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Captain Rejects Takeoff as Boeing 747 Veers off Slippery Runway

The airline's flight attendant procedures did not provide adequate guidance to flight attendants on how to coordinate their actions during and after the impact sequence, the official U.S. report said.

FSF Editorial Staff

The crew of the Tower Air Boeing 747-136 was cleared for takeoff on Runway 4L at John F. Kennedy International Airport (JFK), New York, New York, U.S. The runway was contaminated with packed snow and patchy ice. There was a 10-knot to 12-knot (18.5-kilometer per hour [kph] to 22.2-kph) crosswind from the northwest, and light snow was falling. The captain, who was the pilot flying, applied takeoff power. As the airplane accelerated, the captain felt the airplane moving to the left. He applied right rudder and used the nosewheel steering tiller but was unable to maintain directional control.

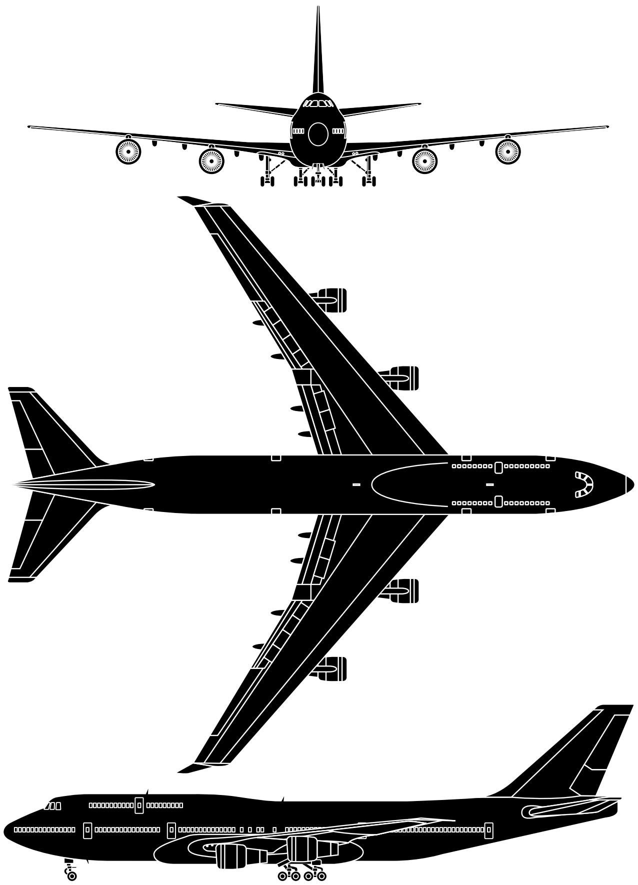
The captain rejected the takeoff, and the airplane went off the left side of the runway and continued for a short distance. The airplane came to rest approximately 1,464 meters (4,800 feet) from the runway threshold and 183 meters (600 feet) left of the runway centerline (Figure 1, page 3). One cabin crew member was seriously injured, and 24 passengers received minor injuries in the Dec. 20, 1995, accident. The airplane sustained substantial damage and was declared a total loss.

The final report of the U.S. National Transportation Safety Board (NTSB) said that the probable cause of the accident to Tower Air Flight 41 "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."

The report added: "Inadequate Boeing 747 slippery-runway operating procedures developed by Tower Air and the Boeing Commercial Airplane Group and the inadequate fidelity of [Tower Air] 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 report said that the accident investigation was hampered because the flight data recorder (FDR) on the accident aircraft was not functioning correctly. The accident aircraft was being operated under U.S. Federal Aviation Regulations (FARs) Part 121 as a regularly scheduled passenger/cargo flight from JFK to Miami, Florida, U.S., the report said.

The captain, first officer and flight engineer of the accident flight met in the company operations office before 0830 hours local time. The captain received "a thorough weather briefing prepared by Tower Air's dispatch department, which included special weather conditions for JFK," the report said. "[The captain] 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 discrepancies, and proceeded to the airplane."



Boeing 747

The four-engine Boeing 747-100 first flew in 1969. It has a maximum takeoff weight of 322,050 kilograms (710,000 pounds) and can seat up to 500 passengers, although typical configurations accommodate 74 first-class and 308 tourist-class passengers. It has a maximum level speed of 517 knots (958 kilometers per hour) and a cruise service ceiling of 45,000 feet (13,715 meters). With 374 passengers and baggage it has a range of 5,028 nautical miles (9,138 kilometers).

Source: *Jane's All the World's Aircraft*

When the captain arrived at the airplane, "the flight engineer had previously completed the external safety inspection and was seated in the cockpit," the report said. "The first officer joined them shortly, and all preflight checks were completed by 0930." In the cockpit, the crew "discussed the amount of snow accumulation, the slippery conditions on the taxiways and runways, the need to taxi slowly, taxi procedures on packed snow and ice, and their plans to use engine anti-ice and wing heat," the report said.

The aircraft pushed back from the gate, and at 1100 it received a final deicing/anti-icing treatment. "The flight was cleared to Runway 4L and taxied out at 1116," the report said. Aboard the accident flight were the three flight crew members; two cockpit jumpseat occupants; 12 cabin crew members including a purser, an assistant purser and a deadheading flight attendant (in uniform); and 451 passengers.

At 1118, the first officer said, "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?"

From the gate area, the captain said that he "taxied [the airplane] forward several hundred feet and made a 90-degree 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 three knots [5.6 kph] according to the captain's inertial navigation display), and the braking action was adequate."

The captain "stopped the airplane to clear the engine of any ice by increasing power to 45 percent N_1 [engine fan speed expressed as a percentage of the maximum revolutions per minute (RPM)] for 10 seconds, but the airplane began to slip as power was advanced, and they could not complete the procedure at that time," the report said.

About 1124, the crew of another flight radioed the JFK U.S. Federal Aviation Administration (FAA) air traffic control tower (ATCT) and asked about the availability of Runway 31L, and was told that the runway was closed and would probably open in "a couple of hours," the report said. Overhearing this information, the captain of the accident flight "did not consider Runway 31L to be a viable option for his flight's takeoff."

As the crew taxied to Runway 4L, the flight engineer went into the cabin to visually inspect the aircraft's wings. "He returned and reported, 'It's very clean out there,'" the report said. "A few seconds later, at 1132:06, the flight was cleared to taxi into position and hold on Runway 4L."

As he taxied the airplane onto the runway, the captain "centered the airplane and moved the nosewheel steering tiller to neutral as the airplane was barely moving," the report said. "[The captain brought the airplane] to a complete stop, set the parking brake and did the engine anti-ice run-up. The airplane did not move during the run-up."

While holding on the runway, the "captain said that he could see the runway centerline intermittently," the report said. "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, and about 1136, the tower controller said, "Tower forty-one heavy, wind three three zero at one one, runway four left RVR's [runway visual range] one thousand eight hundred [feet (549 meters)], cleared for takeoff," the report said. "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 then released the parking brake, held the toe brakes and increased engine power to 1.1 engine-pressure ratio (EPR), the report said. [EPR measures engine thrust, comparing the total turbine discharge pressure to the total pressure of the air entering the compressor.] "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."

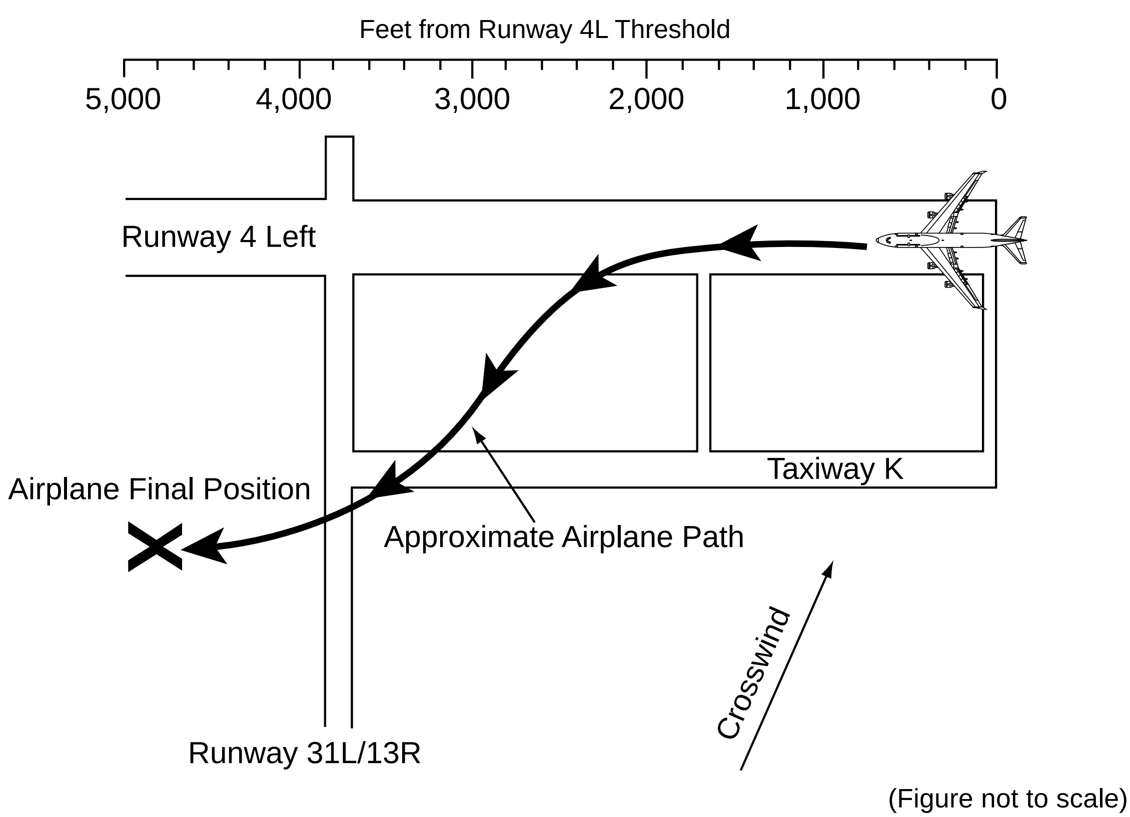
The takeoff began normally, with the captain using only minor corrections to maintain the airplane on the centerline. "Before receiving the 80-knot [148-kph] call he expected from the first officer, the captain felt the airplane moving to the left," the report said. "He said he applied right rudder pedal (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."

The captain said that he knew where the runway centerline was, "but he was unable to control the direction of movement," the report said. "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."

A flight attendant who was seated in the aft-facing jumpseat at door R4 (Figure 2, page 4) sensed, at the beginning of the takeoff and during the ensuing accident sequence, "movement toward the right side of the runway with a skidding sensation," the report said. "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."

The flight attendant also said that while the airplane was sliding, "she heard a 'metal sound' in the aft galley, and she

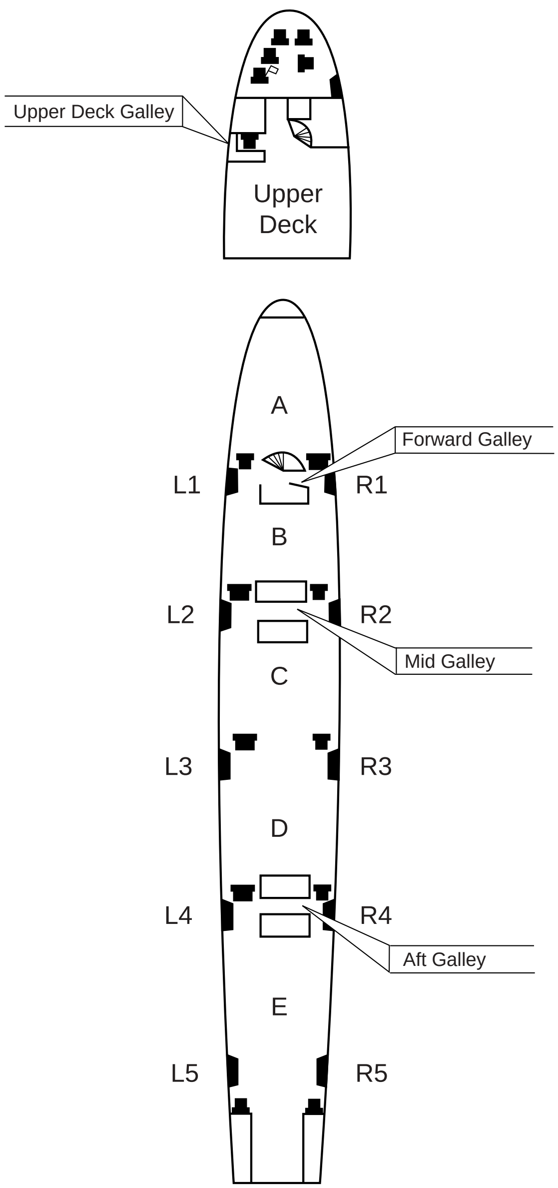
Path of Tower Air Boeing 747 Following Rejected Takeoff, Dec. 20, 1995



Source: U.S. National Transportation Safety Board

Figure 1

Cabin Layout, Boeing 747, Tower Air Flight 41, Dec. 20, 1995



Source: U.S. National Transportation Safety Board

Figure 2

saw an ice cart and a beverage cart come loose," the report said. "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."

During the accident sequence, "the R2 flight attendant observed that a bin in the mid galley had popped out about [five centimeters to seven centimeters (two inches to three inches)] and that the L2 flight attendant got out of her seat to secure it while the airplane was still sliding," the report said. "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.'"

The flight attendant stationed at door R4 also said that "she and several passengers smelled kerosene after the airplane stopped," the report said. "She commented that if she had not been injured, she would have evacuated." There was no fire.

During the accident sequence, "the fuselage forward of the no. 2 main-entry door and below the floor level received severe impact damage," the report said. "It was crushed upward where the nose landing gear had collapsed, still attached, 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 [public address] and interphone systems."

The report added: "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."

In the passenger cabin, the floor had "sustained substantial damage in Zone A," the report said. "The floor was displaced upward approximately [60 centimeters (two feet)] in the center of the cabin seat rows 6, 7 and 8."

When the airplane finally stopped, "the first officer called the control tower, and the flight engineer made a [PA] announcement for the passengers to remain seated," the report said. "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 [temperature caused by the] wind-chill factor outside, the captain elected to keep everyone on board."

In the passenger cabin, the purser "tried to call the cockpit on the interphone," the report said. "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. 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 report continued: "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 in the rear part of Zone C. Three flight attendants stated that they attempted to use the interphone to communicate with the

Cockpit Voice Recorder Transcript, Tower Air Flight 41, Dec. 20, 1995

Time	Source	Content
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.
1123:26	**CAM-?:**	Yep.
1123:27	**CAM-6**:	Slippery out there.
1123:33	**D9901**:	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	**D9901**:	Yes sir, any word uh, thirty one?
1123:44	**GND**:	No, it's still closed.
1123:46	**D9901**:	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	**D9901**:	OK, earlier they had an eleven o'clock. That's why we were checking.
1124:16	**GND**:	All right.
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]

purser, and these attempts were unsuccessful. According to their statements, none of the flight attendants attempted to use the megaphones."

When rescue personnel arrived at the airplane, "they proceeded to the L1 exit," the report said. "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 remained engaged even after the arm/disarm handle was moved to the manual position, and the L2 door was opened by the rescue personnel. [The NTSB defined a girt-bar as "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."] The purser then announced instructions about deplanement over the PA system. Passengers deplaned by rows and boarded buses."

The accident aircraft was purchased by Tower Air in 1991 from Trans World Airlines (TWA), the report said. TWA had installed the FDR system that was aboard the accident flight.

When the FDR was removed following the accident and examined in the NTSB laboratory, investigators found 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 report said. "The FDR data were also transcribed at the TWA facility in St. Louis, Missouri, [U.S.,] 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."

When reviewing the maintenance records for the accident aircraft, investigators found that in September 1995, the FDR had been removed for a routine annual check, which was performed by TWA, the report said. On Nov. 3, 1995, "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."

On Dec. 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," the report said. "According to the maintenance log, on Dec. 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 [one of the digital acquisition units (DAU) in the FDR system]."

The maintenance log indicated that a functional check of the FDR system had been performed following the replacement of the DAU, and that the aircraft was used in regular service that same day, the report said. Based on interviews with Tower Air maintenance personnel and documents obtained during

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.
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.
1131:59	**CAM**:	[Sound similar to cockpit door opening]
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 checklist.
1132:16	**CAM-3**:	Before-takeoff checklist.
1132:17	**TWR**:	DHL seven, wind three two zero at one one. Frequency change approved.

the investigation, the NTSB concluded that "Tower Air did not perform the FDR functional test."

The report noted: "If Tower Air had performed this test, it would have identified the malfunctioning [FDR system components] (as the [NTSB] was able to do in its postaccident testing). Consequently, the [NTSB] 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 [NTSB] investigation."

The NTSB found other irregularities in Tower Air's maintenance program during the investigation, but these irregularities did not contribute to the accident, the report said. The NTSB noted that "the continuing airworthiness surveillance and reliability programs in the maintenance department of Tower Air were performing inadequately at the time of the accident."

The NTSB recommended that the FAA "review the structure and performance of the continuing airworthiness surveillance and reliability programs in the Tower Air maintenance department," the report said. "Also, the [NTSB] believes that the FAA should reassess inspectors' methods of evaluating maintenance work, focusing on the possibility of false entries through selective analysis of records and unannounced work-site inspections."

The captain, 53, held an airline transport pilot (ATP) certificate with ratings for the Lockheed L-188, McDonnell Douglas DC-9, B-747 and airplane multi-engine land. He had approximately 16,445 total hours of flight time, with 2,905 hours in the B-747 (1,102 as pilot-in-command). The captain held a current FAA first-class medical certificate with the limitation that he wear corrective lenses while flying.

The captain was hired by Tower Air in 1992 as a first officer on the B-747 and upgraded to captain in 1994, the report said. His last line check before the accident flight was on July 17, 1995.

The first officer, 56, held an ATP certificate with ratings for the Learjet, Nord 265, B-747, Boeing 727 and airplane multi-engine land, and commercial privileges for single-engine land, Boeing 707, Boeing 720 and Lockheed T-33. He had 17,734 total hours of flight time, with 4,804 hours in the B-747. The first officer held a current FAA first-class medical certificate with the limitation that he wear corrective lenses while flying.

The first officer was hired by Tower Air in January 1995 as a first officer on the B-747, the report said. He received recurrent simulator training in lieu of a proficiency check on July 26, 1995.

The flight engineer, 34, 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. He had 4,609 total hours of flight time, with 2,799 hours as a flight engineer in the B-747. He held a current FAA first-class medical certificate with the limitation that he wear corrective lenses while flying.

1132:23	**CAM-3**:	Flight attendants please be seated for takeoff. Thank you.
1132:35	**CAM-3**:	Takeoff announcement is complete.
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.
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-?**:	Okay.
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 checklist complete.
1135:25	**CAM-?**:	OK.
1135:26	**RDO-2**:	Tower Air forty-one is in position four left.

He had an FAA statement of demonstrated ability for defective color vision.

The flight engineer was hired by Tower Air in March 1995 as a flight engineer on the B-747, the report said. His recurrent training was completed on Sept. 19, 1995.

The NTSB reviewed the weather conditions at JFK on the morning of the accident and the captain's decision to use Runway 4L. Between 0645 and 1245 that morning, 3.3 centimeters (1.3 inches) of snow fell, the report said. The peak wind for the day, which occurred at 1014, was from the north at 24 knots (44.4 kph). "No [postaccident] local or special weather observation was made at the time of the accident, as required by NWS [U.S. National Weather Service] directives, because the weather observer was not notified of the accident in time to fulfill this requirement," the report said.

On the morning of the accident, Runway 4L "had been closed to aircraft operations for snow removal, sanding and inspection," the report said. At 0933, a supervisor for the Port Authority of New York and New Jersey (PNY&NJ) conducted an inspection, and a coefficient-of-friction measurement survey was conducted by a friction-test vehicle, the report said. The supervisor conducting the inspection estimated that "the surface was approximately 60 percent covered with patches of snow and ice," the report said.

The friction-measurement survey indicated an average friction coefficient of 0.32 on Runway 4L, with friction coefficients of 0.39 in the touchdown zone, 0.26 at the midpoint and 0.31 in the roll-out area, the report said. PNY&NJ procedures required that any friction readings of 0.40 or below for any one-third of the runway must be reported to the JFK tower. "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 report said.

The report said that JFK tower "had no record that this information was received from PNY&NJ." No information about the runway inspection or friction-measurement survey was communicated to the crew of the accident flight. "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 report said.

The report said that "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," the report said. "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."

The report noted: "Although five minutes before the accident ATC [air traffic control] changed the departure runway to 31L

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, crosswind 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.
1136:31	**RDO-2**:	Cleared for takeoff four left, Tower Air forty-one.
1136:34	**CAM-1**:	Checklist is complete?
1136:35	**CAM-3**:	Yes, checklist 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.
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.

for traffic following Flight 41, the [NTSB] 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."

The report concluded: "Based on the absence of definitive runway-friction measurements for Runway 4L, reported winds of less than 15 knots [27.8 kph] (the maximum recommended crosswind component for B-747 takeoffs on slippery runways), the flight crew's reports of acceptable visibility down the runway and the reported unavailability of the alternative Runway 31L, the [NTSB] concludes that the captain's decision to attempt the takeoff on Runway 4L was appropriate."

As part of the investigation, a study of the accident flight was conducted in a B-747 engineering simulator at the Boeing Airplane Systems Laboratory in Seattle, Washington, U.S., the report said. The simulator was programmed "to reflect the operating weight, CG [center of gravity], flap setting and outside air temperature applicable to the accident flight," the report said. "During simulator sessions, takeoffs were attempted under dry, wet, snowy and icy runway–friction conditions, with crosswind components of 12 [knots] and 24 knots [22.2 kph and 44.4 kph] (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)."

The pilots conducting the simulator evaluation "had actual experience operating the B-747 on slippery runways [and] agreed that the Boeing engineering simulator adequately reflected the ground-handling characteristics of the actual airplane in slippery conditions," the report said. "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 flight crew training."

The simulator was operated "under slippery-runway conditions, with a left crosswind component of 12 knots, [and] the evaluation pilots were able to reproduce the approximate path of the accident airplane as it deviated from the centerline and departed the runway," the report said. "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 evaluation revealed that "simulator responsiveness to tiller inputs was reduced by the slippery-runway conditions," the report said. "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. [As soon as] 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."

1137:18	**CAM-1**:	OK.
1137:19	**CAM**:	[First sound of impact]
1137:20	**CAM-?:**	Pull up. Pull up.
1137:21	**CAM**:	[Second sound of impact]
1137:21	END OF RECORDING	

CAM	=	Cockpit-area microphone voice or sound source
RDO	=	Radio transmission from accident aircraft
GND	=	Radio transmission from JFK ground control
TWR	=	Radio transmission from JFK local control
D9901	=	Radio transmission from Delta Air Lines Flight 9901
SB117	=	Radio transmission from British Airways Flight 117
KW134	=	Radio transmission from Carnival Flight 134
GMTC	=	Radio transmission from ground-maintenance vehicle
-1	=	Voice identified as captain
-2	=	Voice identified as first officer
-3	=	Voice identified as flight engineer
-6	=	Voice identified as jumpseat rider
-?	=	Voice unidentified
*	=	Unintelligible word
#	=	Expletive

Source: U.S. National Transportation Safety Board

In the majority of the 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 [knots]–80 knots [92.5 kph–148.0 kph])," the report said. "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 evaluation revealed that "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 report said.

As a result of the simulator evaluations, the report concluded that "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."

The report added that "the captain's failure to reject the takeoff in a timely manner was causal to this accident."

The NTSB also conducted a spectrum analysis of the accident aircraft's engine sounds on the cockpit voice recorder (CVR) to determine how engine power was applied during the accident sequence, the report said. "Because the FDR was not working, the [NTSB] 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. …

"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 relatively high speed (approximately 97 knots [197.5 kph]).

"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 [NTSB] 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 flight crew statements confirmed that the engine RPM increase recorded on the CVR was not an engagement of reverse thrust. …

"Based on the spectrum analysis … the [NTSB] determined that the captain abandoned his attempt to reject the takeoff, at least temporarily, by restoring forward thrust. The [NTSB] 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."

Investigators evaluated the procedures existing at the time of the accident by both Tower Air and Boeing for operating the B-747 on slippery runways. "Tower Air and Boeing procedures urge pilots to use the rudder and rudder-pedal steering during takeoff," the report said. "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."

The report noted: "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 report concluded that "current B-747 operating procedures provide inadequate guidance to flight crews regarding the potential for loss of directional control at low speeds on slippery runways with the use of the tiller. The [NTSB] 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 flight crews against the 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)."

Following the accident, Tower Air informed the NTSB "that it had re-evaluated and eliminated its standard procedure of guarding the tiller during the takeoff roll through 80 knots," the report said. "The [NTSB] concludes that this procedural change by Tower Air will make overcontrol of the tiller less likely for it own operations; however, other air carrier operators of the B-747 may need to make similar changes to their procedures."

The NTSB recommended that the FAA "issue a flight standards information bulletin (FSIB) to POIs [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," the report said.

Investigators reviewed the actions of the flight attendants during the accident sequence. "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," the report said. "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."

The NTSB expressed concern about the lack of communication among the cabin crew after the airplane had come to rest.

The report continued: "Because these commands are important instructions that can prevent or reduce passenger injuries, the [NTSB] is concerned that nine of the flight attendants did not shout any commands. The [NTSB] 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 NTSB recommended that the FAA "issue an FSIB to POIs of [FARs] 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," the report said.

The NTSB expressed concern about the lack of communication among the cabin crew after the airplane had come to rest. "[Although] the decision not to evacuate the airplane (made independently by the flight attendants and the flight crew) may have been appropriate, these decisions were made without adequate knowledge of the postaccident condition of the airplane," the report said. "Flight attendants had vital information that they did not relay to the purser or the flight crew. For example, flight attendants did not provide information to the flight crew 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."

Investigators reviewed Tower Air's flight attendant procedures and found 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," the report said. "The [NTSB] 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."

The NTSB noted that flight attendant emergency procedures at other air carriers could also be inadequate and recommended that the FAA issue "an FSIB requiring POIs of [FARs] 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 flight crews and other flight attendants, and handling postaccident environments in which normal communications systems have been disrupted," the report said.

The NTSB also recommended that the FAA encourage use of this accident as a case study for crew resource management (CRM) training among flight and cabin crews to improve communication and coordination, the report said.

Investigators reviewed the security of service carts, galley containers, drawers and other galley items that were not contained during the accident sequence. "The most serious breach of galley security occurred in the aft galley complex, between the R4 and L4 exits [Figure 2, page 4]," the report said. "The two carts that came loose injured the R4 flight attendant and blocked the R4 exit."

Investigators could not determine "whether the primary latching mechanisms were engaged on the carts that were released from the aft galley," the report said. "However, the bending in the secondary latches indicated that those latches were engaged but were not adequate to secure the carts."

The report said that the forces during the accident sequence were not severe enough to cause the latches to fail. The NTSB therefore concluded "that the material or installation of secondary latches in the galleys of [the accident aircraft] was inadequate," the report said.

The NTSB recommended that the FAA "develop certification standards for the installation of secondary galley latches ... on all transport-category aircraft," the report said. "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."

The NTSB also found that "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," the report said. The investigation revealed that "flight attendants did not actually operate carts in a galley setting until they began flying."

The report concluded: "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 [NTSB] 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."

As a result of its investigation, the NTSB made the following additional recommendations to the FAA:

- "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;

- "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 flight crew training accurately simulate the slippery-runway handling characteristics of the airplane;

- "After completing this evaluation, issue a flight standards information bulletin urging principal operations inspectors 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; [and,]

- "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."♦

Editorial note: This report was adapted from *Runway Departure During Attempted Takeoff, Tower Air Flight 41, Boeing 747-136, N605FF, JFK International Airport, New York, December 20, 1995*. Report No. NTSB/AAR-96/04, prepared by the U.S. National Transportation Safety Board. The 91-page report contains illustrations and appendices.

Further Reading from FSF Publications

"After Loud Bang, Captain Rejects Takeoff; DC-10 Runs Off End of Runway." *Accident Prevention* Volume 53 (October 1996).

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