Tower Air indicated that 120 enforcement actions had been closed since the carrier's inception. As of January 1996, 17 cases were open. Two were operational and the others were maintenance related.

1.18.7 Aircraft Performance

Because no meaningful data from the FDR were available, a study was conducted to investigate the aircraft movement during the attempted takeoff. The aircraft manufacturer derived total airplane thrust values from the results of the Board's CVR sound spectrum study (see section 1.16.2). The derived engine thrust was used to calculate ground speed and distance traveled data, using the Boeing engineering computer simulator. Selected comments and sounds from the CVR were also correlated to the time base. The derived information was then used to graphically represent the probable airplane movement during the accident sequence.

This showed that at 1136:25, flight 41 was cleared for takeoff. By 1137:02, engine N_1 rpm had reached 88 percent (approximately 160,000 pounds of total thrust), the airspeed had increased to about 40 knots, and the airplane had traveled about 630 feet from the runway threshold (including a nominal 250 feet to turn onto the runway and align the nosewheel before initiating the takeoff).

At 1137:04, the captain said, “Set time, takeoff thrust.” The power remained stable at about 88 percent N_1. The takeoff continued normally as the flight engineer confirmed the request. At 1137:10 the words “watch it” were spoken twice. At this time, 25 seconds after the start of the takeoff roll, the airspeed had increased to about 80 knots, and the airplane had traveled 1,350 feet. Within a second there was an audible “click” on the CVR, and the engine rpm began to decrease from about 88 percent to 75 percent by 1137:13. Within 2 seconds thrust began to increase to a maximum of 91 percent N_1, about the time the airplane departed the left edge of the runway.

Between 1137:12 and 1137:15 there were comments from various flightcrew members (“OK, losing it”; “going to the left”; “to the right”; “you’re going off”; and “going off”). During the same period, the airspeed increased from 88 knots to 94 knots, and the airplane traveled from 1,650 feet to 2,100 feet down the runway. At 2,100 feet, the LMWLG departed the runway edge. The aircraft performance study indicated that the airspeed was about 97 knots at this time. The RMWLG departed the runway edge at 1137:16.5, at an airspeed of about 100 knots.

Based on the Safety Board’s measurements of the tire marks on runway 4L associated with the landing gear of the accident airplane, between 2,000 and 2,050 feet from the runway threshold, the airplane was at an angle of 15.4^{o} from the runway centerline. Between 2,050 feet and the 2,100-foot point where the LMWLG left the runway edge, the angle was 11.5^{o} from the centerline. The tire marks over the next 200 feet of travel indicated that the airplane departed the runway at an angle of 10.4^{o} to the left of the runway centerline.

2. ANALYSIS

2.1 General

The flightcrew was properly certificated and qualified in accordance with applicable regulations and company requirements. All three crewmembers were experienced at their respective positions. Evidence from crew duty time, flight time, rest time, or off-duty activity patterns did not indicate that behavioral or physiological factors affected the flightcrew on the day of the accident.

The ATC personnel involved with the flight were all properly certificated and qualified.

The airplane was properly certificated, equipped, and maintained (with the exception of the FDR system) in accordance with FARs and approved regulations. The weight and balance were within allowable limits.

In analyzing this accident, the Safety Board focused on flightcrew actions and decisions, B-747 procedures for slippery runway operations, the performance of air carrier training simulators for B-747 operations on slippery runways, flight attendant actions and cabin safety issues, Tower Air management oversight of maintenance and operations, FAA surveillance of Tower Air, and FAA policies and procedures regarding the evaluation of slippery runways.

2.2 Flightcrew Actions and Decisions

2.2.1 Pre-takeoff Events

Although the flightcrew was not provided the runway friction values obtained by the airport operations crew, they had obtained sufficient indications from the slipperiness of the taxiways, the appearance of runway 4L, and the blowing snow to recognize that they were operating in a challenging environment of wind, reduced visibility, and runway slipperiness.

Based on the existing surface and wind conditions on the day of the accident, the captain might have considered using runway 31L (which was more favorably oriented to the wind) for his departure. However, when the captain overheard the response of JFK ground control to another flight's inquiry about runway 31L that it would remain closed for another couple of hours, he determined that runway 31L was not a viable option for departure. Although 5 minutes before the accident ATC changed the departure runway to 31L for traffic following flight 41, the Safety Board recognizes that the captain's decision to use runway 4L was based on the limited information available to him at the time. Further, air traffic controllers were not required to offer flight 41 the option of switching to runway 31L, once the airplane was established holding short at runway 4L. Based on the absence of definitive runway friction measurements for runway 4L, reported winds of less than 15 knots (the maximum recommended crosswind component for B-747 takeoffs on slippery runways), the flightcrew's reports of acceptable visibility down the runway, and the reported unavailability of the alternative runway

31L, the Safety Board concludes that the captain's decision to attempt the takeoff on runway 4L was appropriate.

2.2.2 The Attempted Takeoff and Loss of Control

Flight 41 attempted its takeoff under crosswind conditions with a runway contaminated with packed snow and patchy ice. At the approximate time of the takeoff attempt, there were crosswinds of 10-12 knots. Gusts of up to 22 knots were reported in the general area near the time of the accident.

Asymmetric thrust (for example, inadequate thrust from the No. 1 engine) could have resulted in the loss of directional control experienced by flight 41. In the absence of a cross-check of other engine instruments, a malfunctioning EPR indicator could have led the flightcrew to unknowingly set inadequate thrust for the No. 1 engine. However, given the flight engineer's recollections of evenly matched engine acceleration and consistent EPR and N_1 indications from all four engines, and the absence from the CVR of flightcrew discussions of abnormal throttle alignment, the Safety Board concludes that asymmetric thrust was not a factor in the loss of directional control.

Having verified the realism of the Boeing engineering flight simulator in reproducing the ground handling characteristics of the B-747 on slippery runways, the Safety Board applied the findings of its August 8, 1996, flight simulation study to the circumstances and events in this accident.

In all simulations in which the pilot did not use the nosewheel steering tiller for directional control (including those conducted with icy runway conditions and winds gusting up to 40 knots), the simulated airplane was controllable along the runway centerline. In contrast, when pilots attempted to maintain the runway centerline using the tiller under slippery runway conditions with a 12-knot crosswind, a slight overcontrol at the very beginning of the takeoff roll repeatedly led to the loss of traction and steering capability from the nosewheel, followed by the loss of directional control.

Given that it is very unlikely that the captain did not try to control the airplane's tendency to weathervane into the crosswind, and given the consistent controllability of the airplane under accident conditions when the tiller was not used (during the simulation study), the Safety Board concludes that the captain's failure to correct the airplane's deviation from the centerline resulted from his overcontrolling the nosewheel steering through the tiller. This conclusion is supported by the captain's statement that he added increasing amounts of tiller steering input during the loss of control sequence and departed the runway still holding full right tiller.

The Safety Board was unable to determine with certainty the event that precipitated the captain's overcontrol with tiller inputs. Simulation study results suggest that the B-747 has a tendency to react to crosswinds at very slow airspeeds with an initial, slight downwind drift. It would have been natural for the captain to have reacted to this slight deviation with a tiller input, because the deviation would have occurred at a slow airspeed as the airplane was just beginning its takeoff roll.

However, there could have been a number of additional reasons for why the captain applied steering inputs through the rudder or tiller at the start of the takeoff roll. These include a line-up that was slightly off the runway centerline, a wind gust, or a slight thrust imbalance from one or more engines as they accelerated to takeoff power. Still, regardless of the reason for beginning the control inputs, the simulation study indicated that the runway deviation was unlikely to have precipitated a loss of control without excessive steering inputs through the tiller.

It is logical that overcontrol of the tiller on any aircraft would be more likely on a slippery runway than a dry runway, because airplane heading is less responsive to tiller inputs in slippery conditions. When a pilot makes a tiller input and does not obtain the expected reaction from the airplane, it is possible that the pilot will, at least initially, provide additional input to obtain the expected reaction. The lag in airplane response followed by additional control input could result in overcontrol of the tiller to the extent that the nosewheel exceeds its critical angle and loses traction.

The simulation study also demonstrated that at least enough rudder effectiveness was obtained by 50-80 knots airspeed to shallow the simulator's leftward veer before it departed the runway. In most simulations, directional control could be regained by timely use of the rudder. Given the effectiveness of rudder inputs in controlling heading deviations in the simulation study, the Safety Board sought to understand why the captain of the accident airplane was unable to recover directional control before the airplane departed the left side of the runway. The Safety Board's aircraft performance study of the tire marks on runway 4L from the accident airplane (see section 1.18.7) indicated that it departed the left edge of the runway with a shallowing leftward veer. This evidence implies that the captain was beginning to regain control of the airplane when it left the runway. The simulation study results indicated that tiller inputs alone would have been incapable of this recovery of control.

When interviewed after the accident, the captain recalled that he had applied increasing amounts of right rudder as the airplane veered to the left. However, based on the consistent effectiveness of rudder inputs in the simulation study and the tire mark evidence that directional control was being regained at the runway's edge, the Safety Board concludes that the captain of flight 41 first relied on right tiller inputs as the airplane continued to veer left, then applied insufficient or untimely right rudder inputs to effect a recovery.

2.2.3 Timeliness of the Rejected Takeoff

In his postaccident interview with the Safety Board, the captain stated that after noting the airplane's failure to respond to his initial input of right rudder, and before deciding to reject the takeoff, he applied additional right rudder and tiller steering inputs. He then described his attempts to reject the takeoff by retarding power to idle and applying maximum braking, right rudder, and nosewheel steering input.

Thus, instead of rejecting the takeoff immediately after experiencing difficulty obtaining directional control, the captain continued to attempt to regain directional control with progressively greater rudder and nosewheel steering inputs. Because the FDR was not working, the Safety Board did not have sufficient information to measure the delay between the first indication of loss of control and the captain's subsequent reduction of engine power. However, some measure of the extent of the delay can be gained from the simulation and performance studies. The simulation study showed that loss of directional control began at the relatively slow airspeeds when the aerodynamic rudder had not yet become effective (less than 50 knots), while the aircraft performance study showed that the accident airplane departed the left side of the runway at a relatively high speed (approximately 97 knots).

The captain stated that he reduced power while the airplane was still on the runway, and that he had no recollection of subsequently reapplying power. However, the Safety Board's CVR spectrum analysis clearly indicated that the thrust was partially reduced and then reapplied in significant amounts as the airplane left the runway. Physical evidence from the engines and flightcrew statements confirmed that the engine rpm increase recorded on the CVR was not an engagement of reverse thrust.

Because the CVR ceased recording shortly after the reapplication of power to the engines, the Safety Board was unable to determine the amount of time that the airplane traveled off the runway under significant power. However, based on the spectrum analysis of engine sounds on the CVR, the Safety Board determined that the captain abandoned his attempt to reject the takeoff, at least temporarily, by restoring forward thrust. The Board's aircraft performance study indicated that as a result of the reapplication of thrust, the airplane continued to accelerate as it approached the edge of the runway.

2.2.4 B-747 Slippery Runway Operating Procedures

Because the Safety Board recognized that on a slippery runway, directional control of the B-747 could be lost rapidly by overcontrol of the tiller, it evaluated the existing procedures established by Tower Air and Boeing for operating the B-747 on slippery runways. As a result of the Tower Air procedure to guard the tiller during takeoff until 80 knots, the captain was ready to use the tiller during the beginning of the takeoff roll.

Tower Air and Boeing procedures urge pilots to use the rudder and rudder pedal steering during takeoff. However, B-747 procedural information produced by both the airline and the manufacturer permit the tiller to be used at the beginning of the takeoff. In its 1994 Standards Memo, Tower Air stated, "Use of the tiller is not recommended unless rudder pedal steering is not sufficient during the early takeoff roll." Boeing stated in its Flight Crew Training Manual for the B-747, "Do not use nosewheel tiller during takeoff roll unless required initially due to crosswind." The Safety Board is concerned that these procedures encourage use of the tiller at the beginning of the takeoff roll, during which the Safety Board's simulation study found the B-747 to be most susceptible to loss of control on slippery runways.

The Safety Board concludes that current B-747 operating procedures provide inadequate guidance to flightcrews regarding the potential for loss of directional control at low speeds on slippery runways with the use of the tiller. The Safety Board believes that the FAA should require modification of applicable operating procedures published by Boeing and air carrier operators of the B-747 to further caution flightcrews against use of the tiller during slippery runway operations, including low-speed operations (for airplanes equipped with rudder pedal steering) and to provide appropriate limitations on tiller use during these operations (for airplanes not equipped with rudder pedal steering).

The Safety Board was informed by Tower Air after the accident that it had reevaluated and eliminated its standard procedure of guarding the tiller during the takeoff roll through 80 knots. The Safety Board concludes that this procedural change by Tower Air will make overcontrol of the tiller less likely for its own operations; however, other air carrier operators of the B-747 may need to make similar changes to their procedures. Consequently, the Safety Board believes that the FAA should issue a flight standards information bulletin (FSIB) to POIs assigned to air carriers operating the B-747, informing them of the circumstances of this accident and requesting a review and modification, as required, of each air carrier's takeoff procedure regarding pilot hand position with respect to the tiller.

The Safety Board recognizes that it may be a natural reaction for a pilot to persevere in a takeoff attempt when faced with an apparently minor hesitation of an airplane to respond to rudder input. However, the circumstances of this accident indicate that during takeoff in a B-747 on a slippery runway, the pilot must abort at the very first indication of a directional control loss.

The Boeing B-747 Operations Manual and Tower Air B-747 Flight Manual direct pilots who are performing takeoffs on slippery runways to immediately reject the takeoff if deviations from the runway centerline cannot be controlled. While this accident demonstrates the soundness of this advice, the accident also indicates that the provisions in these manuals are not adequately specific, particularly in their references to deviations that "cannot be controlled."

Tower Air's chief of flight standards suggested a criterion for rejecting takeoffs under slippery runway/crosswind conditions that may be useful for pilot decisionmaking in the future. He linked the takeoff rejection decision to the recommended procedure of limiting rudder pedal steering input to one-half full travel to get optimal cornering friction. He indicated it was clear that if a pilot could not control the airplane with one-half rudder pedal travel, the takeoff should be rejected.

This advice may be operationally useful for all B-747 pilots, if it can be verified by the FAA and aircraft manufacturer. The Safety Board concludes that current B-747 flight manual guidance is inadequate about when a pilot should reject a takeoff following some indication of a lack of directional control response. Consequently, the Safety Board believes that the FAA should require Boeing to develop operationally useful criteria for making a rapid and accurate decision to reject a takeoff under slippery runway conditions; then require that B-747 aircraft flight manuals, operating manuals, and training manuals be revised accordingly.

2.2.5 Training Simulators for B-747 Slippery Runway Operations

The air carrier and FAA pilots who participated in the August 8, 1996, simulation study believed that the Boeing engineering simulator had more realistic ground handling performance than the simulators Tower had provided for pilot training. The Board is concerned that air carrier B-747 pilots currently are not able to obtain needed training on slippery runway procedures, including proper tiller and rudder techniques, because training simulators have not incorporated the latest ground handling model (such as that implemented on the Boeing engineering simulator). Further, although existing flight test data on slippery runway handling characteristics are limited, the increasing use of high capacity FDRs and quick access maintenance recorders enables data on slippery runway handling to be obtained from actual line flying experience. Many B-747-400 models are equipped with these recorders.

The Safety Board concludes that improvements in the slippery runway handling fidelity of flight simulators used for B-747 pilot training are both needed and feasible. Consequently, the Safety Board believes that the FAA should evaluate B-747 simulator ground handling models and obtain additional ground handling data, as required, to ensure that B-747 flight simulators used for air carrier flightcrew training accurately simulate the slippery runway handling characteristics of the airplane. The Safety Board also believes that after completing this evaluation, the FAA should issue an FSIB urging POIs assigned to air carrier operators of the B-747 to enhance simulator training for slippery runway operations, including limitations on tiller use and instructions for rudder use during the takeoff roll.

2.2.6 Summary of Flightcrew Actions and Decisions

The captain’s use of the tiller control for nosewheel steering during the takeoff roll, combined with his untimely or inadequate use of rudder inputs, allowed the loss of directional control to develop. As this occurred, the airplane’s deviation from the centerline and its unresponsiveness to steering inputs provided cues that, regardless of the adequacy of existing procedures and training methods, should have prompted the captain to reject the takeoff more quickly than he did. Therefore, the Safety Board concludes that the captain’s failure to reject the takeoff in a timely manner was causal to the accident.

Still, better procedures for operating the B-747 under slippery runway conditions and improved ground handling fidelity of the flight simulators used for B-747 pilot training could have better prepared the captain for handling the situation that confronted the accident flight. Therefore, the Safety Board concludes that the inadequate B-747 slippery runway operating procedures developed by Tower and Boeing, and the inadequate fidelity of B-747 flight training simulators for slippery runway operations, contributed to the cause of this accident.

Further, the Safety Board concludes that the captain abandoned his attempt to reject the takeoff, at least temporarily, by restoring forward thrust before the airplane departed the left side of the runway; this contributed to the severity of the runway excursion and damage to the airplane.

2.3 Galley Security

Service carts, galley containers, drawers and other galley items were not contained during the off-runway excursion. The most serious breach of galley security occurred in the aft galley complex, between the R4 and L4 exits. The two carts that came loose injured the R4 flight attendant and blocked the R4 exit.

The Safety Board could not determine whether the primary latching mechanisms were engaged on the carts that were released from the aft galley. However, the bending in the secondary latches indicated that those latches were engaged, but were not adequate to secure the carts. The Safety Board was unable to calculate the inertial loads imposed on N605FF during the crash sequence because of the malfunctioning FDR. However, the condition of the seats and the comments of the various occupants suggest that the airplane did not experience the loads specified in 14 CFR 25.561(b). Because the crash forces were not severe enough that the latch material should have failed, the Safety Board concludes that the material or installation of secondary latches in the galleys of N605FF was inadequate. Consequently, the Safety Board believes that the FAA should develop certification standards for the installation of secondary galley latches; then use those standards to conduct an engineering review of secondary galley latches on all transport-category aircraft. Further, the FAA should require changes to existing installations as necessary to ensure that the strength of secondary latches and their installation are sufficient to adequately restrain carts.

2.4 Flight Attendant Actions and Training

2.4.1 Flight Attendant Communication

Several flight attendants acknowledged seeing or hearing things not associated with normal operations, such as crunching and tearing noises, engine separation, and significant spillage of carry-on luggage, during the airplane's off-runway excursion. However, only three of the 12 flight attendants on board the accident airplane shouted commands to passengers to "Grab Ankles! Stay Down!" during the impact sequence. Because these commands are important instructions that can prevent or reduce passenger injuries, the Safety Board is concerned that nine of the flight attendants did not shout any commands.

The Board recognizes that in the large cabin of the B-747, not all flight attendants had access to the same information about the event; therefore, flight attendants might have formed different opinions about the gravity of the situation. However, the Safety Board concludes that during this accident sequence, despite some ambiguity about the situation, there were ample indications in most parts of the passenger cabin to have caused a greater number of flight attendants to shout brace commands before the airplane came to a stop. The Safety Board believes that the FAA should issue an FSIB to POIs of 14 CFR Part 121 air carriers to ensure that flight attendant training programs stress the importance of shouting the appropriate protective instructions at the first indication of a potential accident, even when flight attendants are uncertain of the precise nature of the situation.

Further, the inconsistent pattern of the flight attendants' emergency commands before the airplane came to a stop, the large cabin layout of the B-747, and the large size of its cabin crew highlight the importance of communication among flight attendants. Communication was an issue in the cabin crew's actions immediately after the airplane came to a stop. While the decision not to evacuate the airplane (made independently by the flight attendants and the flightcrew) may have been appropriate, these decisions were made without adequate knowledge of the postaccident condition of the airplane. Flight attendants had vital information that they did not relay to the purser or the flightcrew. For example, flight attendants did not provide information to the flightcrew about the separation of the No. 4 engine, the severe floor disruption in the forward cabin, the smell of smoke and kerosene in the cabin, or the condition of the injured flight attendant.

Normally, the PA and interphone systems provide effective means of communications among flight attendants and between the cabin and flight deck. In this accident, the purser was unaware that his PA announcements were only audible in the forward cabin, and thus passengers and flight attendants in the rear of the airplane did not receive any information about the decision not to evacuate. Further, the purser and three flight attendants attempted to use the interphone system without success. Flight attendants did not use megaphones as an alternative to these communications systems. The deadheading flight attendant went forward in the cabin to find out what was planned, but he did not return to the aft cabin to share the information with the other flight attendants.

The Safety Board's review of Tower Air flight attendant procedures revealed that no back-up procedures had been established for communicating or assessing conditions in the postaccident contingency of inoperative or unpowered PA and interphone systems. However, the likelihood of impact damage to PA and interphone equipment, as demonstrated in this accident, indicates that such back-up procedures are essential.

The Safety Board recognizes that not all of the flight attendants involved in this accident had adequate information to realize the need to establish communications throughout the cabin. However, after an unusual occurrence such as a rejected takeoff (especially on a wide-body airplane), positive communications are essential to coordinate the crew's response, even if the decision is not to evacuate.

The Safety Board concludes that the existing Tower Air flight attendant procedures provided inadequate guidance to flight attendants on how to communicate to coordinate their actions during and after the impact sequence. Further, because the Safety Board is concerned that the flight attendant procedures of other air carriers may also be inadequate, the Safety Board believes that the FAA should issue an FSIB requiring POIs of 14 CFR Part 121 air carriers to ensure that their air carriers have adequate procedures for flight attendant communications, including those for coordinating emergency commands to passengers, transmitting information to flightcrews and other flight attendants, and handling postaccident environments in which normal communications systems have been disrupted.

2.4.2 Flight Attendant CRM Training

The circumstances of this accident imply that flight attendants (particularly those assigned to wide-body aircraft) would benefit from the opportunity to practice communications procedures and coordination skills. CRM training can provide this opportunity.

While the FAA has issued guidance on this training, the Safety Board recognizes that the new requirements for flightcrew and flight attendant CRM training do not specify the specific form and content of this training. The communication and coordination issues raised by this accident, both among flight attendants and between flight attendants and flightcrew would be appropriately addressed in joint CRM training by providing experience and practice in a realistic, line-oriented setting. Therefore, the Safety Board believes that the FAA should issue an FSIB that encourages the use of this accident as a case study for CRM training.

2.4.3 Flight Attendant Galley Training

Although Tower Air operated B-747s with three different kinds of galleys and service carts (with significant differences in the method used to secure each type of cart), new flight attendants were only provided “hands on” training with a single empty cart. Further, their classroom did not have a galley mock-up, and the actual airplane galleys used for “walkaround” training usually were not equipped with carts when trainees were brought aboard. Therefore, flight attendants did not actually operate carts in a galley setting until they began flying. The Safety Board concludes that Tower Air flight attendant galley security training was inadequate because flight attendants had not received “hands on” training with all the galley equipment that they were required to operate. The Safety Board believes that Tower Air should revise its initial flight attendant training program to include “hands-on” training for securing each type of galley and cart included in its B-747 fleet.

2.4.4 Purser Training

The Safety Board is concerned that the flight attendant serving as the assistant purser on the accident flight had not received the training appropriate to that position. While the assignment of a purser and assistant purser was not required by regulation, and was not currently practiced by many air carriers, formal designation of leadership roles in the cabin crew is very beneficial, especially in wide-body aircraft. Although the lack of purser training was not causal in this accident, such training could have resulted in better coordination/communication by the cabin crew if there had been an evacuation.

2.5 Company Management

2.5.1 Maintenance

The Safety Board is concerned that Tower Air failed to recognize the results of the annual check of the FDR system of N605FF in a timely manner. Based on the results of this check, TWA notified Tower Air in a memorandum dated November 3, 1995, that the FDR system had six suspect data parameters. It was more than 1 month later, on December 4, 1995, when Tower Air responded to this notification by entering the discrepancy in the maintenance log of N605FF.

Further, although the company recorded in its maintenance records that the required FDR functional test had been performed on December 7, 1995, the Safety Board concludes, based on the limited amount of time between the rental of the test equipment and the movements of the airplane, that Tower Air did not perform the FDR functional test. If Tower Air had performed this test, it would have identified the malfunctioning CEU and DAU #3 units (as the Safety Board was able to do in its postaccident testing). Consequently, the Safety Board concludes that Tower Air's failure to conduct the FDR functional test resulted in the loss of FDR data related to the accident flight that were of critical importance to the Safety Board's investigation.

On July 11, 1996, the Safety Board issued the following safety recommendations to the Federal Aviation Administration:

> Require that the operators of all airplanes equipped with a Teledyne Controls Aeronautical Radio Incorporated 563 digital flight data recorder system perform a self test of the central electronics unit each flight day to ensure that the system is operating properly. (Class II, Priority Action) (A-96-45)
>
> Modify Master Minimum Equipment Lists to ensure that flight with an inoperative flight data recorder is permitted only until the airplane's first arrival at a suitable repair facility, but not to exceed 3 days. (Class II, Priority Action) (A-96-46)
>
> Increase oversight of flight data recorder system maintenance practices by Tower Air to ensure that repairs are performed in accordance with the maintenance manual. (Class II, Priority Action) (A-96-47)

In a September 6, 1996, letter, the FAA responded to these recommendations. In response to Safety Recommendation A-96-45, the FAA said that it would issue an FSIB to require that a repetitive self-test inspection be performed by operators of the ARINC 563 system at no more that 60 flight-hour intervals. While the recommendation calls for the test to be performed daily, the Board acknowledges that the 60-hour interval will allow operators flexibility in accomplishing this inspection. Therefore, pending the Safety Board's review of the FSIB, the Board classifies Safety Recommendation A-96-45 "Open—Acceptable Response."

In response to Safety Recommendation A-96-46, the FAA said that it would revise MMEL Policy Letter #29 as requested and anticipated that the revised letter would be issued by November 1996. Pending the Safety Board's review of the revised policy letter, the Board classifies Safety Recommendation A-96-46 "Open—Acceptable Response."

In response to Safety Recommendation A-96-47, the FAA said that it was evaluating current oversight of FDR system maintenance practices by Tower Air to ensure that repairs were being performed in accordance with the maintenance manual. Pending the Safety Board's review of the evaluation, which is expected to be completed by December 1996, the Board classifies Safety Recommendation A-96-47 "Open—Acceptable Response."

The Safety Board recognizes that on July 9, 1996, the FAA issued a notice of proposed rulemaking (NPRM) that, if adopted, could affect the continued usage of the ARINC 563 system. The NPRM proposes to increase the number of mandatory parameters recorded by airplane FDRs. For B-747s with the ARINC 563 system installed (such as N605FF), the airplane would be required to record additional parameters, such as pitch, roll, and yaw control input positions.

During the investigation, the Safety Board learned that the manufacturer of the ARINC 563 system's CEU and DAU components had stopped manufacturing these system components. Additionally, the manufacturer no longer issues updates to the system software.

To comply with the proposed rulemaking, airplanes equipped with the ARINC 563 system would need installation of additional sensors and wiring. In addition, system software would need to be upgraded to handle the additional parameters. Because the system is no longer supported by the manufacturer, airlines would most likely replace the entire FDR system, rather than attempt an in-house upgrade. This may result in the elimination of the ARINC 563 system within the U.S. registry and render Safety Recommendations A-96-45 through -47 obsolete. However, because airlines may request and the FAA may grant waivers for certain rules, the Safety Board cannot definitively determine whether the ARINC 563 system will be eliminated. Therefore, the Safety Board urges the FAA to fulfill the Board's objectives in issuing these safety recommendations and ensure that existing ARINC 563 systems continue to function adequately.

As shown by the maintenance history of the FDR that failed to function during the accident sequence, as well as the findings of the FAA NASIP inspection, the installation of the landing gear without assuring it was appropriate for this airplane, and the inadequately documented "C" check, the Safety Board concludes that the Tower Air maintenance program deviated in significant ways from the procedures established in the company's GMM. Although these deviations were not related to the cause of this accident, they are cause for concern.

The Safety Board is equally concerned that the Tower Air continuing airworthiness surveillance and reliability programs, which are the carrier's internal audit and trend monitoring functions, failed to identify these deficiencies. The Safety Board concludes that the continuing airworthiness surveillance and reliability programs in the maintenance department of Tower Air were performing inadequately at the time of the accident. Consequently, the Safety Board believes that the FAA should review the structure and performance of the continuing airworthiness surveillance and reliability programs in the Tower Air maintenance department. Also, the Safety Board believes that the FAA should reassess inspectors' methods of evaluating maintenance work, focusing on the possibility of false entries through selective detailed analysis of records and unannounced work site inspections.

2.5.2 Operations

The November 1995 revisions to the reporting relationships among managers in the Tower Air operations department were significant because they left the DO, who was assigned the responsibility for the proper conduct of flight operations under the GOM, without authority over the day-to-day operations of the airline, flightcrew training, or the activities of the chief pilot and flightcrews. This organizational change was rejected by the POI when it was finally submitted to him for approval following the accident, and the Safety Board concurs with this rejection.

Not only does an airline need individual managers who have appropriate technical qualifications, but the reporting relationships among managers must be such that the operational functions of the airline report through the DO, who has the responsibility for regulatory and procedural compliance in flight operations. Because Tower Air did not have this organizational hierarchy, the Safety Board concludes that Tower Air was operating with an inadequate management structure at the time of the accident. While the regulations contained in 14 CFR Part 119 outline the required technical qualifications for certain operational management positions at air carriers (including the DO), they do not specify the reporting relationships that provide the DO with the necessary authority. Consequently, the Safety Board believes that the FAA should revise 14 CFR Part 119 to specify that the chief pilot and all operational functions under that position report through the DO.

The Safety Board is concerned that Tower Air failed to report significant management personnel and organizational changes to the POI before their implementation, even though this failure did not contribute to the accident. The carrier is responsible for maintaining the accuracy of its GOM, which specifies the company's operational management positions and reporting relationships. Tower Air failed to issue a revised GOM for more than 2 months following its implementation of changes in these areas. The fact that the FAA did not recognize this significant change in the company for this length of time is also disturbing.

2.6 FAA Surveillance

The FAA POI and assistant POI assigned to Tower Air were also responsible for overseeing the certificate of Atlas Air. At the time of the accident, both companies were fast-growing B-747 operators engaged in worldwide flight operations.

The assistant POI acknowledged that neither he nor the POI had sufficient time to conduct routine surveillance of Tower Air. The only en route inspections he performed were those that were also required for a new captain's certification during IOE. The POI conducted one en route check from October 1, 1994, through December 31, 1995.

Because the POI and assistant POI were not able to perform routine surveillance of Tower Air, this surveillance was dependent on the support of geographic inspectors from other FAA offices. Although inspectors involved in geographic support probably would notify an air carrier POI immediately if they detected a gross violation, these inspectors would not necessarily recognize deviations from procedures specific to the airline. Further, they would be unable to recognize trends in inspection findings. Therefore, the success of the FAA's geographic inspection program depends on the POI's review and integration of the inspection results.

The POI assigned to Tower Air acknowledged that his primary source of feedback from geographic surveillance was from reviews of the reports filed in the FAA PTRS data base, which he attempted to review quarterly. However, he stated that he had been unable to review these reports during the 6 months before the accident because of workload.

Further, the Safety Board is concerned that the POI and assistant POI were so burdened with certification activities involving their two carriers that they were unfamiliar with significant, inappropriate management changes occurring at Tower Air. Although these changes were eventually recognized and rejected by the POI, he was unable to detect the change until the formal notification was submitted for his signature.

Based on the POI's dependence on geographic inspections for routine surveillance, his inability to review the findings of these inspections in a timely manner, and his inability to recognize and correct an inadequate operational management structure at Tower Air in a timely manner, the Safety Board concludes that the POI and assistant POI assigned to Tower Air were overburdened, and the FAA program for routine surveillance of the operational functions of Tower Air was inadequate. Consequently, the Safety Board believes that the FAA should immediately implement its plan to assign the Tower Air certificate to a POI and assistant POI who do not have oversight responsibility for any other carriers. Further, based on the circumstances of this accident and Tower Air's recent accident history, the Safety Board believes that the FAA should develop, by December 31, 1997, standards for enhanced surveillance of air carriers based on rapid growth, change, complexity, and accident/incident history; then revise national flight standards surveillance methods, work programs, staffing standards, and inspector staffing to accomplish the enhanced surveillance that is identified by the new standards.

Although the Safety Board recognizes that the FAA needs to rely on locally based inspector resources to accomplish surveillance in each geographic area, the Board has long been concerned about the effectiveness of the FAA geographic inspection program. This program has needed greater standardization of air carrier certifications across FAA regional boundaries, better training for inspectors to make them more knowledgeable about both individual air carrier procedures and industry-wide standards, adequate tools for geographic inspectors to communicate their findings and concerns to POIs, and adequate tools for POIs to use in identifying significant trends in the results of routine geographic surveillance.

The Safety Board examined the FAA geographic surveillance program during its investigation of the February 16, 1995, accident at Kansas City International Airport involving an attempted three-engine takeoff in a Douglas DC-8-63. As a result of this investigation, on November 11, 1995, the Safety Board issued Safety Recommendation A-95-110, recommending that the FAA review the effectiveness of the geographic unit oversight program, with particular emphasis on the oversight of supplemental air carriers and their international operations, and the improvement of overall communications between POIs and geographic inspectors.

In a February 12, 1996, response to Safety Recommendation A-95-110, the FAA stated its plans to implement two improvements to the geographic surveillance program: an Enhanced Certificate Management Plan that will position additional inspectors dedicated to surveillance of a specific air carrier at outlying locations, and a Safety Performance Analysis System that will provide POIs with improved capabilities for monitoring trends in negative inspection findings. On July 5, 1996, citing the FAA's failure to place special emphasis on geographic surveillance of supplemental air carriers and their international operations, the Safety Board classified Safety Recommendation A-95-110 "Closed—Unacceptable Action."

However, immediately following the Safety Board's July 1996 classification of this safety recommendation, the FAA conducted a "90 Day Safety Review,"[27] which generated several internal recommendations for improvements in air carrier surveillance systems, including the geographic surveillance program. Although the Safety Board intends to further evaluate the "90 Day Safety Review" report with respect to a number of specific safety issues, the Board is encouraged by this internal review process. Pending final action by the FAA to implement its internal recommendations to enhance the effectiveness of air carrier surveillance, Safety Recommendation A-95-110 is classified "Open—Acceptable Response."

2.7 Runway Contamination Evaluation

In this accident, the airport personnel completed a runway friction test of runway 4L at 0933 and obtained a reading that, by their own procedures, required a report to the control tower. Although the airport personnel claimed that the report was made, there was no documentation of a timely report in their records; the only such record was of a postaccident entry in the operations office computer. The control tower was required by FAA Order 7110.65J to advise pilots of runway friction readings when they were received from airport management, but the control tower personnel claimed that they did not receive these reports. The Safety Board

[27] Federal Aviation Administration. FAA 90 Day Safety Review. Washington, DC. September 16, 1996 (mimeo).

was unable to determine whether the runway friction measurement data were sent or received. However, the Safety Board concludes that the failure of the PNY&NJ or FAA air traffic control tower personnel to provide these data to the pilots of flight 41 did not contribute to this accident.

Although the guidance currently provided by the FAA on runway friction measurement and reporting may be helpful to airport operators, it is incomplete because friction coefficient measurements of various types are not correlated with braking performance of different airplane types or configurations. The International Civil Aviation Organization (ICAO) Guidance Material Supplementary to Annex 14, Volume I, 6, includes a table of friction coefficient measurements correlated with descriptive values, i.e., good, medium, poor. However, this table is provided for informational use only, and it, too, does not establish clearly defined parameters applicable to airplane types.

The Safety Board is concerned about the frequent occurrence of veeroffs, overruns, and other related events by large airplanes when runways are contaminated with ice, snow, and/or slush (including this accident). The continuing problem with safety during ground operations is related to several problems. There is a clear need to measure the slipperiness of runway and taxiway surfaces. However, those values must then be quantified into meaningful information that pilots can use to evaluate the expected performance of their specific airplane. This would require airport operators to maintain their equipment within specific tolerances, and it would require the technicians operating the equipment to adhere to appropriate standards in using the equipment. If the FAA had been responsive to the Safety Board's 1982 safety recommendations on this subject (see section 1.10.3), the industry might have already resolved these problems.

The FAA has made considerable progress in providing and implementing procedures for airport operators to perform friction measurements during periods of ice/snow and slush contamination. However, such measurements are still not required, and there is no standardization of the equipment currently being used. Further, there are no means to compare measurement standards or translate the data into aircraft performance. A key issue is that no significant progress has been made in correlating stopping distance data from airplane manufacturers' flight tests and calculations with the friction values obtained from measuring devices. An outcome of these correlations could be the establishment of objective standards for air carrier operations on slippery runways, perhaps extending to the establishment of appropriate minimum runway friction levels for operational use.

The Safety Board concludes that the circumstances of this accident indicate that the issue of correlating airplane stopping performance with runway friction measurements should be revisited by the Government and the air transportation industry. Consequently, the Safety Board believes that the FAA should require the appropriate Aviation Rulemaking and Advisory Committee to establish runway friction measurements that are operationally meaningful to pilots and air carriers for their slippery runway operations (including a table correlating friction values measured by various types of industry equipment), and minimum coefficient of friction levels for specific airplane types below which airplane operations will be suspended.

3. CONCLUSIONS

3.1 Findings

1. The flightcrew was properly certificated and qualified in accordance with applicable regulations and company requirements.

2. The air traffic control personnel involved with the flight were all properly certificated and qualified.

3. The airplane was properly certificated, equipped, and maintained (with the exception of the flight data recorder system) in accordance with approved regulations. The weight and balance were within allowable limits.

4. The captain's decision to attempt the takeoff on runway 4L was appropriate.

5. Asymmetric thrust was not a factor in the loss of directional control.

6. The captain's failure to correct the airplane's deviation from the centerline resulted from his overcontrolling the nosewheel steering through the tiller.

7. The captain of flight 41 first relied on right tiller inputs as the airplane continued to veer left, then applied insufficient or untimely right rudder inputs to effect a recovery.

8. Current Boeing 747 operating procedures provide inadequate guidance to flightcrews regarding the potential for loss of directional control at low speeds on slippery runways with the use of the tiller.

9. The procedural change by Tower Air to reevaluate and eliminate its standard procedure of guarding the tiller during the takeoff roll through 80 knots will make overcontrol of the tiller less likely for its own operations; however, other air carrier operators of the Boeing 747 may need to make similar changes to their procedures.

10. Current Boeing 747 flight manual guidance is inadequate about when a pilot should reject a takeoff following some indication of a lack of directional control response.

11. Improvements in the slippery runway handling fidelity of flight simulators used for Boeing 747 pilot training are both needed and feasible.

12. The captain's failure to reject the takeoff in a timely manner was causal to the accident.

13. The inadequate Boeing 747 slippery runway operating procedures developed by Tower Air and the Boeing Commercial Airplane Group, and the inadequate fidelity of B-747

flight training simulators for slippery runway operations, contributed to the cause of this accident.

14. The captain abandoned his attempt to reject the takeoff, at least temporarily, by restoring forward thrust before the airplane departed the left side of the runway; this contributed to the severity of the runway excursion and damage to the airplane.

15. The material or installation of secondary latches in the galleys of N605FF was inadequate.

16. Despite some ambiguity about the situation, there were ample indications in most parts of the passenger cabin to have caused a greater number of flight attendants to shout brace commands before the airplane came to a stop.

17. The existing Tower Air flight attendant procedures provided inadequate guidance to flight attendants on how to communicate to coordinate their actions during and after the impact sequence.

18. Tower Air flight attendant galley security training was inadequate because flight attendants had not received “hands on” training with all the galley equipment that they were required to operate.

19. Based on the limited amount of time between the rental of the test equipment and the movements of the airplane, Tower Air did not perform the flight data recorder (FDR) functional test; this resulted in the loss of FDR data related to the accident flight that were of critical importance to the Safety Board’s investigation.

20. The Tower Air maintenance program deviated in significant ways from the procedures established in the company’s general maintenance manual.

21. The continuing airworthiness surveillance and reliability programs in the maintenance department of Tower Air were performing inadequately at the time of the accident.

22. Tower Air was operating with an inadequate management structure at the time of the accident.

23. The principal operations inspector (POI) and assistant POI assigned to Tower Air were overburdened, and the Federal Aviation Administration program for routine surveillance of the operational functions of Tower Air was inadequate.

24. The failure of the Port Authority of NY & NJ or Federal Aviation Administration air traffic control tower personnel to provide friction measurement data to the pilots of flight 41 did not contribute to this accident.

25. The circumstances of this accident indicate that the issue of correlating airplane stopping performance with runway friction measurements should be revisited by the Government and the air transportation industry.

3.2 Probable Cause

The National Transportation Safety Board determines that the probable cause of this accident was the captain's failure to reject the takeoff in a timely manner when excessive nosewheel steering tiller inputs resulted in a loss of directional control on a slippery runway.

Inadequate Boeing 747 slippery runway operating procedures developed by Tower Air, Inc., and the Boeing Commercial Airplane Group and the inadequate fidelity of B-747 flight training simulators for slippery runway operations contributed to the cause of this accident.

The captain's reapplication of forward thrust before the airplane departed the left side of the runway contributed to the severity of the runway excursion and damage to the airplane.

4. RECOMMENDATIONS

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

--to the Federal Aviation Administration:

Require modification of applicable operating procedures published by the Boeing Commercial Airplane Group and air carrier operators of the B-747 to further caution flightcrews against use of the tiller during slippery runway operations, including low-speed operations (for airplanes equipped with rudder pedal steering) and to provide appropriate limitations on tiller use during these operations (for airplanes not equipped with rudder pedal steering). (A-96-150)

Issue a flight standards information bulletin to principal operations inspectors assigned to air carriers operating the B-747, informing them of the circumstances of this accident and requesting a review and modification, as required, of each air carrier’s takeoff procedure regarding pilot hand position with respect to the tiller. (A-96-151)

Require the Boeing Commercial Airplane Group to develop operationally useful criteria for making a rapid and accurate decision to reject a takeoff under slippery runway conditions; then require that B-747 aircraft flight manuals, operating manuals, and training manuals be revised accordingly. (A-96-152)

Evaluate Boeing 747 simulator ground handling models and obtain additional ground handling data, as required, to ensure that B-747 flight simulators used for air carrier flightcrew training accurately simulate the slippery runway handling characteristics of the airplane. (A-96-153)

After completing this evaluation, issue a flight standards information bulletin urging principal operations inspectors assigned to air carrier operators of the Boeing 747 to enhance simulator training for slippery runway operations, including limitations on tiller use and instructions for rudder use during the takeoff roll. (A-96-154)

Develop certification standards for the installation of secondary galley latches; then use those standards to conduct an engineering review of secondary galley latches on all transport-category aircraft. Require changes to existing installations as necessary to ensure that the strength of secondary latches and their installation are sufficient to adequately restrain carts. (A-96-155)

Issue a flight standards information bulletin to principal operations inspectors of 14 CFR Part 121 air carriers to ensure that flight attendant training programs stress the importance of shouting the appropriate protective instructions at the first indication of a potential accident, even when flight attendants are uncertain of the precise nature of the situation. (A-96-156)

Issue a flight standards information bulletin requiring principal operations inspectors of 14 CFR Part 121 air carriers to ensure that their air carriers have adequate procedures for flight attendant communications, including those for coordinating emergency commands to passengers, transmitting information to flightcrews and other flight attendants, and handling postaccident environments in which normal communications systems have been disrupted. (A-96-157)

Issue a flight standards information bulletin that encourages the use of this accident as a case study for crew resource management training. (A-96-158)

Review the structure and performance of the continuing airworthiness surveillance and reliability programs in the Tower Air maintenance department. (A-96-159)

Reassess inspectors' methods of evaluating maintenance work, focusing on the possibility of false entries through selective detailed analysis of records and unannounced work site inspections. (A-96-160)

Revise 14 CFR Part 119 to specify that the chief pilot and all operational functions under that position report through the director of operations.(A-96-161)

Immediately implement the plan to assign the Tower Air certificate to a principal operations inspector (POI) and assistant POI who do not have oversight responsibility for any other carriers. (A-96-162)

Develop, by December 31, 1997, standards for enhanced surveillance of air carriers based on rapid growth, change, complexity, and accident/incident history; then revise national flight standards surveillance methods, work programs, staffing standards, and inspector staffing to accomplish the enhanced surveillance that is identified by the new standards. (A-96-163)

Require the appropriate Aviation Rulemaking and Advisory Committee to establish runway friction measurements that are operationally meaningful to pilots and air carriers for their slippery runway operations (including a table correlating friction values measured by various types of industry equipment), and minimum coefficient of friction levels for specific airplane types below which airplane operations will be suspended. (A-96-164)

--to Tower Air, Inc.:

Revise Tower Air's initial flight attendant training program to include "hands-on" training for securing each type of galley and cart included in its Boeing 747 fleet. (A-96-165)

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5. APPENDIXES

APPENDIX A - INVESTIGATION AND HEARING

1. Investigation

The National Transportation Safety Board was notified of the accident at 1150 on December 20, 1995. A partial go-team was dispatched to the scene. The following investigative groups were formed: Operations, Air Traffic Control, Airports, Weather, Survival Factors, Maintenance Records, Structures/Powerplants, Systems, Flight Data Recorder, and Cockpit Voice Recorder (CVR). Subsequently a Metallurgical Group was formed and a Sound Spectrum Study of the engine sounds on the CVR was completed.

Parties to the investigation included the Federal Aviation Administration, Tower Air, Inc., the Tower Air Cockpit Crew Association, the Association of Flight Attendants, the Boeing Commercial Airplane Group, and Pratt & Whitney.

2. Public Hearing

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

APPENDIX B- COCKPIT VOICE RECORDER TRANSCRIPT

Transcript of a Fairchild A-100 cockpit voice recorder (CVR), s/n 2059, installed on an Tower Air B-747-136, N605FF, which was involved in runway excursion during takeoff from the John F. Kennedy International Airport, Jamaica, New York, on Dec. 20, 1995.

LEGEND

RDO	Radio transmission from accident aircraft.
CAM	Cockpit area microphone voice or sound source.
INT	Transmissions over aircraft interphone system.
GND	Radio transmission from JFK control ground control.
ATLD	Radio transmission from Atlanta departure control.
A9140	Radio transmission from American flight # 9140.
D9901	Radio transmission from Delta flight # 9901.
SB117	Radio transmission from British Airways flight # 117.
KW134	Radio transmission from Carnival flight # 134.
GMTC	Radio transmission from ground maintenance vehicle.
UNK	Radio transmission received from unidentified aircraft.
PA	Transmission made over aircraft public address system.
-B	Sounds heard through both pilot's hot microphone systems.
-1	Voice identified as Pilot-in-Command (PIC)
-2	Voice identified as Co-Pilot.
-3	Voice identified as Flight Engineer.
-4	Voice identified as 1st ground crewman.
-5	Voice identified as 2nd ground crewman.
-6	Voice identified as jump seat rider.
-?	Voice unidentified
*****	Unintelligible word
@	Non pertinent word
#	Expletive
%	Break in continuity

Note: Times are expressed in eastern standard time (EST).

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
START of RECORDING			
START of TRANSCRIPT			
1106:40 **CAM-?**	wind shifted a little bit. it's three thirty at thirteen instead of three fifty.		
		1107:07 **GND**	Blue Ridge two thirty five, check information Kilo you'll continue by the inner and Kilo-Alpha to cross three one left.
		1107:18 **A9140**	American ninety one forty is clear going to Tango.
		1107:20 **GND**	American ninety one forty Kennedy roger use caution uh, braking action reported nil on that turn, make the right on the outer.
1108:09 **INT-4**	OK, cockpit?		
1108:11 **INT-1**	go ahead.		
1108:12 **INT-4**	OK, everything is done, and uh, you're cleared to start.		
1108:16 **INT-1**	OK uh, the de-ice coordinators name please?		
1108:21 **INT-4**	yes, hold on a second.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
1108:34 **INT-4**	Graciano, Graciano. with a G.		
1108:40 **INT-1**	OK and the type of uh, fluid used? was it a fifty fifty mixture type one?		
1108:47 **INT-4**	uh fifty five ...		
1108:57 **INT-5**	yes on the uh, type one it's fifty five forty five.		
1109:00 **INT-1**	OK and type two is uh, one hundred zero?		
1109:03 **INT-5**	absolutely.		
1109:04 **INT-1**	OK thanks uh, here comes number four engine and uh, will you call the N ones for me on each engine please?		
1109:12 **INT-5**	absolutely.		
1109:13 **INT-1**	thank you.		
1109:14 **CAM-3**	EPR's set. ******.		
1109:21 **INT-1**	here comes number four.		
1109:22 **INT-4**	OK.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
1109:27 **CAM**	[miscellaneous unintelligible background conversation]		
1109:29 **CAM-1**	uh, he's just gotta check.		
1109:30 **CAM-3**	the pre-takeoff ice check ***.		
1109:36 **CAM-1**	OK, go ahead and check that * put it in.		
1109:39 **CAM-3**	first of all, standby. let's get some bleed air back ** guys.		
1109:43 **CAM-2**	uuh.		
1109:46 **CAM**	[several unintelligible comments]		
1109:47 **CAM-1**	let's do a uh, let's do a before start check list.		
1109:53 **CAM-3**	** pressurizing.		
1109:55 **CAM-2**	OK uh, we'll go uh, INS?		
1109:57 **CAM-1**	three in nav.		
1109:58 **CAM-2**	beacon?		
1109:59 **CAM-1**	on.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
1110:00 **CAM-2**	doors?		
1110:00 **CAM-3**	checked lights out.		
1110:01 **CAM-2**	brake pressure?		
1110:02 **CAM-3**	pump on and checked.		
1110:04 **CAM-2**	fuel boost pumps?		
1110:05 **CAM-3**	on.		
1110:06 **CAM-2**	gear down lock pins?		
1110:07 **CAM-3**	removed.		
1110:09 **CAM-2**	OK, number one air pump?		
1110:10 **CAM-3**	auto.		
1110:12 **CAM-2**	cabin report?		
1110:12 **CAM-1**	verified.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
1110:14 **INT-1**	OK, here comes number four.		
1110:15 **INT-4**	OK guys.		
1110:17 **CAM-?**	start pressure's a little low but I don't		
1110:18 **CAM-3**	yeah, it's indicating about twenty seven **.		
1110:20 **CAM-?**	alright.		
1110:22 **CAM-3**	turn number four.		
1110:29 **INT-4**	N one.		
1110:38 **CAM-3**	max motoring.		
1110:44 **CAM-1**	light off.		
1110:46 **CAM-?**	well you know **...		
1110:48 **CAM**	[sound similar to momentary power interruption]		
1110:54 **CAM-3**	I'm going to get the warning CB off?		
1110:56 **CAM-1**	OK.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
1110:57 **CAM-3**	OK.		
1111:05 **CAM-3**	OK, I'll reach up and cross check. *** I've got forty psi duct pressure **** bleed valves engine, bleed air valves open.		
1111:13 **CAM-1**	OK, call the N one for me again. we're going to motor this thing a bit.		
1111:17 **INT-4**	OK captain. uh, the packs are off?		
1111:19 **INT-1**	yeah they are.		
1111:20 **INT-4**	OK.		
1111:22 **CAM-3**	OK, turn number four.		
1111:24 **INT-1**	here comes four.		
1111:25 **INT-4**	OK, captain.		
1111:26 **INT-1**	you guys having fun yet?		
1111:28 **INT-4**	lots of fun, I love it. ha ha.		
1111:32 **INT-4**	N one.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
1111:34 **INT-1**	[sound similar to two microphone clicks]		
1111:40 **CAM-3**	EGT below a hundred. max motoring.		
1111:45 **CAM-?**	*** area.		
1111:47 **CAM**	[several unintelligible comments]		
1111:51 **CAM-3**	twenty five.		
1111:54 **CAM-3**	thirty.		
1111:58 **CAM-3**	thirty five.		
1112:04 **CAM-3**	forty.		
1112:07 **CAM-3**	forty five.		
1112:08 **CAM-3**	starter cutout.		
1112:09 **INT-1**	here comes three.		
1112:11 **INT-4**	*.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
1112:14 **CAM-3**	do you want me to transfer number four electrics?		
1112:17 **CAM**	[sound similar to electrical power transfer]		
1112:18 **CAM-2**	anti-ice OK?		
1112:19 **CAM-1**	please.		
1112:20 **CAM-3**	OK start number three.		
1112:22 **CAM-1**	***.		
1112:31 **INT-4**	rotation.		
1112:33 **CAM**	[sound similar to two microphone clicks]		
1112:38 **CAM-3**	max motoring.		
1112:45 **CAM-1**	light-off.		
1112:48 **CAM-3**	twenty five.		
1112:52 **CAM-3**	thirty.		
1112:56 **CAM-3**	thirty five.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
1113:00 **CAM-3**	forty.		
1113:04 **CAM-3**	forty five starter cutout.		
1113:06 **INT-1**	here comes two.		
1113:07 **INT-4**	*.		
1113:09 **CAM-3**	turn number two.		
1113:13 **CAM-1**	I'm not using rich by the way seems to be ***.		
1113:17 **INT-4**	*.		
1113:25 **CAM-3**	max motoring.		
1113:33 **CAM-1**	light up		
1113:35 **CAM-3**	twenty five.		
1113:40 **CAM-3**	thirty.		
1113:46 **CAM-3**	thirty five.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
1113:50 **CAM-3**	forty.		
1113:54 **CAM**	[sound of click]		
1113:55 **CAM-4**	forty five starter cutout.		
1113:56 **INT-1**	here comes one.		
1113:57 **INT-4**	*.		
1113:58 **CAM-3**	turnin' one.		
1114:05 **INT-4**	*.		
1114:07 **INT-1**	[sound similar to two microphone clicks]		
1114:14 **CAM-3**	max motoring.		
1114:22 **CAM-1**	light up.		
1114:24 **CAM-3**	twenty five.		
1114:28 **CAM-3**	thirty.		
1114:32 **CAM-3**	thirty five.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
1114:37 **CAM-3**	forty.		
1114:40 **CAM**	[sound of two clicks]		
1114:40 **CAM-3**	forty five starter cutout.		
1114:41 **CAM-1**	flaps ten.		
1114:43 **CAM**	[sound of numerous clicks]		
1114:51 **INT-4**	cockpit.		
1114:54 **INT-1**	OK you're cleared to disconnect. show the pin on the left side and uh, we're going to do a control check right here if you want to watch it and we'll be out of here. thanks a lot for your help and we'll see you tonight.		
1115:03 **INT-4**	OK captain. give me your last name please sir. they need it for de-icing.		
1115:06 **INT-1**	yeah Law, L A W, Lima Alpha Whiskey.		
1115:10 **INT-4**	thank you sir.		
1115:11 **CAM-3**	ship's power.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
1115:13 **CAM-1**	after start checklist.		
1115:14 **CAM-2**	electrical power?		
1115:15 **CAM-3**	set.		
1115:16 **CAM-2**	APU bleed?		
1115:18 **CAM-3**	closed.		
1115:18 **INT-4**	OK you can do your uh, flight control check, while I'm standing by.		
1115:22 **INT-1**	OK.		
1115:24 **CAM-1**	go ahead.		
1115:25 **CAM-2**	hydraulics?		
1115:25 **CAM-3**	auto, normal, quantity checked.		
1115:28 **CAM-2**	nose steer pin?		
1115:30 **CAM-1**	ah well we have that. let me do a control check here Ralph.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
1115:32 **CAM-3**	OK.		
1115:33 **CAM-3**	two up on the left, one down on the right. neutral. two up on the right, one down on the left. neutral. two down, two neutral, two up, two neutral.		
1115:45 **INT-1**	OK, the control check is complete. show the pin on the left side. thanks a lot.		
1115:49 **INT-4**	have a nice day.		
1115:55 **CAM-2**	how about flaps?		
1116:06 **CAM-1**	after start check. where are we here?		
1116:08 **CAM-2**	uh, we're down to nose steering uh, area clearance.		
1116:12 **CAM-1**	nose steering checked, area clearance, clear on the left.		
1116:15 **CAM-2**	clear right.		
		1116:18 **RDO-2**	Tower Air four one coming out of uh, Golf Quebec.
		1116:21 **GND**	Tower forty one, taxi via Quebec. hold short of November. Expect runway four left for departure.

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
1116:27 **CAM-1**	ask him how long if's any delays.		
		1116:29 **RDO-2**	thank you, we'll hold short uh, four left. do you know if there are any delays at this time?
		1116:31 **GND**	at this time, no delays.
		1116:32 **RDO-2**	thanks.
1116:35 **CAM-2**	leave the flaps still down **?		
1116:37 **CAM-?**	*.		
1117:03 **CAM-1**	started to taxi at sixteen.		
1117:05 **CAM-3**	OK.		
1117:14 **CAM-?**	ouch.		
1117:52 **CAM-2**	expect four left Ralph.		
1117:54 **CAM-3**	OK. and uh, we checked that already *.		
1118:03 **CAM-2**	that's less than **.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
1118:04 **CAM-3**	yeah, that's true.		
1118:22 **CAM**	[sound of yawn]		
1118:31 **CAM-2**	the flakes are getting bigger. does that mean it's going to stop soon, or does that mean it's going to accumulate more snow?		
1118:46 **CAM-1**	you ready on the rudders Ralph?		
1118:47 **CAM-3**	yes I am.		
1118:49 **CAM-3**	two left... two neutral... two right... two neutral. two up on the left, one down on the right. neutral... two up on the right one down on the left... neutral... two down... two neutral... two up... two neutral.		
1119:12 **CAM-1**	taxi check.		
1119:13 **CAM-3**	taxi check list. nacelle anti-ice?		
1119:15 **CAM-2**	on.		
1119:17 **CAM-3**	flight ‘n nav instruments?		
1119:20 **CAM-2**	uh, set, and cross check uh, how do you want your flight director?		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
1119:24 **CAM-?**	*.		
1119:26 **CAM-3**	altitude selector?		
1119:27 **CAM-2**	five thousand feet armed.		
1119:29 **CAM-3**	flaps ten?		
1119:30 **CAM-2**	ten indicate uuuh, at least ten. and flaps ** green light.		
1119:38 **CAM-3**	eight green. controls?		
1119:40 **CAM-2**	checked.		
1119:42 **CAM-3**	stab and trim, five point three units?		
1119:45 **CAM-2**	five point three. OK. set one two three checked.		
1119:54 **CAM-3**	takeoff data V speeds, one three four, one four zero, one five zero. and three rating one point four three.		
1120:04 **CAM-1**	checked set.		
1120:05 **CAM-2**	checked set.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
1120:06 **CAM-3**	annunciator lights? checked.		
1120:15 **CAM-3**	taxi checklist complete.		
		1120:27 **GND**	Tower forty one heavy, pick up information Kilo.
		1120:31 **RDO-2**	uh, Kilo I believe we have that. stand by one.
		1120:42 **RDO-2**	forty one has Kilo, thank you.
		1120:45 **GND**	roger.
		1122:10 **GND**	Tower forty one continue on the inner. at Mike join the outer. cross three one left at Kilo.
1122:19 **CAM-2**	OK by the inner and uh, Mike outer and uh, Kilo Alpha, cross three one left uh, Tower Air.		
1122:29 **CAM-1**	going to four left, Mike.		
1122:30 **CAM-?**	yeah.		
1122:37 **CAM-1**	inner outer at Mike. cross at Kilo four left.		
1122:38 **CAM-2**	Kilo Alpha.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
1122:43 **CAM-2**	no, let me recheck. I think it was Kilo.		
1122:46 **CAM-1**	that's alright.		
1122:47 **CAM-2**	OK.		
1122:56 **CAM-1**	I'm gonna uh, stop and run these engines right here.		
1123:00 **CAM-2**	OK.		
1123:09 **CAM-1**	Mike, keep your eye outside. if we start to move let me know.		
1123:13 **CAM-2**	** tell ground what we're doing?		
1123:14 **CAM-1**	naw.		
1123:16 **CAM**	[sound similar to increase in engine RPM]		
1123:20 **CAM-2**	feels like we're moving.		
1123:21 **CAM**	[sound of click]		
1123:23 **CAM**	[sound similar to decrease in engine RPM]		
1123:25 **CAM-6**	it started to move.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
1123:26 **CAM-?**	yep.		
1123:27 **CAM-6**	slippery out there.		
		1123:33 **D991**	and ground, Delta nine (niner) one.
1123:35 **CAM-1**	it's an ice rink here.		
		1123:37 **GND**	Delta ninety nine zero one, ground.
		1123:40 **D991**	yes sir, any word on uh, thirty one?
		1123:44 **GND**	no, it's still closed.
		1123:46 **D991**	the estimate uh, is what now?
		1124:06 **GND**	I don't know when it's gonna open. probably be a couple of hours. may want to call the Port Authority.
		1124:11 **DL9901**	OK, earlier they had an eleven o'clock. that's why we were checking.
		1124:16 **GND**	alright.

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
		1124:24 **GND**	Tower forty one heavy, you can stay on the inner. cross three one left at Kilo.
		1124:29 **RDO-2**	inner to three one left at Kilo, thank you, Tower forty one.
1125:45 **CAM-1**	boy they got some sick # at America West with their pay sheets, don't they?		
1125:49 **CAM-2**	I tell you I ***.		
1125:52 **CAM-6**	shades of Braniff.		
1125:53 **CAM**	[sound of laughter]		
1125:55 **CAM**	[sound similar to electric seat motion]		
1125:58 **CAM-?**	***.		
		1126:05 **GND**	Tower forty one heavy, cross runway three one left. on the other side monitor nineteen one, good day.
		1126:10 **RDO-2**	Tower forty one, we'll monitor on the other side. thanks.
1128:50 **CAM-?**	***.		
1129:04 **CAM-2**	*** body gear steering.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
1129:35 **CAM-?**	* right.		
1129:49 **CAM-1**	get around the corner here, Ralph take a little walk and check the wings for me will you.		
1129:53 **CAM-3**	sure.		
1130:06 **CAM**	[sound of clicks similar to crew harness release]		
1130:42 **CAM-1**	OK?		
1130:42 **CAM-3**	OK.		
1130:46 **CAM**	[sliding sound similar to seat adjustment]		
1130:55 **CAM**	[sound of clicks similar to cockpit door operating]		
		1131:46 **SB117**	uh, Speed Bird uh, one one seven, just for your information, we'll be leaving our flaps down ***.
		1131:52 **TWR**	uh Roger, I can't see you from up here anyway. you uh, it'll be full flaps down?
		1131:53 **SB117**	uh, yes.

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
1131:59 **CAM**	[sound similar to cockpit door operating]		
1132:01 **CAM-3**	it's very clean out there.		
1132:03 **CAM-1**	OK.		
1132:03 **CAM-3**	**.		
		1132:07 **TWR**	Tower forty one heavy, four left, taxi into position and hold. traffic down field right to left.
1132:11 **CAM-1**	right.		
		1132:13 **RDO-2**	position and hold ni.. four left, Tower Air forty one heavy.
1132:15 **CAM-1**	position and hold, before takeoff check list.		
1132:16 **CAM-3**	before takeoff check list.		
		1132:17 **TWR**	DHL seven, wind three two zero at one one. frequency change approved.
1132:23 **CAM-3**	flight attendants please be seated for takeoff. thank you.		
1132:35 **CAM-3**	takeoff announcement is complete.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
1132:47 **CAM-3**	air condition packs off.		
1132:52 **CAM**	[sound of three clicks]		
1132:53 **CAM-3**	ignition, flight start.		
1132:54 **CAM-3**	transponder and radar?		
1132:56 **CAM-2**	on and on.		
1132:58 **CAM-3**	and stand by for body gear steering.		
		1133:40 **TWR**	TWA one eighty six, cleared to land. wind three three zero at one two.
		1134:00 **GMTC**	tower car nine nine.
		1134:01 **TWR**	nine nine, Kennedy.
		1134:02 **GMTC**	OK uh, all clear of runway three one left. the runway will be (ops) at this time, full length, and uh safety check and brake check.
		1134:10 **TWR**	nine nine, roger.

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
		1134:14 **KW134**	and tower, Carnival one thirty four with you on the ILS four right.
		1134:18 **TWR**	Carnival one thirty four, Kennedy tower runway four right, braking action reported fair to good towards the middle of the runway and poor at the turn off. wind three three zero at one two, number two.
1134:26 **CAM-2**	I don't guess you'll be able to get much of a run up.		
1134:29 **CAM-1**	no. just do the best we can. if it starts to move, we're going to take it.		
1134:34 **CAM-?**	OK.		
1134:35 **CAM**	[sound similar to crew seat operation]		
1135:09 **CAM-2**	I see an airplane looks like it's clear down the end.		
1135:12 **CAM-?**	hold on.		
1135:18 **CAM-3**	body gear steer?		
1135:22 **CAM**	[sound of click]		
1135:22 **CAM-3**	disarmed, before takeoff check list complete.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
1135:25 **CAM-?**	OK.		
		1135:26 **RDO-2**	Tower Air four one is in position four left.
		1135:29 **TWR**	yes sir, just continue holding.
1135:34 **CAM-1**	try a run up here and see what happens.		
1135:39 **CAM**	[sound similar to increase in engine RPM]		
1135:47 **CAM-1**	start your clock **.		
1135:49 **CAM-?**	**.		
1135:52 **CAM-3**	it's about forty five right there.		
1136:02 **CAM-2**	it’s about fifteen.		
1136:04 **CAM**	[sound of click and sound similar to decrease in engine RPM]		
1136:15 **CAM-1**	pretty good uh, cross wind from the *.		
		1136:25 **TWR**	Tower forty one heavy, wind three three zero at one one, runway four left, RVR's one thousand eight hundred, cleared for takeoff.

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
		1136:31 **RDO-2**	cleared for takeoff four left, Tower Air forty one.
1136:34 **CAM-1**	check list is complete?		
1136:35 **CAM-3**	yes. check list is complete.		
1136:39 **CAM**	[sound of click similar to parking brake release]		
1136:40 **CAM**	[sound similar to increase in engine RPM]		
1136:44 **CAM-3**	power's stable.		
1136:48 **CAM**	[sound similar to crew seat operation]		
1137:00 **CAM**	[low frequency sound similar to further increase in engine RPM]		
1137:04 **CAM-1**	set time, takeoff thrust.		
1137:05 **CAM-3**	set the takeoff thrust.		
1137:10 **CAM-?**	watch it.		
1137:10 **CAM-?**	watch it.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
1137:11 **CAM**	[sound of click]		
1137:11 **CAM**	[low frequency sound similar to engine noise can no longer be heard]		
1137:12 **CAM-3**	OK, losing it.		
1137:12 **CAM-2**	going to the left.		
1137:13 **CAM-?**	going to the left.		
1137:13 **CAM-3**	to the right.		
1137:14 **CAM-3**	you're going off.		
1137:15 **CAM-?**	going off.		
1137:16 **CAM-1**	aw #.		
1137:17 **CAM-1**	easy guys.		
1137:18 **CAM-1**	OK.		
1137:19 **CAM**	[first sound of impact]		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
1137:20 **CAM-?**	pull up. pull up.		
1137:21 **CAM**	[second sound of impact]		
1137:21 **END of RECORDING**			

END of TRANSCRIPT