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DC-10 Destroyed, No Fatalities, After Aircraft Veers Off Runway During Landing

Fifty feet above the runway, the first officer — the pilot flying — made a decision to go around, but the captain took control and landed the aircraft. The aircraft rolled off the runway about 1,700 feet after touchdown. Although the captain was not faulted for continuing the landing, an official U.S. report raised training, procedural, technical and record-keeping issues in connection with the accident.

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The after-landing accident of an American Airlines McDonnell Douglas DC-10-30 has resulted in U.S. National Transportation Safety Board (NTSB) recommendations for flight crew and air traffic control training and procedures, airplane emergency evacuation lighting and runway maintenance.

American Airlines Flight 102 (AAL 102) departed the right side of Runway 17L, following landing at Dallas/Fort Worth (Texas, U.S.) International Airport (DFW) on April 14, 1993. Two passengers were seriously injured, and 35 passengers, one flight crew member and two cabin crew members were slightly injured during the evacuation of the airplane. Damage to the airplane was estimated at US$35 million. Because of the repair costs, the hull was considered destroyed.

In its accident investigation report, the NTSB determined that the probable cause of the accident was "the failure of the captain to use proper directional control techniques to maintain the airplane on the runway."

AAL 102 departed Honolulu, Hawaii (HNL) at 1753 Hawaii-Aleutian Standard Time (2353 Central Daylight Time [CDT]). The flight from HNL to touchdown at DFW took about seven hours and seven minutes.

About 30 minutes before landing, the captain announced on the public address system that the flight would be deviating around weather in the Dallas/Fort Worth area and that there "shouldn't be any particular problem other than some bumpy air ... nothing dangerous," the report said. The passengers were asked to be seated and the flight attendants were asked to "go ahead and round up everything ... just as a precaution."

At 0630 CDT, AAL 102 was in contact with the Fort Worth Air Route Traffic Control Center (ARTCC). The flight was vectored from the northwest of DFW for a south landing. Concerned about the weather north of the airport, the captain asked the Fort Worth Center controller about the possibility that the flight "might be able to come in from the south and land to the north," the report said. The controller

replied that he could investigate the possibility of a north landing. The captain told the controller to "wait 'til we get a little closer and look at it. The radar at this range is not really as accurate as it is when we get in 40, 50 miles [64.4, 80.5 kilometers] away," the report said.

For about the next 10 minutes the captain and first officer discussed what they observed on their airborne weather radar. "The captain indicated they were 80 miles [128.8 kilometers] out, that he saw 'yellow scud' on the scope, and they were 'not looking at anything that even approaches red,'" the NTSB report said. Minutes later, the captain and first officer agreed that they were seeing red returns. The report said that one of the crew commented, "Red should be a really bad cell."

Two minutes later, the flight deck crew saw a brilliant flash of light and the cockpit area microphone picked up a rumble that sounded like thunder. "Everything appears to be functioning," the flight engineer said. The report said that several passengers and flight attendants reported a possible lightning strike.

The NTSB said that the captain told air traffic control (ATC), "We just had a big blast of lightning," and said that he didn't believe the airplane had been struck by it. "He [the captain] again requested a landing to the north. The controller expressed his doubts that a north landing would be approved, but assured him that he would forward the request," the report said.

AAL 102 was handed off from the ARTCCC to DFW approach control. "On initial radio contact with approach control, the captain verified the status of his request [for a north landing], but was told that DFW's southbound departures would preclude landing to the north," the report said. Shortly thereafter, the captain asked for a 50-degree heading change to deviate around weather, which the controller approved.

At 0645:31, the captain stated on the cockpit microphone, "I don't know what the [expletive] happened with this radar." This prompted the first officer to ask, "Is it not working or is it working?" the report said.

The report said that the flight engineer briefed the captain and first officer on the current ATIS [automatic terminal information service]: "Echo, 1,400 [feet (427 meters)] overcast, 2½ miles [four kilometers] visibility, winds 220 at 6, [altimeter] 29.48 inches [998 millibars], lightning cloud-to-cloud, cloud-to-ground, thunderstorms moving northeast and pressure falling rapidly."

At 0647:58, AAL 102 was descending to 3,000 feet (915 meters), and received a broadcast from ATC that DFW weather was 1,400 feet overcast, visibility 2½ miles, with thunderstorms, rain showers and fog. The wind was 140 at 11, altimeter 29.49 inches, and all aircraft were told to expect a south landing.

The controller told AAL 102 to expect the instrument landing system (ILS) Runway 17L and stated the localizer frequency. The captain acknowledged by repeating the localizer frequency and asked, "How's it look coming down final on your radar?" The report said that the controller replied, "I show an area of weather at 15 miles [24 kilometers] either side of DFW Airport, proceeding straight north 15 miles on each side for about 30 miles [48.3 kilometers]."

The captain then asked, "Okay, can you give us a good heading then to come in on?" The controller responded that he could give a good heading to the localizer, but there was weather all the way down the final approach course. The captain then asked if the weather was moving. The controller replied that the weather did not appear to be moving, and he gave a heading to intercept the localizer, the report said.

Two minutes later, the flight deck crew saw a brilliant flash of light and the cockpit area microphone picked up a rumble that sounded like thunder. "Everything appears to be functioning," the flight engineer said.

"At 0650:33, the captain radioed, 'I don't think we're going to be able to do that, that's a pretty big red area on our scope about 90 degrees, and that's about what we're looking at. We're gonna have to, just go out I guess and wait around to see what's going on here,'" the report said. The controller told AAL 102 that eight miles [12.9 kilometers] south of their position, a McDonnell Douglas DC-8 was intercepting the localizer at 3,000 feet and had reported a smooth ride.

The captain responded, "Okay, we'll head down that way then and, worse comes to worse, we'll go out from there," the report said. The controller gave AAL 102 a heading of 200 degrees to intercept the Runway 17L localizer.

"The airplane was in approach configuration with the flaps set to 15 degrees," the report said. "At 0652, the captain questioned the first officer as to the veracity of the localizer frequency, despite the fact that the captain had read it back to approach control at 0649:34. Subsequently, at 0652, the captain questioned the first officer as to whether they were landing on Runway 17L or 17R. The first officer reminded the captain that they were landing on Runway 17L. At 0652:40, they were cleared for the approach.

"The first officer requested that the captain and flight engineer be alert for any indication of wind shear. The captain encouraged him to carry 10 to 15 knots of extra airspeed, and the first officer assured him that he would do so. When asked to describe their flight conditions by approach control at 0653:20, the captain stated that they were in the clouds with 'just a little ripple and pretty good-size rain.'

"At 0653:32, about a minute before intercepting the localizer, the cockpit area microphone recorded a click. The first officer asked if the captain and engineer thought that it was a lightning strike. The captain said that he had been hit twice before, and that 'that's what it looks like,' but went on to say, 'I don't think this is going to be a problem.'

"The captain reported a 10- to 15-knot gain in airspeed at 0655:36. Approach control informed them that the DC-8 had reported fluctuations of 10 to 15 knots on their approach to Runway 18R. They extended the landing gear at 0655:53. After the ride was reported as 'light occasionally moderate chop,' approach control transferred AAL 102 to DFW Tower," the report said.

When the captain contacted DFW Tower, the controller cleared the flight to land and said the winds were calm. During their final approach, the flight crew had the airplane in about a 10-degree right crab to compensate for a right crosswind. At 0658:38, the flight engineer reported descending through 500 feet (152.5 meters), and the captain reported the runway lights in sight.

When the captain contacted DFW Tower, the controller cleared the flight to land and said the winds were calm.

At 0659:03, the captain said, "I've got a plus ten, sinking a thousand." Thirteen seconds later, the automated cockpit voice called out "50" [feet (15.2 meters)], and the first officer said, "I'm gonna go around." The captain stated, "No, no, no, I got it." The first officer responded, "You got the airplane." The captain took control and landed the airplane, the report said.

Several witnesses observed the wind conditions as the DC-10 touched down. "An American Airlines MD-80 captain was waiting for takeoff in the ramp area next to [Runway] 17R. He looked southeast and observed the windsock as straight out, with the wind from the west. He saw the accident airplane fly by and touch down. He then noticed the windsock fully inflated, with the wind out of 340 degrees to 350 degrees," the report said.

AAL 102 touched down 4,303 feet (1,312 meters) from the threshold of runway 17L. The airplane paralleled the runway centerline for approximately 1,700 feet (518 meters), then turned gradually to the right until it went off the runway.

During the landing, "a sound of a thump, similar to aircraft touchdown was recorded at 0659:29 on the CVR [cockpit voice recorder]," the report said. "The second thump was recorded about two seconds later. At 0659:36, the first officer said, 'Okay, 120 knots.' At 0659:38, the captain said, 'Oh [expletive].' At 0659:41, the first officer said, '100 knots,' then, 'Okay, we're off the grass,' and, at 0659:45, '80 knots.' One of the flight crew members then said, 'Gosh darn,' and a sound similar to a horn sounded in the cockpit."

The airplane came to rest upright about 2,607 feet (795 meters) from the departure end of Runway 17L and about 250 feet (76 meters) from the right edge of the runway, with the nose on perpendicular taxiway 31. The airplane was "supported by the forward fuselage, the center and right main landing gear, and the left wing and No. 1 engine. The left main gear strut was fractured and the nose gear was folded aft. The airplane came to rest slightly nose low and about 10 degrees left wing low. In its final resting position, the left wing and forward fuselage, as well as the right main and center gear, provided support and areas of ground contact. Several witnesses, including pilots of other airplanes on taxiways, noted that a large fire developed aft of the left wing of the accident airplane about the time it came to rest," the NTSB report said.

At 0659:53, the captain called for an emergency evacuation of the airplane. "At 0700:15, one of the flight crew members made an announcement on the public address system to evacuate the airplane," the NTSB said. "However, only one flight attendant reported hearing the announcement. The flight attendant, seated in the forward left portion of the first class cabin, stated that he initiated the cabin emergency evacuation by activating the evacuation signaling system. Two other flight attendants also reported initiating the evacuation without hearing any call from the cockpit."

The NTSB report added: "The flight attendants attempted to evacuate the passengers from exits on both sides of the cabin. The left roll and nose-down pitch attitude of the airplane caused the angle of the right rear slides to steepen to what appeared to some witnesses as a near vertical angle.

"Initially, flight attendants directed passengers out of four right cabin emergency exits and the two forward left exits. Because fire was seen aft of the left wing, the flight attendants did not open the two aft left emergency exits (3-L and 4-L). After some of the passengers had exited from the right side exits, cabin crew members moved the passengers forward to other exits.

"At one point during the evacuation from [exit] 3-R, passengers bunched up on the right wing because of the steepness of the slide from the wing to the ground. A flight attendant saw a holdup at the top of the slide and came out on the wing. Noting the steepness of the slide, the high number of older passengers attempting to evacuate, and the passenger pileup at the bottom of the slide, the flight attendant told the passengers on the wing that they would have to return to the cabin and use another exit. At the same time, some passengers said that a flight attendant inside the cabin, behind the group of people trying to exit onto the right wing, told them that they would have to move quickly from the airplane because of a fire out the left side cabin windows."

The report said that some elderly passengers were unwilling to jump onto the slides until they were urged to do so or were pushed onto the slides. "Some female passengers wanted to take personal items with them, especially purses. Flight attendants warned against taking these items and physically removed them from several passengers as they jammed forward attempting to enter the slides. The urgency of the situation was described by several passengers and flight attendants as becoming apparent when the glow from the left side fire was observed clearly in the dark cabin through the aft left cabin windows. Many of them said later that the flight attendants and nearly all the passengers evacuated expeditiously and as calmly as possible from the dark cabin," the report said.

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Crash, fire and rescue services arrived at the accident site within minutes. "The DFW fire and rescue department's crash alarm sounded about 0701, within about one minute from the time the airplane came to rest. About one minute later, the first trucks were arriving at the airplane. They extinguished a fire at the left wing in about 50 seconds, while the passengers were still exiting the airplane. DFW emergency medical services (EMS) responded with three DFW ambulances and eight mutual aid ambulances."

The NTSB said that of a total of 202 persons aboard the airplane (189 passengers, three flight crew, 10 cabin crew), "two injuries were described as serious, involving fractured bones or spinal injuries to passengers that occurred during the evacuation of the airplane. There were 38 reported minor injuries (35 passengers, two cabin crew, and one flight crew)."

The report added: "Two passengers received minor injuries that could be attributed to ceiling panels as the airplane slowed to a stop in the soft soil. However, most of the minor injuries and all of the serious injuries were reported to have occurred during the emergency evacuation, especially as passengers attempted to slide down steep-angled slides from the right side of the cabin, landing in sticky mud that made it difficult or impossible for some of them to move away from the bottom of the slides.

"The flight attendant stationed at 3-R said that the problem was exacerbated by the high number of elderly persons attempting to evacuate at that exit. The steep angle of the slides at 3-R and 4-R resulted from the final resting attitude of the airplane. In addition to deep mud at the bottom of the slides, winds, driving rain, and slippery slides heightened the difficulties. Due to the resting attitude of the airplane, slides at 3-R and 4-R were described by some witnesses as not touching the ground, a situation that contributed significantly to the steepness of the slides."

In addition, several passenger and crew statements said that the cabin was only partially illuminated during the evacuation. "The airplane's emergency cabin lighting system consisted of two subsystems: one to illuminate overhead and door exit lights, and one to illuminate the floor path and side wall exit sign lights. Both emergency lighting systems were removed from the accident airplane and shipped to their respective manufacturers where each subsystem was subjected to additional testing under Safety Board supervision," the report said.

One of the eight control modules for the floor path and side wall exit sign lights was found to be nonfunctional.

The cabin overhead and door emergency lighting system was disassembled and re-examined. "All logic units tested satisfactorily; however, examination of the system battery packs, which contained 24 individual power cells, revealed that the tap wire or primary lead was incorrectly soldered onto all four battery packs. In addition, individual battery cells were out of the original factory-assembled sequence. This factor affected the amount of charge each battery cell would accept during charging and thereby diminished the overall level of power for the battery packs," the report said.

The NTSB report said that "American Airlines' maintenance records showed that the battery packs had been serviced by the airline's maintenance department. It was established that neither the manufacturer of the battery packs nor the system's manufacturer had provided written guidance to the airline's maintenance department on

the importance of ensuring, during maintenance, the replacement of individual power cells in the same sequence from which they were removed, as well as ensuring the correct procedure for soldering the tap wire to the battery packs.

"Due to the decreased power and charge level, there was sufficient power to indicate an operational system at the flight engineer's instrument console, but not enough to actually operate the system. The tests concluded that as a result of improper soldering of the tap wires and the improper configuration of the individual cells, which constituted the battery packs used by American Airlines maintenance, the power and charge level was not sufficient to illuminate the overhead and door emergency lighting system," the report said.

The airplane's cabin was inspected for damage. "During the landing, after the airplane departed the right side of the runway, a few ceiling panels and some articles stored in overhead bins were reported to have fallen, striking two passengers. In rows 11 to 16, two ceiling panels by the right aisle and two by the left aisle were separated from the ceiling. Overhead panels were opened for inspection, revealing no evidence of fire, smoke, or lightning strike. The oxygen masks were found deployed above seats A and B in row 22," the report said.

Investigators examined the airplane wreckage and found that "the forward fuselage underside sustained crushing damage in the area of the nose gear wheel well and aft to the area where the nosewheels penetrated the lower lobe galley," the report said. "Other areas of the forward skin along the belly were wrinkled and torn. All of the examined fractures and cracks showed evidence of overload, resulting from the crash.

"The nose gear was found folded aft. The wheel and tire assembly penetrated the floor of the lower lobe galley, and the wheels were turned about 90 degrees to the right. The center main gear was found attached to the airplane in the down and locked position with the wheel well structure aft of the gear undamaged. The center main gear had sunk into the mud up to the lower fuselage of the airplane, requiring separation from the structure for recovery of the airplane.

"The right main landing gear remained attached to the airplane, in the down and locked position, and supported the right side of the airplane. The tires were buried in mud to a depth of approximately two feet [0.6 meters]. The left main landing gear was found separated from the wing structure. It came to rest against the trailing edge of the left wing's outboard flap. The No. 1 engine pylon was still connected to the left wing, but the engine had been rotated counterclockwise (aft looking forward) and turned inward and nose up. No right wing damage was observed."

When the No. 2 engine was examined, investigators found an improper thrust reverser cascade configuration. "All the cascades on the No. 2 engine were undamaged. However, two of the 32 cascades, located at the five o'clock position, were the incorrect part numbers and styles for the installation, according to the operator's DC-10-30 illustrated parts catalogue."

The airplane's flight control systems were examined, and "no pre-existing conditions that could have adversely affected the flight controls" were found.

Investigators looked for evidence that the airplane had been struck by lightning. "Two areas of the airplane's fuselage skin were identified as possible entry points for a lightning strike. They were two small black pits that were located below the window line aft of the L-2 door (left cabin exit door, second from the front of the cabin). No additional damage was observed around these pits.

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"The top of the light lens on the right wing tip trailing edge exhibited melting and discoloration characteristic of a lightning strike. Melting and discoloration were also observed along the boundary of the lens and on the static discharger located outboard and adjacent to the lens. Three other dischargers were found broken: one each on the right wing trailing edge, left wing trailing edge, and left wing tip," the report said.

When the airplane was examined for fire damage, "the most severe fire damage was on the underside of the left wing, aft and outboard of the No. 1 engine rear pylon. The lower left wing skin, between the front and rear spars and outboard of the rear pylon to the No. 3 flap track fairing, was heavily sooted. Less sooting was found farther inboard on the wing and outboard of the No. 2 flap track fairing. The lower surface of the inboard aileron and portions of the flaps and wing panels between the No. 1 and No. 2 flap track fairings were burned through. Melted metal hung from the lower surfaces of the inboard aileron and the outboard portion of the inboard flap on the left wing. The outboard side of the No. 1 flap track fairing was significantly more burned than the inboard

side. Both sides of the No. 2 flap track fairing were burned through. Only minor fire damage forward of the front spar was observed. All fuel tanks were found intact," the report said.

Investigators reviewed the weather briefing obtained by the flight crew before departing HNL and during the flight. The report said that "American Airlines meteorology and flight dispatch sections correctly advised AAL 102 of expected thunderstorms, moderate-to-heavy rain showers, low-level wind shear, and variable surface winds, gusting 20 to 40 knots, upon arrival at DFW."

During the investigation, data were obtained regarding thunderstorm activity during the approach and landing of AAL 102. "During the final approach of AAL 102, cloud bases north of DFW were, from the evidence, likely 1,000 to 2,000 feet [305 to 610 meters] broken to overcast. Doppler radar at 0650:23 showed an area of radar echoes up to and including VIP [video integrator processor] level-4 intensity, northwest through north of the airport. Cockpit communications and sounds similar to windshield wipers, recorded on the CVR, indicated that AAL 102 was in and out of thunderstorms and rain showers during most of its approach. The flight crew reported runway lights in sight, at 0658:14, and the airplane touched down at 0659:29.

"The evidence shows that a line of moderate-to-heavy rain showers and thunderstorms was crossing Runway 17L as AAL 102 was landing."

"The first period of moderate-to-heavy rain showers at DFW ended at the weather observatory located in the Delta Air Lines hangar, about 0645. These showers moved off to the east of the airport. The precipitation recording chart at the facility showed that only about 0.02 inch [0.05 centimeter] of rain fell during the next 15-minute period, ending at 0700. Interviews and statements by the duty observer and oncoming weather observers confirmed that rain shower intensity increased about 0658.

"At 0645, the leading edge of the second band of significant precipitation was approximately seven miles west of [Runway] 17L. Doppler radar at 0650:23 showed that the line was slightly west of the airport complex. The LLWAS [low-level wind shear alerting system] west sensor went into sector alert at 0653:25, as the line traversed the area."

The report said radar returns from Doppler radar at 0656:10 showed that the leading edge of mostly "VIP level-2 echoes was near the terminal area, and that VIP level-3 and VIP level-4 echoes were just west of [Runway] 18R.

"The runway visual range (RVR) sensor for [Runway] 17L was located between [Runways] 17R and 17L, approximately 1,000 feet south of the thresholds. According to the NWS [National Weather Service] recording, the RVR began a marked decrease around 0659 and stabilized between 0700 and 0701. This decrease in runway visibility is consistent with a heavy rain shower passing over the RVR location. In addition, the captain of American Airlines Flight 1710, which was awaiting clearance for departure on [Runway] 17R, later stated: 'The aircraft [AAL 102] appeared to be in a normal attitude and altitude for landing as he crossed the runway threshold. The rain had just picked up to a more moderate to almost heavy level as I watched him for a very short time.'

"The evidence shows that a line of moderate-to-heavy rain showers and thunderstorms was crossing Runway 17L as AAL 102 was landing. The flight crew of AAL 102 should have had sufficient information to realize that this was occurring at the time of landing," the report said.

Data from several sources were used to estimate the winds during the final three minutes of flight of the accident airplane. "The calculated wind directions varied between approximately 225 and 310 degrees during the final 2 1/2 minutes before touchdown (except for the final seven seconds of data, which are assumed to be inaccurate since the airplane was in a side-slip). The calculated wind speeds varied from 30 to 50 knots early in the approach to 15 to 30 knots as the airplane neared the touchdown point," the report said.

The NTSB report added: "The calculated wind direction varied randomly between a quartering headwind and a quartering tailwind between 0657 and 0659. At 0659, AAL 102 was approximately 270 feet [82 meters] AGL [above ground level], and the wind was from about 270 degrees at 25 knots. Wind speed then decreased to about 15 knots, and changed to a direct crosswind at approximately 0659:08 when the airplane was at 150 feet [45 meters] AGL. Calculated wind directions remained constant, but the speeds increased to 25 to 30 knots over the next few seconds. These data would indicate that AAL 102 was subjected to a direct right crosswind of 25 to 30 knots, when the first officer stated, 'I'm gonna go around,' at 0659:17, about one second after the automated voice called out '50' [feet AGL].

"Wind conditions could not be continued in the program after touchdown, because the crosswind component cannot be calculated by this method when the airplane is on the ground. After touchdown, the closest LLWAS anemometer to the airplane (centerfield) was used to provide winds calculated during the airplane's ground roll.

"Prior to touchdown, the airplane transitioned from a 20-degree crab to a two-degree right-wing-down (RWD) roll and a 10-degree airplane-nose-left (ANL) rudder deflection. The data show that the airplane touched down at 0659:29 and tracked near the centerline of [Runway] 17L for about eight seconds, averaging an eight-degree ANL rudder deflection. During the eight seconds after touchdown, the airplane decelerated to 116 knots indicated airspeed (KIAS), while the rudder was deflected on average about eight degrees ANL, the aileron position averaged five degrees RWD, and the elevator averaged seven degrees airplane nose down (AND).

"About six seconds after touchdown, the airplane heading began to move to the right of runway heading. At seven seconds after touchdown, flight data recorder (FDR) data show that the airplane's rudder, elevator, and ailerons moved in the direction of the neutral position (zero deflection). The airplane then began to track to the right of the runway centerline. The heading change continued to the right, except for one point when the rudder was deflected 15 degrees ANL for one second, upon which the heading stabilized for about two seconds. Also, there was basically no movement of the elevator or ailerons from the neutral position prior to the airplane departing the right shoulder of the runway. The right main landing gear departed the runway shoulder with the airplane's speed slowing to about 95 KIAS about 14 seconds after airplane touchdown.

"The effects of the misconfigured reverser cascades on the No. 2 engine were examined. Calculations, using information from the airplane and engine manufacturers, showed that input into the flight controls could readily offset the effect of the two misconfigured thrust reverser cascades, at the speeds of the accident airplane, prior to its departure from the landing runway."

"Prior to touchdown, the airplane transitioned from a 20-degree crab to a two-degree right-wing-down (RWD) roll and a 10-degree airplane-nose-left (ANL) rudder deflection."

The NTSB reviewed the actions of air traffic controllers during the arrival of AAL 102; "At 0643:09, the Feeder West controller at the Dallas/Fort Worth TRACON [terminal radar approach control] received the request to land in the opposite direction made by the flight crew of AAL 102 to the Fort Worth Center controller. The Feeder West controller denied this request because of the operational impact on the airport and surrounding airports. That is, when changes, such as those requested by AAL 102, occur at DFW, airport operations, arrivals and departures must be stopped at nearby airports. Their proximity to DFW and the overall airspace configuration makes it operationally impractical to allow an opposite direction approach each time it is requested. Additionally, the DFW air traffic control facility has a local order that states unless an emergency conditions exists, opposite direction approaches will not be conducted. Furthermore, the weather conditions at the time of the request did not warrant a runway change.

"At 0656:36, the flight crew of AAL 102 made initial contact with the local [tower] controller. Although a wind shear alert had occurred at 0653:25, the controller did not issue an advisory in accordance with the ATC handbook. It states that after the last wind shear alert, a wind shear advisory will be issued to all pilots for 20 minutes by either an ATIS message or, at facilities without ATIS, by a controller. In this case, the ATIS broadcast containing the wind shear advisory was not broadcast until after the accident had occurred.

"Although the flight crew of AAL 102 did not receive the wind shear advisory, the approach controller relayed a pilot report (pirep) received from the pilot of the heavy DC-8, which was landing on Runway 18R. The controller stated to AAL 102 that the DC-8 pilot reported that he had encountered an airspeed fluctuation of plus or minus 10 knots at the outer marker and plus or minus five knots on short final.

In a recommendation to the FAA, the NTSB said that "because pilots rely on controllers to issue pertinent weather information, such as wind shear alerts, in a timely fashion, the Safety Board believes that the ATC handbook should be amended to require controllers to continue to verbally broadcast wind shear advisories until he/she is assured that the information has been recorded and is being broadcast on the ATIS, and pilots have had time to receive the information. Although wind shear was not a factor in this accident, the rapidly changing weather conditions occurring at the airport might have been more apparent to the flight crew of AAL 102 if a timely wind shear advisory had been made."

The flight crew of AAL 102 consisted of a captain, first officer, and flight engineer. The captain, 59, had logged a total of 12,562 flight hours, 555 of which were in the DC-10. He was first employed by American Airlines in 1966, and was designated a captain in the DC-10 in 1991. He held a U.S. airline transport pilot certificate, and was type-rated in the DC-10, Boeing 727 and DC-9, the report said.

The first officer, 40, held a U.S. commercial pilot certificate, and multi-engine and single-engine land ratings. He was first employed by American Airlines in 1986. He had logged a total of 4,454 flight hours, of which 376 were as a first officer in the DC-10.

The flight engineer, 60, held a U.S. flight engineer certificate. He was first employed by American Airlines in 1955. He had logged a total of 20,000 flight hours, all of which were as a flight engineer, and 4,800 hours of which were in the DC-10.

The flight crew were interviewed individually during the investigation, and the report summarized their description of events during the approach and landing. "When the first officer had the runway in sight, he disconnected the autopilot, but not the auto throttles," the report said. "He swung the nose of the airplane slightly to the left, and the airplane drifted left. He swung the nose of the airplane back to the right and said that he was 'not comfortable.' He felt that they were 'high' and that the airplane would need too much nose down to accomplish the landing. He announced that he was going to make a missed approach.

"The captain said he believed the aircraft was drifting to the left, and he felt he could make a safe landing. He did not want to make a missed approach and have to deal with the thunderstorm activity again. He said that they were at 200 feet [61 meters] AGL and that he took control of the airplane from the first officer. He made an alignment correction, but said it was not necessary to make an attitude/glideslope adjustment. He was confident that the landing would be within 'the desired 3,000-foot [915-meter] touchdown zone.' He said that there was no need to go around, no wind shear, no airspeed, height, or alignment problem.

"The captain said he believed the aircraft was drifting to the left, and he felt he could make a safe landing. He did not want to make a missed approach and have to deal with the thunderstorm activity again."

"He [the captain] aligned and landed the airplane on centerline. The touchdown was very smooth. After he lowered the nose, he activated the reverse thrust. The spoilers had extended and the normal reverse deployed, but he felt only a slight deceleration. At that time, he said that the airplane 'weathervaned' about five degrees to the right. He acted 'instinctively' to return to the centerline of the runway. He released the control column and used nosewheel steering handwheel control. He commented that the airplane does not normally need forward pressure on the control column. He felt some 'sliding,' but he did not use asymmetric reverse power. He applied the brakes, although he commented that braking was normally not done until the airplane was moving slower than 100 knots. After the airplane did not respond to his actions, he said that 'there was nothing we could do but hang on.'

"The first officer said that after the captain took control of the airplane, the airplane seemed to 'float,' and that he was not sure where the touchdown was made. The CVR data showed that the first officer made call-outs expected of the non-flying pilot. After the landing, he did not hold forward pressure on the control yoke after the nosewheel touchdown. He said it was not normal procedure to do so unless he was previously briefed. When asked his opinion regarding the captain continuing the approach to landing after the first officer judged the need to initiate a missed approach, the first officer replied, 'I've got to trust him.'"

The NTSB also reviewed the pilots' use of control column pressure and nosewheel steering during landing. The report noted: "DAC [Douglas Aircraft Co.] had published specific information regarding the use of forward pressure on the control column during the landing roll, as well as on the use of the nosewheel steering handwheel, in an AOL [all operator letter], two flight crew newsletters, and in its DC-10 Flightcrew Operating Manual. However, the Safety Board could find no reference to these procedures in American Airlines DC-10 Operating Procedures or training program. The 'technique' section of the American Airlines DC-10 Operating Manual makes a short reference to the importance of forward pressure on the yoke after touchdown. However, the manual does not provide either a procedure or technique for the non-flying pilot to apply forward pressure on the yoke after touchdown."

The NTSB report said that when asked, "the captain said that he thought forward pressure was not necessarily a DC-10 procedure, but generally a good thing to do. The first officer said that he did not push forward on the yoke, after the captain released it, and would not unless it was specifically requested by the captain."

The report added: "The information published by DAC regarding the necessity for forward pressure on the yoke, after landing, explained that it was necessary to reduce lift and improve steering characteristics of the nose gear. In addition, DAC's DC-10 Flightcrew Operating Manual states that, 'The pilot not flying must apply sufficient forward pressure on the control column to maintain the nose-wheel firmly on the ground for maximum directional control.'"

In addition, the NTSB reviewed the captain's use of reverse thrust during the landing: "For about seven seconds, about one second after touchdown, until about the time the airplane departed the runway, the FDR shows that the captain kept all three engines near maximum reverse thrust. DAC, and some other operators of the DC-10,

provide written operations procedures that address the use of reverse engine thrust during loss of directional control on a landing roll. In general, the operating procedures instruct the pilot to bring the engines out of reverse thrust. The pilot may then use forward thrust, as necessary, to help the airplane realign. American Airlines addresses this issue not in the Operating Procedures section of its manual, but in the Operating Technique section.

"During post-accident depositions, American Airlines' DC-10 fleet manager, a current DC-10 check airman, was asked his opinion regarding the American DC-10 Operating Manual reference to application of forward thrust to regain directional control on a landing runway. He said that he would not use it. He stated that it should be removed from the manual and that 'it might be something that they picked up from DAC.'

"The Operating Techniques section of American Airlines' DC-10 Operating Manual ... merely urges the use of 'appropriate control inputs' to return the airplane to the runway centerline. The guidance does not specify the necessity of maintaining forward pressure on the control column to ensure nosewheel steering effectiveness.

"If the captain were at the controls during the landing roll, the only way he could 'reduce the nosewheel steering angle,' as suggested by this technique, would be to release the yoke and to use his left hand on the handwheel steering control, while making the appropriate rudder input. This technique, published without the requirement for the non-flying pilot to hold forward pressure on the yoke, is considered ineffective. Further, the technique could lead one to believe that the use of handwheel steering control to steer back toward the runway centerline, during attempted deceleration, is appropriate. However, as the manufacturer's procedure describes, such high speed use is not the purpose of the handwheel steering control.

"The Safety Board is concerned that American Airlines has placed critical items in its Operating Techniques section of the manual to avoid the 'regulatory' nature of procedures. It seems apparent that certain aspects of flying an airplane, such as use of flight controls during landing, should be considered procedural and should be standardized so that they can be practiced and evaluated during training and are used consistently by line pilots. The implication of citing an action as a technique, rather than as a procedure, could permit non-standard use of critical flight control inputs by pilots during critical phases of flight, such as evident during this accident. The Safety Board believes that the FAA should reevaluate the Operating Techniques section of American Airlines' Operating Manual to ensure that critical flight crew actions that are expected to be used are properly included in the Procedures section of the manual."

Investigators found that "prior to the beginning of the airplane's approach to DFW, no briefings on approach, landing or go-around procedures, emergency or otherwise, were conducted. Without an approach briefing, the flight crew must fall back upon standardized operational training."

The NTSB report continued: "After the captain countermanded his [the first officer's] decision to go around on short final and took control of the airplane from him, there was no specific guidance to the first officer regarding his duties to back up the captain during the landing. The American Airlines' Operating Manual does not give clear direction on what the first officer should do following a captain taking control of an airplane.

Investigators found that "prior to the beginning of the airplane's approach to DFW, no briefings on approach, landing or go-around procedures, emergency or otherwise, were conducted."

"When American Airlines' first officers were asked what they would do to assist a captain, undirected, with the flight controls on the landing runway, their statements were not consistent. Some stated that they would not make control input, with the captain at the controls, unless directed. Others stated that they would assist with nosewheel steering, by putting forward pressure on the yoke. When asked if the airplane were about to depart the runway, whether they would make undirected control inputs to assist the flying captain, some said they would not; others said that they would do whatever was necessary to help keep the airplane safely on the runway. The Safety Board concludes that American Airlines' training, pilot standardization, and flight manuals need to provide clear and definitive direction to first officers regarding those unbriefed and unspoken times, especially during emergencies, when their input into the flight controls may be needed."

The NTSB also focused on the actions and decisions of the captain and first officer during the approach and landing: "Given the amount of information about the adverse weather in the DFW area that the captain was aware of, as well as the first officer's assertively articulated suggestion in favor of discontinuing the approach, the Safety Board examined the captain's decision to continue the approach and his decision to countermand the first officer's decision to go around at 50 feet. The Safety Board considered the

factors involved and the context in which the decisions were made to determine whether they were appropriate.

"Despite the thundershowers north and south of DFW, as AAL 102 proceeded to the ILS approach to [Runway] 17L, there were no weather conditions that made the decision of the captain to initiate or continue the approach unacceptable. Although the airplane was in a 10-degree right crab on short final to [Runway] 17L, this condition was not inherently unsafe. The DC-8, which had landed on [Runway] 18R about four minutes before AAL 102, had reported a 'smooth ride' that had been passed by an approach controller to AAL 102. Also, on approach to [Runway] 17L behind AAL 102, an SA-340 captain, who flew a missed approach beginning about 600 feet [183 meters] AGL, reported that he experienced light to moderate turbulence during the approach and no wind shear activity."

The NTSB report concluded that the captain of AAL 102 was "well within his authority to take the airplane from the first officer after the first officer had announced, without prior warning, that he was going around. The fact that the captain was able to land the airplane on centerline provides evidence that he was in control of the airplane through the touchdown. No clear evidence exists that there was any fault in the captain's decision-making throughout the initiation or continuation of the approach to [Runway] 17L, or in his decision to take control of the airplane from the first officer and land on the intended runway. The departure from the runway resulted from the captain's failure to maintain directional control of the airplane after touchdown rather than from events or decisions made prior to touchdown.

"Finally, in light of the captain's improper aircraft control during the landing roll, the relatively long duration of his overnight flight, and the fact that the captain's sleep periods were disrupted in the 48 hours prior to the accident, the Safety Board considered the possibility that fatigue adversely affected his performance. These factors and the captain's age of 59 years led the Safety Board to believe that the captain might have been fatigued to some extent. Even though the circumstances surrounding the flight crew's activities from April 12 through 14 could have led to a deterioration of his judgment and piloting skills, there is no information available regarding the captain's ability to perform under either long-term or short-term fatigue. Therefore, a finding that his performance on the accident flight was the result of fatigue could not be supported, nor could it be dismissed."

As a result of its investigation, the NTSB expressed concern about American Airlines' record-keeping of flight crew training and performance: "The Safety Board attempted to obtain information about the quality of the past training and checking performance of the flight crew of AAL 102 from American Airlines, but was unable to do so because of the lack of detailed information in the records. The FAA-approved record-keeping system only provided information on when pilots completed required actions such as flight checks. Their performance on those checks, or even the number of unsuccessful checks, was not included. As a result, the Safety Board was unable to determine if the quality of the performance of the flight crew on AAL 102 was an aberration or was consistent with a performance decrement.

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"At the time of the accident, American [Airlines] employed over 9,000 pilots based at several domiciles throughout the United States. Given the extent of supervision possible by one chief pilot over several hundred pilots, the Safety Board believes that American's record-keeping systems for its pilots did not provide sufficient information to allow the airline, or the FAA, to determine if trends existed to suggest changes in flight crew performance over time, or to evaluate the effectiveness of the overall training program. Such information could be easily obtained and recorded by the airline and would enable the airline to assist a flight crew member who might be experiencing performance difficulties. Such a program would enhance safety by allowing the airline to undertake a performance enhancement before a problem developed outside of the training environment."

The NTSB recommended that the FAA "review record-keeping systems of airlines operating under FAR [Federal Aviation Regulations] Parts 121 and 135 to determine the quality of information contained therein and, if necessary, require the airlines to maintain information on the quality of pilot performance in training and checking programs."

In addition, investigators examined the condition of the landing runway used by AAL 102: "The investigation found a buildup of rubber at the approach end of [Runway] 17L that showed a coefficient of friction below the FAA minimum standard. According to airport records, for the

past three years, rubber removal was conducted at four- and eight-month intervals. There was an average of 261 landings on [Runway] 17L each day. FAA guidance suggests a rubber removal frequency of every two months for runways with a frequency of turbojet landings of more than 210 per day. The Safety Board concludes that DFW should monitor the runways more frequently, and, if necessary, remove the rubber buildup on all runways, in accordance with the referenced directive [FAA Advisory Circular AC 150/5320-12B]. However, because the accident flight landed long, the airplane did not traverse the areas where rubber buildup was found. Although this buildup needs to be corrected, it did not contribute to the loss of directional control on the runway."

The NTSB report said that the FAA should take "a more assertive role" in overseeing airport runway friction measurement programs: "Therefore, the Safety Board concludes that FAA airport safety and certification inspectors should have the responsibility for ensuring that airports certificated under 14 CFR [Code of Federal Register] Part 139 establish and maintain programs for measuring coefficient of friction levels to an acceptable standard above that of 'maintenance planning' on runways handling air carrier operations.

The NTSB also recommended that, "Specifically, the Safety Board concludes that 14 CFR Part 139 should require such friction measurement programs and correction programs. FAA airport certification and safety inspectors should be required to review airport certification manuals to ensure that friction measurement programs are established and continued. In addition, these FAA inspectors should be provided with the training and resources necessary to conduct friction measurement checks." ♦

Editorial Note: This article was adapted from *Aircraft Accident Report, Runway Departure Following Landing, American Airlines Flight 102, McDonnell Douglas DC-10-30, N139AA, Dallas/Fort Worth International Airport, Texas, April 14, 1993,* Report No. NTSB/AAR-94/01, prepared by the U.S. National Transportation Safety Board. The 167-page report includes illustrations and appendices.

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