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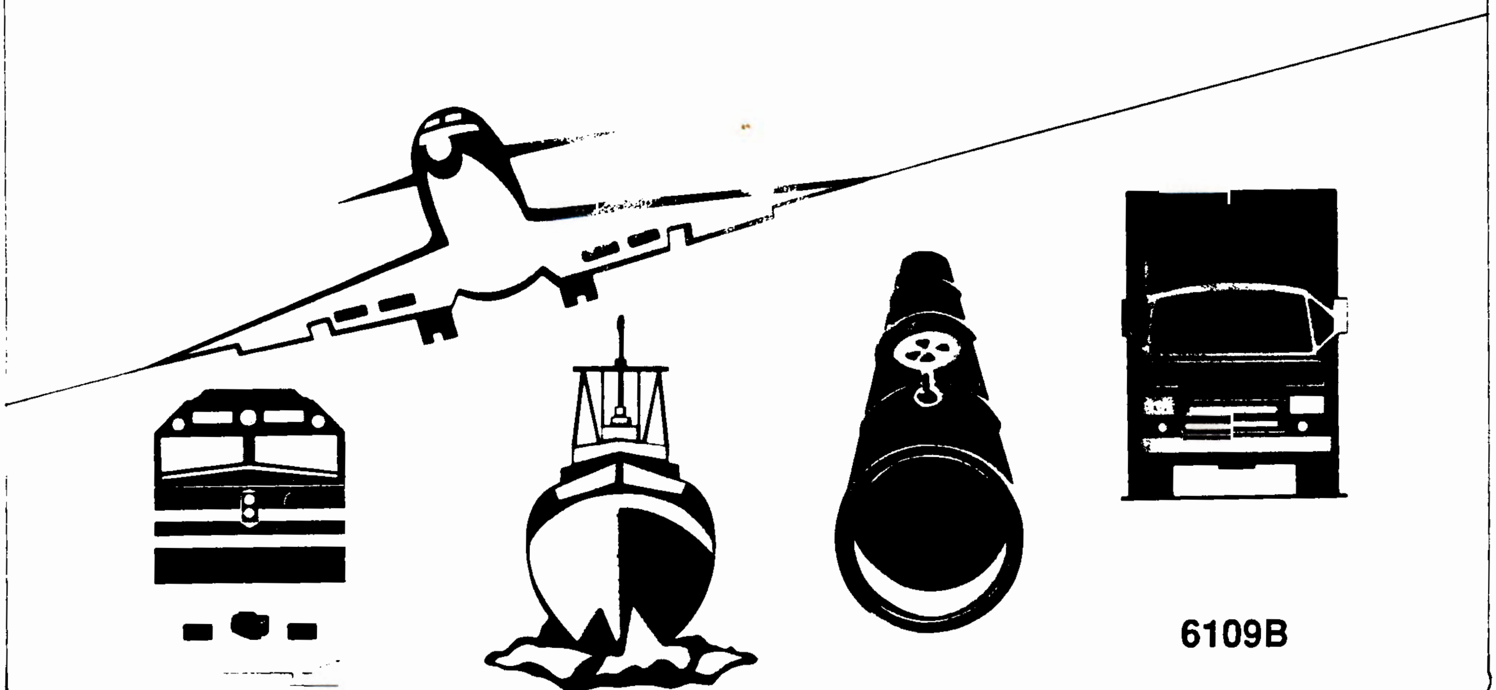
NTSB/AAR-94/01

NATIONAL TRANSPORTATION SAFETY BOARD

WASHINGTON, D.C. 20594

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



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APRIL 14, 1993

Adopted: February 14, 1994
Notation 6109B

Abstract: This report explains the runway departure of American Airlines flight 102, a DC-10-30, after landing at Dallas/Fort Worth International Airport, Texas, on April 14, 1993. The safety issues discussed in the report include weather conditions affecting the flight, flightcrew and air traffic control training and procedures, airplane emergency evacuation lighting, and runway maintenance. Recommendations concerning these issues were made to the Federal Aviation Administration, Dallas/Fort Worth International Airport, and American Airlines, Inc.

CONTENTS

EXECUTIVE SUMMARY

On April 14, 1993, about 0659:43 central daylight time, American Airlines flight 102, a McDonnell Douglas DC-10-30, departed runway 17 left, following landing at Dallas/Fort Worth International Airport, Texas, after a nonstop, overnight flight from Honolulu International Airport, Hawaii. It was raining at the time of the landing, and there were numerous thunderstorms in the area. There were 189 passengers, 3 flightcrew members and 10 cabincrew members aboard the airplane. Two passengers received serious injuries, and 35 passengers, 1 flightcrew member, and 2 cabincrew members received minor injuries during the evacuation of the airplane. The airplane sustained substantial damage.

The National Transportation Safety Board determines 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.

The safety issues in this report focused on weather conditions affecting the flight, flightcrew and air traffic control training and procedures, airplane emergency evacuation lighting, and runway maintenance.

Safety recommendations concerning these issues were addressed to the Federal Aviation Administration, Dallas/Fort Worth International Airport, and American Airlines, Inc.

NATIONAL TRANSPORTATION SAFETY BOARD
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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

1. FACTUAL INFORMATION

1.1 History of the Flight

On April 14, 1993, about 0659:43 central daylight time,[1] American Airlines flight 102 (AAL102),[2] a McDonnell Douglas DC-10-30, departed the right side of runway 17 left, following landing at Dallas/Fort Worth International Airport, Texas (DFW), after a nonstop, overnight flight from Honolulu International Airport, Hawaii (HNL). With a 1753 Hawaii-Aleutian Standard Time departure, (2353 cdt), on April 13, 1993, the flight from HNL to touchdown at DFW took about 7 hours and 7 minutes. The first officer was at the controls prior to landing, and the captain made the radio transmissions. It was raining at DFW at the time of the landing, and there were numerous thunderstorms in the area.

Of the 202 persons aboard the airplane, there were 189 passengers, 3 flightcrew members, and 10 cabincrew members. The flightcrew consisted of a captain, first officer, and flight engineer. The 10 cabincrew members were positioned throughout the first class and coach cabins, seated in jumpseats near the eight cabin emergency exits, during the approach and landing.

Prior to departure from HNL, the flightcrew received a weather briefing that indicated possible thunderstorms and turbulence at the time of arrival at DFW. During their predeparture briefing, the captain told the flight attendants that possible turbulence was expected upon arrival.

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[1]Unless otherwise indicated, all times are central daylight time (cdt).

[2]Flight 102 was operating as a scheduled passenger flight under 14 Code of Federal Regulations (CFR), Part 121.

While inbound to DFW, the flightcrew received approach and destination weather information from an American Airlines flight dispatcher, Fort Worth Center Air Route Traffic Control (ARTCC) and DFW approach control, as well as recorded Automatic Terminal Information Service (ATIS) arrival information and in-cockpit radar data. See Section 1.17.1, Flightcrew Interviews, for additional information about the flightcrew's statements about the accident circumstances.

About 30 minutes prior to the landing, at 0629:57, the captain announced on the public address system:[3]

> our flight attendants to go ahead and round everything up...and take your seats, and just as a precaution, our radar is showing numerous areas of rain showers around the Dallas/Fort Worth area...we'll be doing a little bit of deviating, radar is working very well, so we can kinda pick our path through these cells that are up ahead...shouldn't be any particular problem other than some bumpy air...nothin' dangerous...more of a nuisance than anything else.

During the final approximately 1/2 hour of flight, the flightcrew received frequent updates of destination and inbound weather information from the combination of sources, including a description of numerous thunderstorms, extending north and south of DFW. The weather reports changed while the airplane was on approach.

After the flight was cleared for the Bridgeport Boyds Two arrival, the captain asked the Fort Worth Center controller, at 0634:13, about the possibility that the flight "might be able to come in from the south and land to the north." The controller replied that he could "check with them."

The captain stated, "...let's 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 oh forty fifty miles away."

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[3] See appendix C for a complete transcript of the cockpit voice recorder (CVR). Where the identifications of words or the times of radio transmissions disagree (up to about 4 seconds) between the recordings on the accident flight CVR and by air traffic control (ATC), the CVR identification words and recorded times are used. Where words or phrases in radio transmissions are "unintelligible" in the CVR, the ATC transcribed recording is used.

From about 0636:39 to 0645:51, there were conversations between the pilots about the radar. At 0637:05, the captain indicated that they were 80 miles out, that he saw "yellow scud" on the scope, and they were "not looking at anything that even approaches red." About 0639:53, the captain and first officer agreed that they were picking up red radar returns. At 0640:18, one of the flightcrew members, who was not identified, stated that "red should be a really bad cell."

Around the Bridgeport VOR, at 0642:23, the flightcrew saw a brilliant flash of light and the cockpit area microphone picked up a rumble that sounded like thunder. This coincided with the report of a possible lightning strike observed by several passengers and flight attendants. The flight engineer found no system malfunctions and observed that the cockpit instrumentation appeared to be functioning properly. (See figure 1 photographs of lightning damage).

When the captain described the lightning to air traffic control (ATC) at 0642:54, he stated that he did not believe the lightning had come into contact with the airplane. He 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.

As communications with AAL102 were transferred from Fort Worth Center to DFW approach control, their request for a north landing was made. On initial radio contact with approach control, the captain verified the status of his request but was told that DFW's southbound departures would preclude landing to the north. In a postaccident interview, the captain stated that he accepted the landing to the south because his airborne weather radar showed that the opening in the weather to the south that he had planned to use had filled in with weather.

DFW arrival information Echo was received by the flight engineer at 0644:35, about 15 minutes before landing. It stated, in part:

> The one one three five Zulu special, measured ceiling one thousand four hundred overcast, visibility two and one half, thunderstorms, rain showers and fog. Temperature, six seven, dew point six five. Wind two two zero at six. Altimeter two niner four eight.
>
> Thunderstorms in all quadrants, moving northeast. Frequent lightning in clouds, cloud to cloud, cloud to ground. Pressure's

Figures 1a and 1b.--Lightning damage to right wing tip.

> falling rapidly. Attention all aircraft, convective SIGMET [significant meteorological information] four one central, four two central, four four central and four five central affects the DFW area. ILS [instrument landing system] runway one seven left, one eight right approaches in progress....

At 0645:31 the captain stated on the cockpit microphone, "I don't know what the [expletive] happened with this radar."

At 0645:51, the first officer asked, "...is it not working or is it working?"

At 0646:24, the flight engineer provided the captain and first officer with the information that he had received from the ATIS transmission, with the exception of "thunderstorms all quadrants" and the information after "attention all aircraft, convective SIGMET...."

At 0647:58, while descending to 3,000 feet, AAL102 received the following radio transmission from the Feeder West controller (FW):

> For everyone landing at DFW, the weather now is measured ceiling one thousand four hundred overcast, visibility two and one half, thunderstorms, rain showers, fog, wind one four zero at one one, altimeter two niner four niner, and uh, expect south landing.

At 0649:15, after being instructed by approach control to switch radio frequencies and contact another approach controller, the captain radioed, "Approach, American one oh two heavy we're uh, out of four for three." The controller stated, "American one zero two heavy, expect ILS runway one seven left, localizer frequency one uh, one zero point three."

At 0649:34, the captain stated, "One one zero three OK uh, how's it look on your scope for gettin' in there?" After the controller stated instructions to "Fly heading one three zero," the captain again asked, "OK, one three zero. How's it look coming down final on your radar?"

The controller replied that:

> Well uh, I show an area of weather at, at fifteen miles either side of DFW airport proceeding uh, straight north uh fifteen miles on uh, each side uh, for about thirty miles.

At 0650:09, the captain asked, "OK, can you uh, give us a good heading then to come in on?"

The controller replied:

> Uh, well I can give you a good heading to intercept the localizer but there's weather all down the final is what I'm saying there's I don't see any openings on the final of I see a weather area all the way down the final.

The captain then stated, at 0650:18, "OK uh, and is this stuff moving?" The controller replied, "Uh, does not appear to be moving uh, much if any American one zero two heavy if able, turn right heading one five zero and join the runway one seven left localizer."

At 0650:33, the captain radioed, "Uh, I don't think we're goin' to be able to do that that's uh, that's a pretty big red area on our scope uh, about ninety degrees and that's about what we're looking at. Uh, we're gonna have to, just go out I guess and wait around to see what's goin' on here." The controller replied, at 0650:46, "American one zero two heavy, eight miles south of you's a heavy DC-8 at three thousand joining uh, the final's uh, reporting a smooth ride at three. The captain replied, "Oh, OK, eight miles south of us?"

At 0650:59, the captain radioed, "OK uh, we'll head down that way then and uh, worse comes to worse we'll go out from there." The controller replied, "OK, one zero two heavy, turn right heading two zero zero and intercept the runway one seven left localizer."

The airplane was in approach configuration with the flaps set to 15 degrees. 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 windshear. The captain encouraged him to carry 10 to 15 knots of extra airspeed, and the first officer assured him that he would do so.[4] When asked to describe their flight conditions by approach control at 0653:20, the captain stated that they were in the clouds with "just ah 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 their ride was reported as "light and occasionally moderate chop," approach control transferred AAL102 to DFW tower control.

On initial contact with DFW tower, at 0656:39, AAL102 was cleared to land. The flightcrew completed the landing checklist and activated the windshield wipers at 0657:54.

The flightcrew later stated that the airplane was in a crab due to a crosswind from the right on final approach. Flight data recorder (FDR) data after the accident verified that the airplane was in about a 10-degree right crab on short final approach. The flightcrew later stated that they could see the runway during final approach and that they could see down the runway during the approach and after touchdown.

On short final, at 0659:17, less than 1 second after the automated voice called out "fifty" [feet], the first officer stated, "I'm gonna go around." The captain stated, "No, no, no, I got it." The first officer responded, "You got the airplane." As the first officer said the word "airplane," the automated voice said "thirty." The captain took control and landed the airplane.

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[4] V ref was 146 knots indicated airspeed (KIAS). V bug was 160 KIAS.

A sound of a thump, similar to aircraft touchdown was recorded at 0659:29 on the CVR. The sound of a second thump was recorded about 2 seconds later. At 0659:36, the first officer said, "OK, hundred and twenty knots." At 0659:38, the captain said, "Oh [expletive]." At 0659:41, the first officer said, "hundred knots," then, "OK, we're off the grass," and, at 0659:45, "eighty knots." One of the flightcrew members then said, "Gosh darn," and a sound similar to a horn sounded in the cockpit. At 0659:53, the captain stated, "Emergency evacuation."

When he was interviewed, the flight engineer stated that as the airplane proceeded down the runway, he believed that the spoiler handle "was not coming back fast enough." He reached over the pedestal to manually move the handle to help deploy the spoilers.[5]

At 0700:15, one of the flightcrew members made an announcement on the public address system to evacuate the airplane. 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 CVR recording ended about the time of estimated generator power shutdown, following the captain's statement, at 0700:34, "spoiler handle won't stay closed."

A special weather report, at 0701, about 1 minute after the accident, described the weather at DFW as:

> Ceiling measured 900 feet overcast; visibility 1 1/2 miles, thunderstorm, heavy rain shower, fog; surface wind 300 degrees at 22 knots gusting to 33 knots; altimeter setting 29.51 inches of mercury (Hg); Remarks--Wind shift 0700, thunderstorms all quadrants moving northeast, occasional lightning in cloud, cloud to ground, pressure rising rapidly.

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[5]The postaccident systems examination found that the spoiler handle was driven by an actuator, which, once activated, resulted in handle movement of one speed during deployment. Therefore, once the spoiler system was activated, the handle movement would be constant.

Witnesses at the fire station and elsewhere stated that it had been raining during and following the landing of the airplane. The rain appeared to become heavier following the accident, and one witness later described it as "coming down in sheets."

The captain of a Simmons SA-340, flying the ILS to 17L behind AAL102, later stated that on the approach he encountered light to occasional, moderate turbulence. He needed a 20-degree heading correction to hold the localizer course inbound, but the correction became less severe as his airplane approached the airport. He also reported that he used a +20-knot speed correction. He was in instrument meteorological conditions (IMC) throughout the approach, but he saw the ground after descending below about 700 feet above ground level (agl). After the crash of AAL102, which was ahead of him, when his airplane was about 600 feet agl, he was advised by air traffic control to go around. The captain stated that he overflew DFW on the missed approach, on the way to an approach and landing at Love Field in Dallas. He did not observe any indication of windshear in the vicinity of DFW during the overflight.

The flightcrew of a Delta Air Lines B-737 was awaiting departure from 17L, with the airplane positioned on the perpendicular taxiway at the north end of the runway. After AAL102 touched down, the B-737 was taxied into position for takeoff. About that time, the B-737's captain noticed the windsock, which was about 200 feet southwest of the approach end of 17R, indicating the wind out of the west at 10 to 12 knots. He saw a glow emanating from the crashed airplane off the runway and observed the fire and rescue response. About 15 to 20 minutes later, he noticed that the windsock was indicating a wind out of the north. He described the rain as intermittent but not heavy.

An American Airlines MD-80 captain was waiting for takeoff in the ramp area next to 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 as the Delta Air Lines B-737 took position and held on 17-R for departure.

Two Delta Air Lines mechanics were outside their maintenance hangar when AAL102 touched down. The hangar was east of the accident runway, and the mechanics were standing on the ramp on the north side of the hangar. They reported that they remained dry, sheltered by the hangar, as the wind was blowing the rain away from them. They observed the fire where the airplane came to rest, and they watched the fire and rescue response.

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 fire was extinguished soon after emergency vehicles arrived at the crash site (they began to arrive about one minute after the airplane came to rest). But the fire affected the urgency of passenger egress because it could be seen glowing through the left windows of a darkened aft cabin (see Survival Aspects section 1.15).

Investigators examined the landing runway after the accident and found three long sets of lightly shaded tire traces that paralleled the centerline but then angled to the right and departed the runway. The tracks from the right main landing gear continued as furrows in the soil.

Then the airplane traveled across high speed taxiway 3S before returning to the soft soil. The airplane came to rest, upright, about 2,607 feet from the departure end of 17L and about 250 feet from the right edge of the runway, with the nose on perpendicular taxiway 31. (See figures 2, 3 and 4).

The first tire marks found on the runway were traced to the left and right main landing gear, and started at 4,303 feet from the beginning of the runway. The tracks approximately paralleled the runway centerline for about 1,700 feet, then turned gradually to the right until they departed the runway.

The accident occurred in darkness (0700 was official sunrise) just after the airplane landed on runway 17L at DFW about 0659:43 cdt, during a thunderstorm, at 32 degrees 53.18 minutes north latitude and 97 degrees 01.62 minutes west longitude.

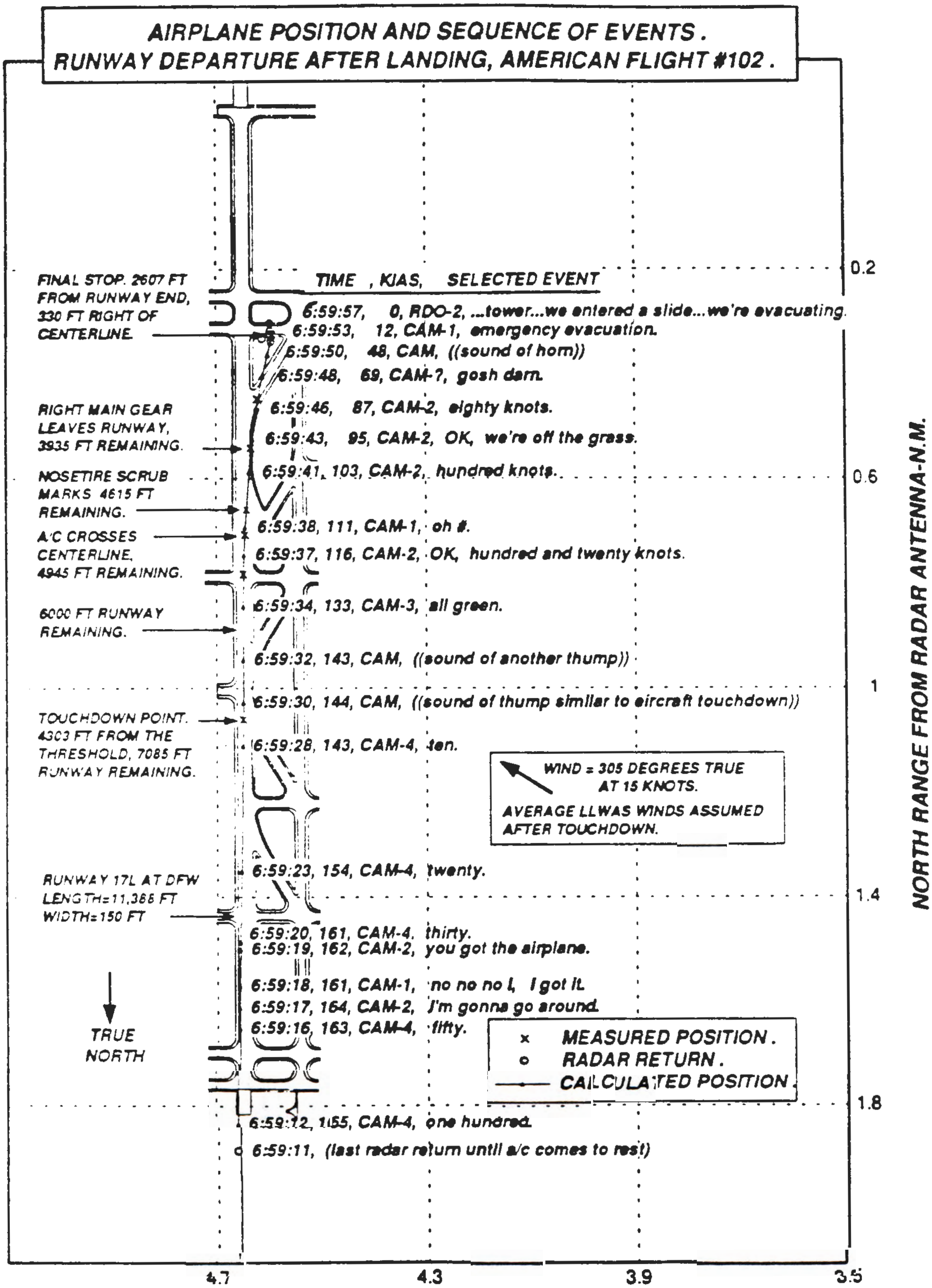

Figure 2.--Approach and landing.
History of airplane motion and events.

Figure 3a.--Tire marks on landing runway 17L (looking north).

Figure 3b.--Tire marks on high speed taxiway 3S, and trenches in the soil leading to the final resting position of the airplane.

Figures 4a and 4b.--Airplane resting attitude and location.

1.2 Injuries to Persons

Injuries	Flightcrew	Cabincrew	Passengers	Other	Total
Fatal	0	0	0	0	0
Serious	0	0	2	0	2
Minor	1	2	35	0	38
None	2	8	152	--	162
Total	3	10	189	0	202

1.3 Damage to Aircraft

The airplane sustained substantial damage, estimated at $35 million. Based on the damage and repair costs, the hull was written off as destroyed.

1.4 Other Damage

Damage to the airport facility consisted of trenches in the soil, dug by the airplane and landing gear, a damaged culvert, broken taxiway sign, and four fractured taxiway lights.

1.5 Personnel Information

1.5.1 Flightcrew General Background

The captain, first officer, and flight engineer comprised a three-person flightcrew on the accident airplane. The captain, age 59, had a total of 12,562 flight hours, 555 of which were in the DC-10. He was employed by American Airlines on August 1, 1966, and was designated a captain in the DC-10 in November 1991. He held an Airline Transport Pilot Certificate and was type rated in the DC-10, B-727, and DC-9, with a commercial type rating in the B-377.

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

The flight engineer, age 60, held a current Flight Engineer certificate. He was employed by American Airlines in October 1955. He had 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.[6]

1.5.2 Flightcrew Activities Prior to the Accident Flight

The flightcrew had been in an off-duty status for a minimum of 6 days prior to beginning the 3-day accident trip. The crew reported for duty at DFW about 0900 on April 12, 1993, and completed the flight from DFW to HNL, arriving around 1900 Dallas time. Each crewmember slept for varying periods that night between 2200 and 0700 Dallas time, and napped for varying periods between 1700 and 2100 Dallas time the next evening prior to reporting for duty on the accident flight.

The captain and flight engineer reported that they did not feel tired during the overnight flight from HNL to DFW. The first officer reported that he felt tired on two occasions during the flight and said that at those times he briefly used oxygen to "perk-up."

The captain stated that he had not previously been paired on a flight with the first officer, but that some years earlier he had been paired with the flight engineer on a B-727 flight.

1.6 Aircraft Information

The airplane, registration N139AA, Serial No. 46711, was owned and operated by American Airlines. The airplane was built by the Douglas Aircraft Company and was sold new to National Airlines on June 11, 1973. It was operated by National Airlines as registration N80NA, and, following the transfer of National Airlines to Pan American World Airways, it was operated by Pan American with the same registration. The airplane was sold by Pan American to American Airlines on November 4, 1983. American Airlines sold the airplane to First Security Bank of Utah on December 31, 1984, and then leased the airplane back. The airplane accumulated 35,348 airframe flight hours and 9,163 cycles when operated by National and Pan American, and 39,483 flight hours and 8,757 cycles when operated by American Airlines, resulting in a total, at the time of the accident, of 74,831 hours and 17,920 cycles.

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[6] A more detailed summary of the flightcrew's background is contained in appendix B.

The weight and balance information was prepared by American Airlines Dispatch at HNL. It was presented for use by the flightcrew on a computer printout containing "Airport Analysis Data." The calculated weight and balance for the accident flight were within limits for takeoff from HNL, the en route flight, and the landing at DFW. Upon landing, about 3 flying hours of fuel remained in the airplane's fuel tanks.

With 173,000 pounds of fuel for takeoff, the calculated gross weight for the accident flight, departing HNL on April 13, 1993, was 503,000 pounds. Considering forecast winds and the route of flight, dispatch estimated that 133,000 pounds of fuel would be consumed en route, and that the landing weight at DFW would be 370,338 pounds.

The airframe was last inspected as follows:

Inspection	Date	Hours	Cycles
Periodic Service	4/13/93	74,824	17,919
A Check	4/08/93	74,753	17,910
B Check	3/20/93	74,546	17,870
Phase Check	3/14/92	70,224	16,947

The engines were last inspected as follows:

	Serial No.	Total Time (Hours)	Total Cycles	Time Since EHM (Hours)	Cycles Since EHM
Engine No. 1	455414	60,602	12,916	12,228	1,661
Engine No. 2	455292	46,838	9,873	285	50
Engine No. 3	455302	50,530	10,767	2,480	536

The maintenance logbooks for the 4 months prior to the April 14, 1993, accident revealed no outstanding discrepancies. There were five writeups that had been deferred, as follows:

Date Entered	Discrepancy
4/01/93	RH logo light inop

4/09/93	Lwr "B" yaw channel inop
4/09/93	Downgrade LMP to #2 single land
4/10/93	Zone B "Lav Occupied" signs burned out
4/11/93	#2 engine B ignition inop

The discrepancy recorded on April 1, 1993, was classified as a "Technical Control Item," which permitted the airline to track the item and schedule its repair within an appropriate time period. Each of the other discrepancies was classified as a Category C Minimum Equipment List (MEL) item, which allowed 10 days for resolution. All five logbook discrepancies were deferred in accordance with the provisions of the MEL.

A logbook entry on April 4, 1993, mentioned to "check hyd. leak in left main gear wheel well." Maintenance action taken after arrival was a field repair of the left main gear antiskid line with a flex line; the leak check was good. An entry on March 31, 1993, noted that the left and right outboard antiskid did not test when the gear was extended, and would not test at the gate. American Airlines maintenance removed and replaced the antiskid control box, and the system checked okay.

The Safety Board investigator's review of the accident airplane logbooks revealed several writeups regarding the engine thrust reversers. A writeup on March 27, 1993, noted that none of the engines could obtain more than 86 percent N1, during reverse operation during the landing that day. An entry on February 18, 1993, stated that the No. 3 engine thrust reverser unlocked, but it was difficult getting a green light. An entry on February 17, 1993, noted that the No. 3 engine thrust reverser lever was stiff on landing ground roll.

All of the above engine thrust reverser discrepancies were recorded as corrected, and there were no pilot reports regarding the engine thrust reversers following the March 27, 1993, writeup.

Because of the finding during the investigation of an improper thrust reverser cascade configuration on the No. 2 engine of the accident airplane, (see section 1.12) the records were examined for this system. American Airlines' records indicated that the fan reverser for the No. 2 engine was installed in May 1991. The procedures required a visual verification for the proper cascade configuration after installation of the fan reverser. There was no criterion for a subsequent periodic inspection of the reverser cascades, and the time of misrigging of No. 2 engine reverser cascades, evidenced by lack of subsequent maintenance on this area, was determined to have occurred at the time of the May 1991 installation.

No discrepancies regarding the emergency lighting system of N139AA were found during the records review, although there were statements that the cabin was only partially lighted during the egress period (see section 1.15). The last operational check of the system, which was called for on the Special Items maintenance card, PS/0912, occurred on April 8, 1993, and the last check of the emergency lighting batteries, which was required on every B Check, occurred on March 20, 1993.

A lightning strike was reported to maintenance personnel by the crew of American Airlines Flight 73, on April 11, 1993. An inspection of the airplane, in accordance with maintenance manual procedures, found no damage from the lightning strike. There was, however, a lightning strike noted by the flightcrew, cabincrew, and passengers, occurring as the accident flight was inbound to DFW, about 17 minutes prior to landing. Examination, as part of the Safety Board's investigation following the accident, found evidence of a lightning strike at the top of the right wing tip.

1.7 Meteorological Information

1.7.1 General Weather Conditions

According to the National Weather Service (NWS), the 0700 surface weather analysis, for April 14, 1993, showed a low pressure center over northeastern Missouri. A moderate cold front trailed southwestward across northwestern Arkansas and southern Oklahoma, through a low pressure center over west-central Texas. A second area of low pressure was centered near Junction, Texas, with a weak cold front extending southeast of Del Rio, Texas. A third low pressure center was located west of College Station, Texas, with a trough of low pressure extending to the south.

At 0101, the National Severe Storms Forecast Center (NSSFC), in Kansas City, Missouri, issued Tornado Watch No. 115. The watch area included parts of western and central Texas and was valid until 0700. The NSSFC issued Tornado Watch No. 116, at 0347, for a large part of central Texas. It included the DFW metroplex area. Tornado Watch No. 116 was valid until 1100, April 14, 1993.

1.7.2 Surface Weather

The weather observations at DFW were taken by Weather Experts, Inc., a private company under contract to the NWS. The company's only role at DFW is to take and disseminate weather observations. This information is used by FAA air traffic controllers, NWS, and other appropriate agencies. The observation facility is on the second floor of the Delta Air Lines maintenance hangar, on the east side of the airport complex.

The following surface weather observations were made for DFW:

Time--0639; Type--Special; 1,500 feet scattered, estimated ceiling 3,500 feet broken, 5,000 feet overcast; visibility 5 miles, thunderstorm, moderate rain shower; surface wind 220 degrees at 3 knots; altimeter setting 29.47 inches of Hg; Remarks--thunder all quadrants moving northeast, frequent lightning in cloud, cloud to cloud, cloud to ground, pressure falling rapidly, wind shifted gradually.[7]

Time--0650; Type--Record; 1,500 feet scattered, measured ceiling 4,000 feet broken, 7,500 feet overcast; visibility 6 miles, thunderstorm, light rain shower; temperature 67 degrees F.; dew point 65 degrees F.; surface wind 220 degrees at 4 knots; altimeter setting 29.49 inches of Hg; Remarks--thunder northeast- southeast moving northeast, frequent lightning in cloud, cloud to ground.

Time--0701; Type--Special [Special weather observation, completed about one minute after the accident]; measured ceiling 900 feet overcast; visibility 1 1/2 miles, thunderstorm, heavy rain shower, fog; surface wind 300 degrees at 22 knots gusting to 33 knots; altimeter setting 29.51 inches of Hg; Remarks--wind shift 0700, thunder all quadrants moving northeast, occasional lightning in cloud, and cloud to ground, pressure rising rapidly.

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[7]The NWS reports the wind direction with reference to true north. The wind direction and speed are a 1-minute average. For air traffic control purposes, the FAA reports wind direction with reference to magnetic north. In accordance with International Civil Aviation Organization (ICAO) rules, the FAA provides wind direction and speed information as a 2-minute average.

Part B of the DFW Surface Weather Observations forms for April 14, 1993, indicated moderate rain showers from 0627 to 0645, light rain showers from 0645 to 0700, and heavy rain showers from 0700 to 0710. Fog was reported from 0633 to 0638 and from 0700 to 0845. Sunrise was at 0700.

In a written statement to Safety Board investigators, the contract weather observer, who was on duty at the time of the accident, stated that at 0659 he was in the process of taking a special observation because of diminished visibility. He then observed the airplane coming to a halt, and he noted that the intensity of the rain shower had increased. He completed the special observation [Type--Special, at 0701, above] and then called the tower with the report. He and the incoming contract weather observer then time checked and annotated all of the recording charts.

1.7.3 Recorded Weather-Measuring Equipment at DFW

Wind Gust Recorder.--The NWS anemometer was about 50 feet south and 10 feet east of the FAA center field anemometer, and approximately 5,000 feet north-northeast of the point where the airplane came to rest. The height of the anemometer was 22 feet agl. Subsequent to the accident, the NWS anemometer was checked, calibrated, and found to be within tolerance.

The gust recorder did not record wind directions, but it did record speeds. According to the gust recorder trace, the wind speed at 0655 for DFW was about 3 knots. Approximately 1 knot was indicated on the chart at 0656. The wind speed was estimated at 4 knots at 0657. The wind speed at 0658 was estimated from the trace at 14 knots. By 0659, the chart showed the wind speed at around 20 knots. At 0700, the wind speed was indicated at around 33 knots (it was later determined to be the peak wind recorded during that period in the vicinity of DFW).

Record of Precipitation.--The rain gauge was approximately 150 feet southwest of the Delta Air Lines maintenance hangar, or about 1/4 mile east from the point where the airplane came to rest. The recorder chart showed that about 0.32 inch of rain fell between 0615 and 0700. The chart also indicated that approximately 0.23 inch of rain fell between 0700 and 0707.

Runway Visual Range (RVR).--The RVR transmittance readings for runway 17L were recorded from a position approximately 1,000 feet south of a point between the thresholds of 17L and 17R. The minimum transmittance value of

0.66 was recorded between 0700 and 0701. The light setting at the time of the accident is unknown. However, according to the Federal Meteorological Handbook Number 1, Surface Observations, Table A3-6C, the transmittance value of 0.66, at light setting 3, corresponded to an RVR of 3,500 feet; at light setting 4, the corresponding RVR was 4,500 feet; and at light setting 5, the corresponding RVR was 5,000 feet.

1.7.4 Radar Mosaics

Radar mosaics for 0650 and 0700, April 14, 1993, were obtained from the Fort Worth Center Weather Service Unit (CWSU). The radar information was accessed directly from the Stephenville radar and processed at the CWSU. The mosaics displayed radar returns in standard VIP format. In addition, the DFW VOR [very high frequency omnidirectional radio range] and DFW corner posts and airways were plotted on the mosaics.

The mosaic for 0650 showed light green (VIP level 1) and dark green (VIP level 2) colors in the vicinity of the DFW VOR. At 0700, the mosaic indicated the colors light green, dark green, yellow (VIP level 3), and brown (VIP level 4) within the same general area.

Radar mosaics for the DFW area at 0630, 0645, 0700, and 0715 were also obtained from the American Airlines Weather Services section. The mosaics were generated by a private meteorological company that used radar data from NWS radar facilities and disseminated the information to the airline within 10 to 15 minutes of the generation time. Radar returns were processed into 16 levels. Shades of green were equivalent to VIP levels 1 and 2, shades of yellow equated to VIP levels 3 and 4, and shades of red corresponded to VIP levels 5 and 6. The mosaics showed shades of green and yellow in the area surrounding DFW during these times. (See appendix F, Selected Weather Radar Data).

1.7.5 Additional Weather Radar Information

In conjunction with the FAA, the Massachusetts Institute of Technology's Lincoln Laboratory was preparing to conduct a test of the Integrated Terminal Weather System (ITWS) at DFW. As part of the test, the University of North Dakota (UND) installed a C-band Doppler radar at Lewisville, Texas, approximately 12 1/2 miles (20 km) north northeast of the approach end of runway 17L. The radar installation was completed on April 13, 1993, and the radar was operable at the time of the accident. Air traffic controllers were using the ASR-7 and ASR-8 for daily operations at DFW.

In addition, there was an FAA airport surveillance radar (ASR-9) at Azle, Texas. The ASR-9, located approximately 33 1/2 miles (54 km) west of DFW runway 17L-35R, depicted weather echoes in the standard six NWS VIP intensity levels. The FAA was not using the ASR-9 operationally.

The Lincoln Laboratory provided reflectivity plots from the UND Doppler radar and the ASR-9 for the time around the accident. In addition, the laboratory provided Doppler radial velocity plots and prepared 3-dimensional weather radar plots of the DFW area for 0656 to 0702.

Examination of the reflectivity plots indicated widespread radar echoes throughout the DFW area. Plots from 0650 to 0702 showed a north-northwest, south-southeast line of equivalent VIP levels 2 to 4 echoes progressing toward the east across the airport. Using ASR-9 data, the laboratory calculated individual storm cell movement to be toward the northeast at around 43 miles per hour.

Lincoln Laboratory constructed minute-by-minute, 3-dimensional radar plots using data from 0.5, 3.4, 6.3, 10.0, 16.7, and 27.5 degree antenna tilts. The plots depict the 39 dBZ isosurfaces (VIP level 2 incorporates 30-40 dBZ) along with runway 17R and 17L and the aircraft track. Plots for 0657, 0658, 0659, 0700, and 0701 are advected echo depictions using calculated storm cell motion. The advected plots potentially become less reliable during the later minutes.

The 3-dimensional plot for 0656 shows 39 dBZ isosurface north and west of DFW runway 17L. The advected plots for 0659 and 0700 depict the isosurface traversing runway 17L.

1.7.6 National Weather Service Forecasts

1.7.6.1 Fort Worth Forecast Office

Terminal Forecast (FT) - The DFW FT in effect at the time of the accident was prepared by the Fort Worth Forecast Office and was valid beginning at 0300 cdt. It called for the following:

> Ceiling 2,500 feet broken, wind 150 degrees at 14 knots; occasional ceiling 1,200 feet overcast, visibility 3 miles with thunderstorm and moderate rain shower; chance ceiling 800 feet obscured, visibility 1 mile with severe thunderstorms, heavy rain showers, hail and wind gusts to 50 knots.

Public Weather Warning - No Tornado or Severe Thunderstorm Warnings were issued by the Fort Worth Forecast Office around the time of the accident.

Local Airport Weather Advisory - No weather advisories for DFW were issued by the Fort Worth Forecast Office on April 14, 1993.

1.7.6.2 Fort Worth Center Weather Service Unit (CWSU)

TRACON [terminal radar approach control] weather briefing prepared by the CWSU at 0635--DFW Terminal Area Forecast valid until 1600:

> Ceiling 2,500 broken, wind 180 degrees at 15 knots; chance ceiling 800 obscured, visibility 1 mile, severe thunderstorm, heavy rain shower, hail, wind gust 50 knots.
>
> 0900: Cold front passage, wind 030 degrees at 10 knots, chance visibility 1 mile, chance thunderstorm, heavy rain shower, hail, wind gust 50 knots.

No Center Weather Advisories were valid for the DFW area for around 0700.

1.7.6.3 National Severe Storms Forecast Center, Kansas City, Missouri

> Weather Watch Number 116 - Tornado. Valid 0415-1100. Axis 55 nautical miles east and west of line 28 nautical miles south-southeast San Antonio to 28 nautical miles south-southwest of Ardmore.
>
> Hail surface and aloft 2 1/2 inches. Wind gusts 70 knots. Max tops to 53,000 feet. Mean wind vector 230 degrees at 40 knots.

Convective Significant Meteorological Information (SIGMET)
MKCC WST 0555
Convective SIGMET 44C
Valid until 0755
Texas
From 20 nautical miles west-southwest of DFW to 30 nautical miles northwest of Austin to 50 nautical miles east-southeast of Del Rio. Line severe thunderstorms 20 nautical miles wide moving from 270 degrees at 30 knots. Tops above 45,000. Tornadoes...hail to 3 inches...wind gusts to 70 knots possible.

Convective SIGMET 45C
Valid until 0755
Oklahoma/Texas
From Fort Smith to 30 nautical miles north-northeast of DFW to 50 nautical miles west-southwest of Wichita Falls to 40 nautical miles northwest Ardmore to Fort Smith. Area thunderstorms moving from 250 degrees at 15 knots. Tops to 40,000 feet.

MKCC WST 0655
Convective SIGMET 48C
Valid until 0855
Texas
From 40 nautical miles east of McAlester to 40 nautical miles south-southwest of McAlester to 20 nautical miles south of Waco to 30 nautical miles west-northwest of San Antonio. Line severe thunderstorms 20 nautical miles wide moving from 270 degrees at 25 knots. Tops above 45,000 feet. Tornadoes...hail to 3 inches...wind gusts to 70 knots possible Texas portion.

1.7.7 American Airlines Weather Forecasts

American Airlines produced several aviation forecasts and advisories under the FAA's Enhanced Weather Information System (EWINS) program. The weather services section, staffed by professional meteorologists, was in the Systems Operations Control Center. Among the products generated by the weather staff were terminal forecasts for specific airports, map features that were entered into computer flight plans, Terminal Significant Meteorological Conditions (SIGMECs), and Thunderstorm SIGMECs.

The weather services section also prepared oral weather briefings for incoming shifts of flight dispatchers. The morning weather briefing on April 14, 1993, was broadcast to dispatchers about 0615, and it lasted approximately 15 minutes. Normally, weather briefings were taped so that dispatchers could review them later in their shifts. The tapes were reusable, and any written notes, prepared to aid in the weather briefings, were not saved. The taped weather briefing for 0615 cdt, April 14, 1993, was not available for evaluation after the accident.

Forecasts valid for the time of the accident, issued by American Airlines' weather services section and passed to the flightcrew of AAL102, are as follows:

The amended terminal forecast for DFW issued at 0600, stated, in part:

DFW April 14, 0610
0600/1,500 feet broken occasional 600 feet overcast visibility 1 mile thunderstorm moderate rain shower. 0800/ 800 overcast 3 miles light rain showers briefly thunderstorm with light rain shower. Wind 0600/ variable 15 knots gusting 20 knots. 0900/south 10-15 knots gusting 25 knots.

The Thunderstorm SIGMEC, valid April 14, 1993, from 0400 to 1100, is as follows:

At 0500, broken area thunderstorms extended from 100 miles south of San Angelo to 20 miles east of Abilene to 60 miles north-northwest of Abilene to 60 miles east to 100 miles south of San Angelo. Line was moving to the northeast at 35 knots. Maximum tops over flight level 50,000 feet. At 0500, a scattered to broken area of thunderstorms extended from Wichita Falls to 60 miles north of Oklahoma City to 40 miles north of Shreveport to Wichita Falls. Movement to the northeast at 20 knots in the north and to the northeast at 40 knots in the south and east. Tops to flight level 40,000 feet. Little change expected in north and slow decrease expected in north. DP/FTW

Weather Watch 115 valid until 0700...Severe thunderstorms/tornadoes possible central/southwest Texas along and 60 miles east and west of a line from 21 miles east-southeast of Del Rio to 32 miles north-northeast of Abilene.

Weather Watch 116 valid until 1100...Severe thunderstorms/tornadoes possible central/north central Texas along and 55 miles east and west of a line from 28 miles south-southeast of San Antonio to 28 miles south-southwest of Ardmore.

The Terminal SIGMEC for DFW/Dallas/Austin/San Antonio follows:

Valid April 14, 0358 to 1000
Line thunderstorms approaching north central Texas along centerline 30 miles southwest Wichita Falls to 60 miles southwest DFW to 80 miles west San Antonio is moving northeast at 30 knots/ Expect occasional thunderstorms with heavy rain/ low level windshear/ surface wind gusts to 40 knots/ frequent lightning possible in vicinity of DFW/Dallas/Austin by 0700 and San Antonio by 0800. Expect occasional thunderstorms throughout the remainder of the period. SR/FTW

1.7.8 Airline-Provided Weather Information

The accident airplane's flight log indicated that the following information was provided to the airplane via Aeronautical Radio Inc. (ARINC) between 0400 and 0700, April 14, 1993:

Time	Product
0418	DFW observation, American FT, NWS FT
0423	Terminal SIGMEC
0428	Thunderstorm SIGMEC, Tornado Watches 115 and 116
0437	Route weather update
0505	DFW observation, American FT, NWS FT

0532	Pilot Report
0619	DFW observation, American FT, NWS FT
0624	Changeover information
0646	Changeover information

1.7.9 Changeover Information

Changeover information disseminated to American Airlines flightcrews include meteorological landing data, arrival gate information, and other pertinent remarks. The information had been transmitted automatically via ARINC to airplanes a few minutes prior to the landing of AAL102. According to American Airlines, Terminal SIGMECs issued within 1 hour of arrival time were normally appended to the changeover information message. The Terminal SIGMEC for DFW issued at 0358, April 14, 1993, and valid until 1000, was not attached to changeover information messages sent to the accident flightcrew at 0624 and 0646.

1.7.10 Low Level Windshear Alert System (LLWAS)

A windshear alert was transmitted by the westfield LLWAS anemometer from 0653:25 to 0655:35. The Local West controller (LCW) issued a windshear alert at 0653:30, 0653:50, and 0654:29 to the flightcrew of a heavy DC-8 which landed about 0655:25 on 18R. The windshear alert was not passed to the accident flight because the alert had terminated before the flightcrew of AAL102 made initial radio contact with the local controller. The ATIS, which advised that windshear advisories were in effect, was initially broadcast at 0704:07, after the accident.

Ten-second and two-minute DFW centerfield LLWAS winds are plotted on the graph from 0656:05 to 0703:05, April 14, 1993 (see figure 5). In addition, calculated cross track winds based on the 10-second data and estimated NWS wind gusts are shown on the graph.

The LLWAS at DFW at the time of the April 14, 1993, accident used five anemometers, located around the periphery of the airport complex, plus a center field anemometer. Subsequent to the accident, FAA maintenance personnel tested

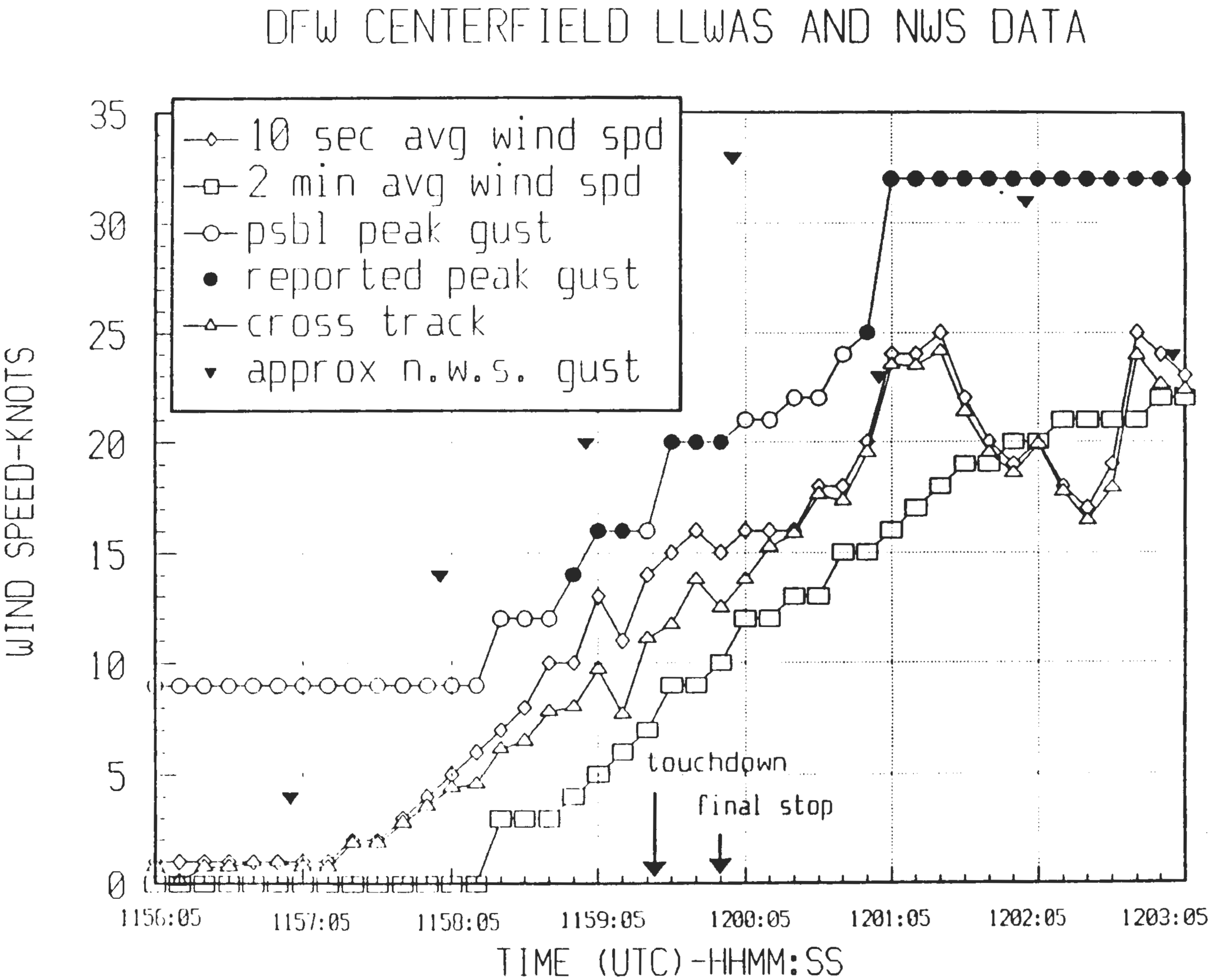

Figure 5.--LLWAS data.

all six sensors. The northwest, west, and center field sensors were found to be out of tolerance. The three anemometers were shipped to the manufacturer and under direction of the Safety Board's Investigation Weather Group Chairman, the "out of tolerance" anemometers were further evaluated. The sensor from the center field was found to be within manufacturer's tolerances. The generator output from the sensor from the northwest DFW field position was found stable, and tested root mean square errors were found only slightly out of tolerance. The sensor from the west field station at DFW failed potentiometer tests in nearly every direction, with high root mean square errors.

Following the April 14, 1993, accident the FAA, the manufacturer of the system, and Massachusetts Institute of Technology's (MIT) Lincoln Laboratory examined the raw LLWAS data and calibrations to gain additional information regarding the performance of the sensors on the day of the accident.

The FAA representative specialists compared wind directions and speeds from the individual anemometers with center field reading during the period from 0000 utc, March 20 to 2359 utc, April 18, 1993. Regarding the west sensor, the FAA concluded that wind speeds varied from minus 2 knots to minus 7.5 knots, from 260 to 350 degrees, when compared to the center field sensor.

Belfort Instrument, the manufacturer of the sensors, concluded that the northwest and center field sensors were unlikely to have contributed to significant LLWAS errors. Considering the large magnitude of error in the west sensor's potentiometer, the manufacturer surmised that the potentiometer may have been damaged by an electrical transient.

MIT/Lincoln Laboratory compared wind speeds from each anemometer with the network mean wind speed for a period of eight days, around the time of the accident. According to laboratory personnel, speed variations within 20 percent of the mean are considered acceptable. The appraisal revealed that the southwest sensor's wind speeds were marginally low when compared to the network mean. Speed values from the other anemometers were within the acceptable standard.

1.7.11 Predeparture Weather Briefing

The following are selected portions of the weather briefing, issued by the American Airlines weather services section to the crew of AAL102, at 0302 utc, April 14, 1993, (2202 cdt, April 13, 1993):[8]

Forecast weather at DFW for 1100 Zulu (1100 utc), about 1 hour before AAL102's landing at DFW:

> 700 foot broken, 1,500 foot overcast, visibility 3 miles, light rain and fog, occasionally 600 foot overcast, 1 1/2 miles thundershowers or rain showers and fog.

In addition, the following weather advisory was issued by the AAL weather services section at 0302 utc on April 14, 1993, in abbreviated format:

> TSTM SIGMEC
> Valid 14 [April] 0215 Zulu to 14 [April] 0800 Zulu, 1993,
> At 0200 Zulu, a scattered to broken line of moderate to heavy thunderstorms, approximately 15 miles wide, was located over Oklahoma along a centerline 20 miles south of Tulsa, to 30 miles west of McAlester, to 30 miles west of Ardmore, moving east-northeast at 15 to 20 knots, with maximum tops at or above 45,000 feet. A scattered area of heavy thunderstorms was located over northeastern Texas, 70 miles south of McAlester, to 40 miles southwest of Texarkana, to 120 miles west of Shreveport to 40 miles east-northeast of DFW, to 70 miles south of McAlester, moving east-northeast at 35 knots, with maximum tops at or above 45,000 feet. A scattered line of heavy thunderstorms was located over west-central Texas, from 50 miles northwest of Abilene to 30 miles east-northeast of Abilene, moving northeast at 15 knots, with tops above 45,000 feet. Some increase in activity over north-central Texas and eastern Oklahoma is expected during the period.

> Also,

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[8] Utc is universal coordinated time, also referred to as "Zulu" time. DFW local time was utc (Zulu) minus 5 hours.

Weather Watch 114. Valid until 0800 Zulu [about 4 hours before AAL102 was to land at DFW] Tornado and severe thunderstorms possible over Texas and Oklahoma, along and 55 miles north and south of a line 41 miles west-northwest of Abilene to 25 miles southwest of Fayetteville, Arkansas.

1.8 Aids to Navigation

The ILS approach to runway 17L transmits on 110.3 megahertz (MHz). The localizer course is 173-degrees magnetic. The touchdown zone (TDZ) elevation is 562 feet msl, and the approach minimums are 200 feet agl and 1/2 mile visibility. The final approach fix (FAF), "Jiffy," has a low-frequency radio compass locator (LOM) and an outer marker radio transmitter and is 4.6 nautical miles from the runway threshold. The minimum altitude at Jiffy and the decision height (DH) for the approach are 2,300 feet and 200 feet (762 feet msl), respectively.

On April 13, 1993, there was construction activity at the approach end of runway 17L. At 1310 cdt, the glideslope portion of the ILS was taken out of service. It was returned to service at 1450 cdt. Around 1600 cdt, the captain of an American Airlines flight stated that there was a glidepath anomaly on the ILS to 17L, and he also noted that there were vehicles in the ILS "critical area." The glideslope was taken out of service at 1410 and returned to service at 1550.

The accident flightcrew reported no difficulties with the ILS glidepath on April 14, 1993. On April 19, 1993, the ILS for 17L was checked by an FAA flight inspection flight. The approach and, specifically, the localizer and glidepath were found to be satisfactory, but the 75 MHz marker beacon was out of tolerance.

1.9 Communications

There were no known difficulties with communications.

1.10 Aerodrome Information

DFW is owned by the cities of Dallas and Fort Worth, Texas, and is operated by the DFW Airport Board. The airport is about 17 miles west of Dallas and 17 miles east of Fort Worth. DFW is 603 feet above mean sea level (msl), and operates with six concrete runways, all of which are grooved. They are runways 13L/31R, 13R/31L, 17L/35R, 17R/35L, 18L/36R, and 18R/36L. There is also one short takeoff and landing (STOL) runway that is superimposed on a taxiway. (See figure 6). The runways are served by eight ILS and nondirectional beacon (NDB) instrument approaches.

Runway 17L-35R is 11,388 feet long and 150 feet wide and has a grooved concrete surface. Runway 17L is served by a Category II instrument landing system (ILS), high intensity runway lighting (HIRL), runway edge and centerline lighting (RCLS), touchdown zone lighting (TDZL), with sequence flashers, and runway threshold/end lighting. Runway 17L is equipped with an ALSF-2 approach lighting system.

Runway 17L-35R was originally constructed as runway 18L-36R, in accordance with plans and specifications entitled "Runways, 18R/36L and 18L/36R Phase II, Paving, Drainage and Lighting," under the issue date of March 1982, Contract C-279-82. The runway designation was changed to 17L-35R prior to its opening.

Runway 17L-35R was designed and constructed in accordance with FAA advisory circulars (ACs) and specifications. The runway is constructed of reinforced Portland cement concrete pavement with 35-foot-wide asphalt concrete shoulders. The pavement has a crowned section of 1.0-percent cross slope on the runway, a 2.0-percent cross slope on the paved shoulders, with a 1.5-inch vertical drop at the outside edge of the shoulder pavement. 17L has a negative 0.18-percent gradient constant throughout its length, and the concrete pavement is grooved transversely 130 feet wide, across the runway's entire length. The grooves are 1/4 inch deep and 1/4 inch wide, and are spaced approximately 1 1/2 inches apart.

Following the accident involving AAL102, investigators worked with the FAA friction program manager in conducting coefficient of friction tests on runway 17L-35R, using the airport's Saab friction test vehicle. Initial erroneous data results were followed by minor repairs to the equipment. Subsequent data, taken on April 16, 1993, found that the friction levels on runway 17L-35R were in the .60 to .65 range with the test vehicle traveling on the runway at 40 miles per hour. Friction tests, taken with the vehicle at 60 miles per hour, revealed friction levels in the range

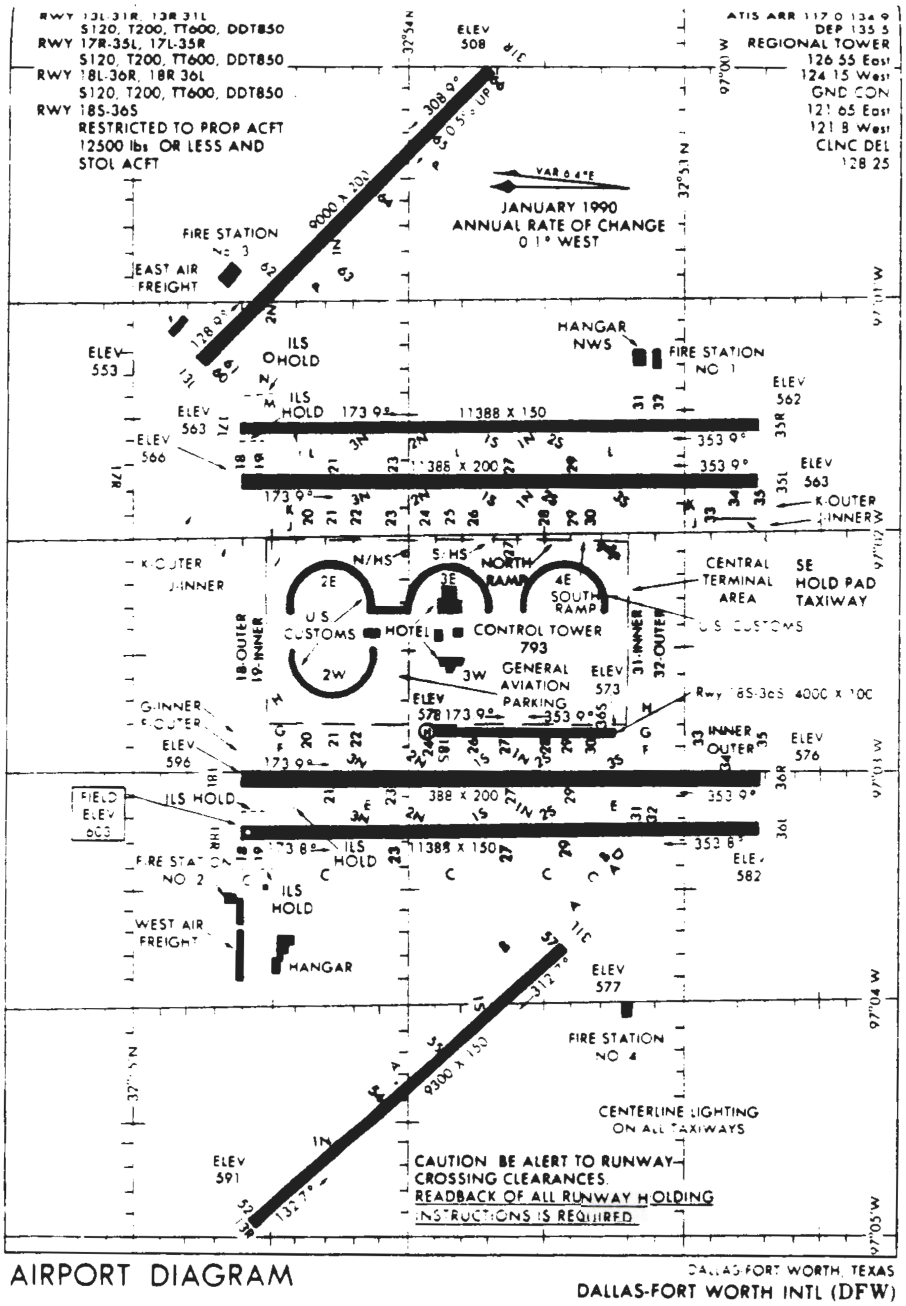

Figure 6.--Airport diagram.

of .52 to .57.[9] Friction values in these ranges fell within the area of "maintenance planning."[10]

Microtexture tests on runway 17L-35R were also accomplished under the direction of the Safety Board.[11] Data from the microtexture tests showed texture depths of .012 inch at 4,000 feet from the threshold of 17L, .010 inch at 6,000 feet, and .014 inch at 7,000 feet. Slope was measured at 1.25 degrees at all three locations. FAA AC 150/5320-12B states:

> Average texture depth in good skid-resistant pavement will average 0.0625 inch or more. Less than that indicates a deficiency in macrotexture that will need correction as the surface deteriorates.[12]

When Safety Board investigators inquired of the FAA Airports Certification Inspector, who was involved in the investigation, whether FAA annual certification inspections include runway coefficients of friction measurements, he replied that it was not within the authority of the inspector(s) to evaluate runway friction coefficients or airport friction measurement programs.

1.11 Flight Recorders

An operable CVR and a 28-parameter flight data recorder (FDR) were recovered from the airplane and transported to the Safety Board's laboratories in Washington, D.C., for readout. Both recorders arrived at Safety Board headquarters on the day of the accident. Neither of them showed any damage, and they provided clear information.

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[9] Coefficient of friction values are a ratio and have no unit of measure.

[10] Reference FAA AC 150/5320-12B, dated 11/12/91, "Measurement, Construction, and Maintenance of Skid-Resistant Airport Pavement Surfaces," Chapter 3, Section IV, paragraph 45 - 46, and Table 3-3.

[11] Ibid., page 22, Pavement Texture Measurement, for provisions followed in runway microtexture test.

[12] FAA AC 150/5320-12B, dated November 12, 1991, states "0.0625 mm" it should read "0.0625 inch." (reference report, "Friction Survey for Runway 17L-35R, DFW, dated May 26, 1993, by Thomas H. Morrow, C.E., P.E.)

1.11.1 Cockpit Voice Recorder

The CVR was a Fairchild model A-100A. It was examined at the Safety Board's Audio Laboratory, beginning on the afternoon following the accident. The recording consisted of four channels of good quality audio information. A transcript was prepared of the entire 31 minutes of recording. (See appendix C for CVR transcript).

1.11.2 Flight Data Recorder

The FDR was a digital Sundstrand Model UFDR-DXUS (Serial No. 9582). The data indicate that at 0658:29, the airplane's main landing gear touched down with the airplane at an attitude of 4.21-degrees nose up and 1.76-degrees left wing down, on a heading of 174.02 degrees. The airplane touched down at an airspeed of 142.75 knots, but the speed fluctuated between 145.0 knots and 139.5 knots over the next 3 seconds. The data also indicated that nose gear touchdown occurred at 0658:31. During the period between main gear and nose gear touchdown, the elevator position values changed from 10.3-degrees nose up to 12.03-degrees nose down.

In the 6 seconds following the indication of main gear touchdown, the heading of the airplane remained at between 174 degrees and 175.4 degrees, as the airspeed decreased to 125 knots. The elevator position values remained nose down, decreasing from a peak value of about 14 degrees to 3 degrees, while the rudder position values fluctuated between 2.8 degrees right rudder to 23 degrees left rudder. The thrust reverser values recorded during this period were consistent with a symmetrical deployment of all three engines' reversers. The N1, or engine gas generator speed values, were also consistent with a symmetrical application of reverse thrust starting at 0659:33. Within the next second, the elevator position changed from 9.8-degrees nose down to 1.84-degrees nose down, where it remained nearly constant, changing less than 0.3 degrees. The rudder position decreased from approximately 6 degrees left rudder to nearly 2 to 3 degrees left of neutral. During the next 6 seconds, the data are consistent with the airplane departing the runway heading to the right of centerline. The heading of the airplane changed 7 degrees to the right as the airspeed decreased to 106.5 knots. Maximum reverse thrust values were recorded during this 6 seconds with N1 between 85.2 and 83.26 percent.

1.12 Wreckage and Impact Information

1.12.1 Wreckage Path Information

Investigators examined the landing runway after the accident and found traces lighter than the surrounding runway surface, or white tire traces from the left, center, and right main landing gears, starting at 4,303 feet from the beginning of the runway, or with 7,085 feet remaining. The center gear tire marks were 4 feet to the right side of the runway centerline. There were no marks of any kind before this point on the runway that could be linked to the accident airplane.

The terms "erasure mark," or "white tire trace," pertain to the phenomenon whereby an airplane tire, subjected to braking and/or cornering on the wet surface, will scrub or erase contaminants from the runway surface resulting in a temporary white appearance of the surface in the tire track. There were a large number of these marks on runway 17L. White tire erasure marks (or traces) found on the surface of the runway were identified as the ground track of AAL102 by tracing the marks to the airplane and checking the spacing with the known dimensions of the DC-10's landing gear and tires. The distance between the white traces was consistent with the DC-10's landing gear measurements.

The set of white traces from the right main gear tires were the most visible, and paralleled the runway centerline for about 1,700 feet, until the airplane was abeam taxiway 27, about 5,988 feet from the beginning of the runway. White tire traces from all three main landing gear became clearly visible as the airplane cornered to the right before it departed the runway. The marks from the left main landing gear tires crossed to the right of the runway centerline about 6,443 feet from the beginning of the runway.

Several scuff marks were found parallel to the center main landing gear track, about 6,773 feet from the beginning of the runway. These marks continued intermittently until they were nearly abeam the entrance to high speed taxiway 3S. One of these marks, about 6,773 feet from the beginning of the runway, was 175 feet long and 7 inches wide, and was located 22 inches right of the mark from the right tire of the center main gear.

The airplane crossed the right shoulder of the runway with the left and center landing gear, while the right gear exited the shoulder and left furrows in the wet soil, about 7,453 feet from the beginning of the runway. Black rubber tire marks became visible as the airplane crossed the runway 17L shoulder and high speed taxiway 3S. On the taxiway, the marks from all three main landing gear were evident as black marks. Measurements of the center main and nose gear tracks showed that the airplane was yawed approximately 9 degrees to the right as it crossed the high speed taxiway. After crossing the taxiway, the airplane returned to the soft soil and left deep trenches from all landing gears.

The airplane came to rest, upright, about 8,781 feet from the approach end of 17L and about 250 feet from the right edge of the runway, with the nose on perpendicular taxiway 31. The heading at final stop was about 203 degrees magnetic.

Separated airplane debris was found in the area between where trenches associated with tire paths ended and the final resting point of the airplane. This debris was primarily from the left main landing gear and associated hardware where the left main landing gear mounted into the wing structure. Shallow trenches or furrows were found consistent with the location of the left wing tip and left outboard flap track fairings. They were found between the grooves in the soil from the left main landing gear and the final resting point of the airplane.

The airplane came to rest 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 strut 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.

1.12.2 Airplane Structure

1.12.2.1 Landing Gear

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. (See figure 7, which is a photograph of the lower lobe galley, showing the final position of the nose gear tires).

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

Figure 7.--Lower lobe galley.

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 2 feet.

The left main landing gear was found separated from the wing structure at the forward "zero margin" trunnion pin and at the aft trunnion pin lug. It came to rest against the trailing edge of the left wing's outboard flap. A portion of the forward trunnion pin was found about 200 feet aft of the left wing. Examination showed that the pin had fractured at the groove. The aft lug of the forward and aft clevises that hold the "zero margin" trunnion pins were also found fractured. The aft trunnion pin was intact. The truck beam of the left main landing gear was found fractured, and the upper side brace was separated at the wing hinge. No indications of fatigue or corrosion were observed along the fractures of the trunnion pin and lugs, truck beam, upper side brace, or any fracture in the landing gear area.

No flat spots or reverted rubber material were found on any of the tires. All tire pressures were documented and found within normal pressure levels, except the left rear tire from the left main landing gear. The pressure gauge for this tire indicated approximately 195 pounds per square inch (psi).[13]

1.12.2.2 Fuselage

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. A circumferential crack-like fracture in the lower fuselage extended just aft of the L-1 and R-1 cabin exit doors across the underside of the fuselage. 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 fairing aft of the left wing was damaged, and the underlying metal fuselage skin was split open. Rubber transfer marks were found on the fairing, and,

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[13]The normal inflation pressures for a DC-10-30, as specified in American Airlines' General Procedures Manual, are as follows: main landing gear, 180 - 190 psi; nose landing gear, 180 - 190 psi; center landing gear, 155 - 160 psi.

in the split, a distinctive circular pattern was found that matched the bottom of the landing gear assembly. Imbedded in the side wall of one of the left main landing gear tires was a piece of metal that matched in color, thickness, and shape a portion of fuselage skin from the breached area. There was also a 3-foot by 6-foot area of damage to the wing-to-body fairing under the left wing, near the front spar.

1.12.2.3 Wings

All slats on the left wing were found extended, except for the No. 2, or second-most inboard slat, which had been driven aft and up by displacement of the No. 1 engine. All spoilers were found retracted, although the outboard edge of the No. 1 spoiler was bent up slightly. The left outboard aileron was found in the up position, and the inboard aileron was down slightly from the up position. The left outboard flap was found partially extended and exhibited damage along the trailing edge, consistent with a secondary impact from the left main landing gear. The left inboard flap was found extended and exhibited up-and-aft impact damage to the middle of the lower surface and the trailing edge. The outboard corner of the flap (36 inches by 44 inches) was found to have burned away. The forward edge of the No. 3 flap track fairing was found torn and buckled and embedded with dirt.

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. The underside of the left wing aft and outboard of the engine sustained fire damage.

No right wing damage was observed. All slats and flaps on the right wing were found extended. All spoilers were retracted, except for the No. 5 or outboard-most spoiler, which was partially deployed. The outboard aileron was up, and the inboard aileron was down.

1.12.2.4 Empennage

No empennage damage was found.

1.12.2.5 Lightning Strike/Static Dischargers

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.

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. Only the retainer portion of the static discharger was found. No similar damage was observed on the remaining static dischargers on the airplane. However, three other dischargers were found broken--one each on the right wing trailing edge, left wing trailing edge, and left wing tip.

1.12.2.6 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 left lower 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.

In the No. 1 engine pylon area, fuel and hydraulic lines, electrical cables, wire bundles, and fire extinguisher lines were severed at a point near the wing-to-pylon interface. Fire damage was present in this area. The outboard side of the pylon was significantly more burned than the inboard side, and a small area immediately below the leading edge of the wing was burned through. No fore-to-aft streaking of soot or metal was seen along the pylon or the underside of the wing.

1.12.2.7 Cabin

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.

1.12.3 Airplane Flight Control Systems

No preexisting failures or conditions that could have adversely affected the flight controls were found. The rudder was hydraulically operated through its entire range of left and right travel. Two steering cables and a pulley bracket from the collapsed nose landing gear steering system were examined at the Safety Board's Materials Laboratory. The laboratory reported that although the cables contained corrosion, their failure was due to overstress. The cables and brackets were in an area with extensive soil impact damage, including broken and bent brackets and torn insulation blankets. Out of 20 antiskid valves tested for response to electrical signals, 5 were found to be out of the prescribed limits established for new parts. The manufacturer of the airplane's brake/antiskid system, Aircraft Braking Systems, Inc., noted that the mode in which the valves exceeded tolerances would have made it less likely for the affected wheels to skid.

1.12.3.1 Flaps

The flap/slat handle in the cockpit was found in the 35-degree position. Postaccident interviews of the flightcrew and the FDR record show that the landing was made at the 35-degree flap setting. The leading edge slats and trailing edge flaps were found in the extended positions--appropriate for the landing configuration. They were examined where the airplane came to rest and were found evenly flecked with mud.

Data from the FDR showed the positions of the left Nos. 2 and 4 slats, right No. 4 slat, and right No. 3 flap panel. A readout of the FDR data showed that the slats were fully extended and that the flap position indicated 37.97 degrees while the airplane was in final approach and landing. Below 70 knots, the No. 2 left inboard slat sensor changed to indicate slat retraction. This slat had separated from the airplane and was found near the final resting point of the airplane.

1.12.3.2 Spoilers

After the airplane came to a stop, the flight engineer reported that he completed his checklists, which included stowing the spoilers. However, he could not stow the spoiler handle beyond 1/3 deployment.

After the accident, the flight engineer stated that the autospoilers had functioned during the landing, but he "thought the speed brake handle was not coming back fast enough, [and he] reached up and pulled [the] speed brake handle."

The spoiler control handle was found in the 1/3-deployed position. On the exterior of the airplane, the spoiler panels were in the stowed position. Mud was packed into the spoiler mixer assemblies in the centerline landing gear wheel well, preventing movement from the 1/3 position until the mud was removed. The spoiler mixers and the cable assemblies attached to each actuator were in positions corresponding to approximately 1/3 of their full rotational travel.

Damage occurred to the electrical and hydraulic portions of the spoiler system, and a spoiler fault indication was displayed on the fault isolation panel under the flight engineer's desk. All spoiler position indication wiring in the left wing was burned in the area where witnesses had reported the postcrash fire. Lower surfaces of the left wing were melted near the No. 1 engine pylon, and damage was visible in the spoiler hydraulic and electrical pathways. Hydraulic lines were also fractured at the top of the separated left main landing gear.

1.12.3.3 Rudder

During the postaccident systems check, each of the four rudder pedals were depressed through their entire range of travel to determine control continuity to the actuators. The rudder control cables were examined for tension at several locations. Once the mechanical integrity was established, the upper and lower actuators were operated to full left and right travel under hydraulic power. The manufacturer of the airplane, Douglas Aircraft Company, noted that the designed range of rudder travel was +/-23 degrees. Investigators arriving on site found the resting position of the rudder at full left deflection.

1.12.3.4 Nosewheel Steering Controls

In the forward electronics compartment, the nosewheel steering cables, routed to the rudder pedals and tiller, were found without tension and slack. A bracket that mounted four pulleys in the nose landing gear well was found separated from the compartment ceiling. The four nosewheel steering cables were routed around the pulleys. Each of the pulleys had a cable impression on one side of the groove. Where the impressions were deepest in two of the pulleys, the pulley side walls were fractured. The forward rudder steering cable that passed through the compartment ceiling was fractured, as was the tiller steering cable that was the most forward cable attached to the steering linkage and followup sector assembly. Examination of the broken nosewheel tiller and pedal rudder cables at the Safety Board's Materials Laboratory found that while corrosion was present on the strands, the fractures found were due to overstress.

1.12.4. Wheels, Tires, and Brakes

The left nosewheel assembly came to rest in the lower lobe galley. The nose landing gear had pivoted 90 degrees right, so that the left wheel was on the bottom when the assembly was viewed from inside the galley. The left tire was properly inflated and showed no flat spots or rubber reversions. Also, scratches were found perpendicular to the tread and parallel to the axle.

The right nosewheel on the nose gear assembly was found inflated properly and had tread remaining. There was no evidence of flat spots or rubber reversion. Scratches perpendicular to the tread and parallel to the axle were also observed on the right nosewheel tire.

There were no indications of flat spots in the tread or rubber in any of the main landing gear tires on the airplane. The investigation revealed the following information relative to the main landing gear brakes:

1. All brakes were manufactured by Goodyear, and were marked with part number 5000758-10R, except for wheels 5 and 7, which were missing the dash number.

2. The DC-10 Maintenance Check Manual showed that the main landing gear brake wear pins must be longer than 1.50 inches.

3. Although the unpressurized wear pin lengths were measured at the crash site, and met extension requirements, the DC-10 Maintenance Check Manual states that the wear pins must be checked with the brake system pressurized. New measurements were made during the detailed inspections of brake assemblies.

4. All brakes were tested to 3,000 psi and functioned normally. When pressure was reduced to 100 psi, the top disc in each assembly could be turned, which was a normal indication.

The antiskid components found in the wreckage path were examined under the Safety Board's direction at the facility of the brake and antiskid system's manufacturer, Aircraft Braking Systems, Inc. (ABSC). No faults were found with the wheel speed transducers, used for antiskid and spoilers, or with the antiskid control box.

As described in the operator's DC-10 Maintenance Manual, the accident airplane was equipped with 20 antiskid pressure control valves, mounted in six manifolds. Two valves led to the brake assembly at each wheel. Testing revealed that 16 of the valves responded to electrical signal applications, signal step changes, and signal releases. One valve was found to be inoperative, and three had damaged or missing valve motor caps that prevented testing. Five of the 16 valves that responded were found out of tolerance. (Reference diagram of brake manifold system, figure 8).

When the right main landing gear antiskid manifold, Serial No. 71-104, was dissembled, the connector and wiring at the connector was found corroded. Erroneous BITE information had not been identified by the electronic control unit on the accident airplane.[14]

The aircraft wiring diagram shows that the antiskid wiring in the airframe uses an air-ground sensing circuit. The circuit was inspected after the

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[14] The manufacturer of the brakes, ABSC, issued a March 15, 1979, Service Letter (DC-10-10-SL-9 and DC-10-30/40-SL-8) stating that antiskid built-in test equipment (BITE) could be used to identify an inappropriate valve circuit malfunction. The manufacturer noted that loss of a wire could diminish pressure release to the associated half of a wheel brake on the affected main landing gear (left, centerline, or right).

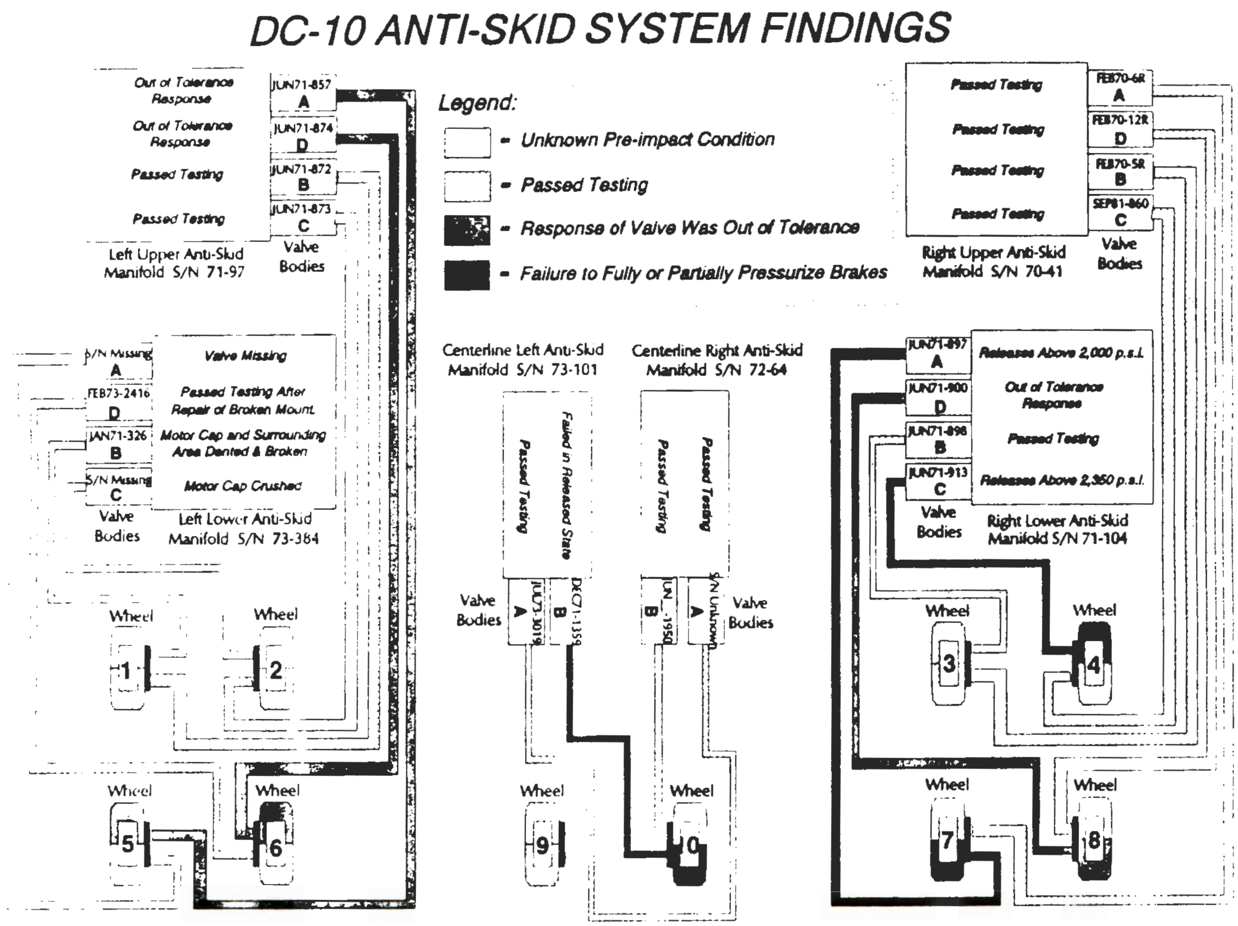

Figure 8.--Brake manifold system.

accident, and actuation of the mechanical portions of the system was confirmed. Electrical integrity was verified by a continuity check.

1.12.5 Other Systems

The airline reported that in February 1993, a Sundstrand MK VII Ground Proximity Warning System (GPWS) was placed into service on the accident airplane. The GPWS system included a mode for aural windshear warning alerts to within 30 feet of the runway surface. The airplane had also been equipped with two Litton LTN-72 inertial navigation units and a Litton LTN-311 Omega navigation system. Safety Board investigators determined that data from these systems could not be used to obtain wind data for the time of the accident landing.

Postcrash examination found that the air-driven generator (ADG) deployed. Cable continuity was established to the ADG from the cockpit activation handle. The ADG uplock bracket was bent, and the cable had been pulled by deformed structure.

1.12.5.1 Powerplants

Examination of the three engines (left or No. 1, center or No. 2, and right or No. 3), engine nacelles, and pylons revealed that all three thrust reversers were fully deployed. Large quantities of mud and grass were ingested by the left and right engines. Only trace amounts of mud were found in the center engine. An anomaly in the center engine reverser cascade configuration was found. The installation of two thrust reverser cascades on the center engine did not correlate to the operator's DC-10-30 Maintenance Manual provisions. No preexisting failures or conditions were found on the three engines that would have prevented normal operations.

All three engines were General Electric CF6-50C2, each rated at 51,800 pounds of thrust. Engines Nos. 1 through 3 had the following manufacturer's serial numbers, respectively: 455414, 455292, and 455302.

1.12.5.2 No. 1 Engine

The No. 1 engine was found resting on the ground, partially attached to the wing. The engine mount was fractured in the area of the pylon-to-wing attachment. The engine and wing were both lying on the ground providing support to the left side of the airplane fuselage. A Safety Board metallurgist, who examined the fractured left engine mount, as well as the fractured nose and left main landing gear struts, found the damage consistent with overload.

The No. 1 engine pylon exhibited internal and external heat damage, scorching and small areas of localized melting, beginning vertically down from the wing leading edge and continuing aft. The outboard wing-to-pylon faring burned through the metal skin near the engine fuel line. The pylon structure was folded at around a 45-degree angle, inboard, midway between the wing and engine, severing all fuel lines, hydraulic lines, fire extinguishing agent lines, bleed air lines, and all electrical connections. The pylon attachment points at the wing and engine remained intact.

The No. 1 engine was found rotated approximately 45-degrees counterclockwise[15] about its horizontal axis, and articulated about 30-degrees up and inboard toward the fuselage. The wing leading edge slat was extended and pressing against the inboard core cowl. Mud was splattered on the exterior of the engine, nacelle, and pylon. Large amounts of mud had entered the engine and coated the inside wall of the inlet duct. Mud was also found downstream of the fan and throughout the engine reverser. Parts of a runway sign were found in the engine and imbedded in the inlet acoustical material. The leading edge of the inlet duct was damaged at the 5:00 and 7:00 positions, and the dents matched the dimensions of the runway sign.

The outboard translating cowl was found separated from the No. 1 engine, whereas the inboard translating cowl remained attached to the engine at the upper "tee" track. All six jackscrew actuators were found extended approximately 22.25 inches. According to the operator's DC-10-30 Maintenance Manual, a 22.25-inch extension of the jackscrews corresponded to a fully deployed reverser translating cowl. One jackscrew shaft was found imbedded in the wing inboard leading edge slat, and a second one was about 50 yards behind the final resting position of the engine. The reverser cascades were in the normal configuration.

The inboard and outboard fan and core cowlings were sprung, ajar, partially crushed, and split at the seams. Black soot covered the upper portion of the exhaust nozzle and core cowl but was limited to the exterior of the engine

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[15] All descriptions using clock positions are referenced looking aft.

nacelle. There was also black and blue discoloration on the lower half of the inboard core cowl.

1.12.5.3 No. 2 Engine

There was some damage to the No. 2 engine fan, but the core engine inlet did not reveal any evidence of mud ingestion. Mud spots and brown water stains were found along the inside of the inlet duct and engine compressor inlet. There was no evidence of fire on the nacelle or pylon.

The rest of the No. 2 engine was undamaged, and the jackscrews were extended 22.25 inches. The hydraulic mechanism that served to open the fan reverser and translating cowls operated normally, with the reversers in the extended position. The low pressure rotor could easily be rotated by hand without contacting associated hardware. No openings, penetrations, or bulges were found in the exterior of the engine cases.

All of the cascades on the No. 2 engine were undamaged. However, two of the 32 cascades, located at the 5 o'clock position, were the incorrect part numbers and styles for the installation, according to the operator's DC-10-30 Illustrated Parts Catalogue.

1.12.5.4 No. 3 Engine

There was no evidence that the No. 3 engine contacted the ground; however, large amounts of mud were ingested by the engine. Mud covered the exterior of the engine, nacelle, and pylon, and the inside wall of the inlet duct. Mud also coated the bleed doors, between the booster and high pressure compressor. There was heavy damage to the fan and fan rub strip. There was no damage to the engine cases, or evidence of fire or damage to engine ducting, tubing, or wiring at any point on the No. 3 engine. There was also no evidence of fire on the interior or exterior of the engine nacelle.

The engine reverser and translating cowls, fan cowls, and core cowls were latched, unsprung, and undamaged. The translating cowls were extended, the cascades were visible, and the blocker doors were in their deployed position; and mud coated each door. The jackscrews were extended 22.25 inches. The hydraulic mechanism to open the fan reverser and translating cowls operated normally with the reverser in the extended position.

All of the engine reverser cascades remained in place and were undamaged. Mud was found in the turning vanes, throughout the inner diameter of the cascades. The cascades were in the normal configuration.

The low pressure rotor could be easily rotated by hand with friction noted at the fan tips. All fan blades were intact from root to tip. However, all of the leading edges and some of the trailing edges were bent, chipped or fractured, and mud deposits, loose dirt and debris were in the plane of rotation. The fan rub strip exhibited heavy circumferential scraping.

1.13 Medical and Pathological Information

Out of a total of 202 persons aboard the airplane (189 passengers, 3 flightcrew and 10 cabin crewmembers), 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 to passengers, 2 to the cabincrew and 1 to the flightcrew).

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 (see section 1.15.1).

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.

1.13.1 Medical Certification and History

The captain held an FAA First Class Medical Certificate issued on March 9, 1993. The certificate contained the limitation "Must have available glasses for near vision." The captain reported that at the time of the accident, he was wearing trifocal corrective lenses, which included lenses for near vision.

The first officer held an FAA First Class Medical Certificate issued on October 23, 1992, without limitations.

The flight engineer held FAA Second Class Medical Certificate issued on March 23, 1993. The certificate contained the limitation "Must have glasses available for near vision." The flight engineer reported that he was in possession of glasses as required at the time of the accident.

The crewmembers reported that they were in good health in the days prior to the accident, that they were not suffering from any chronic or acute ailments or illnesses, and that they were not under the influence of medications, drugs, or alcohol.

1.13.2 Toxicological Testing

In response to the requirements of 14 CFR, Part 40, for postaccident toxicological testing, all three flight crewmembers submitted urine samples, taken approximately 5 hours after the accident.

The specimens were collected by medical personnel at the American Airlines medical facility at DFW. The samples were tested for amphetamines, phencyclidine, cocaine, cannabinoids, and opiates in accordance with Federal requirements. The results of the examinations were negative for the flight crewmembers.

1.14 Fire

About the time the airplane came to rest in the grass to the right of landing runway 17L, witnesses reported seeing a fire erupt near the left wing. The burn pattern showed that the fire was most intense near the area in the rear of the No. 1 engine and along the retreating edge/inboard flap area of the left wing. There was also substantial fire damage to the grass, soil, and underside of the left wing. The main fuel supply line to the No. 2 engine was found fractured.

1.15 Survival Aspects

1.15.1 Evacuation

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 the 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 right side exits, cabin crewmembers moved the passengers forward to other exits.

At one point during the evacuation from 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.

There was a high number of elderly passengers lined up at 3-R and 4-R, and some of them 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.

1.15.2 Flight Attendant Training

All of the flight attendants were qualified by American Airlines on the DC-10, as well as on B-727, B-757, B-767, MD-11, and A-300 airplanes.

Initial flight attendant training is conducted by the American Airlines training facility in Arlington, Texas. During the 7-week program, trainees receive 79.5 hours of instruction in first aid, fire fighting, cabin management, and emergency evacuation procedures and techniques, one of which is flow control (the expeditious and efficient command of passengers from within the aircraft cabin, through usable emergency exits). Instruction is provided during classroom lectures, computer-based instruction, proficiency workshops, and competency checks. Subsequent recurrent training is conducted in two phases annually. Recurrent classroom training is conducted at the flight attendants' base station, and, within the same month, they attend practical evacuation drills at DFW. Practical demonstrations incorporate exit operation, blocked exits, exit malfunctions, flow control, cabin management, primary and secondary exits, and proficiency drills, intended to build critical thinking skills.

1.15.3 Emergency Response

The DFW fire and rescue department's crash alarm sounded about 0701, within about 1 minute from the time the airplane came to rest. About 1 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. Four triage areas were used due to the dispersion of passengers. One triage area was initiated near the airplane at the intersection of taxiway 31 and 17L, two triage areas were at Terminal 4E, and a fourth was at the DPS Headquarters Building (Station 1).

Thirty-one persons were transported to four area hospitals by ambulance. Two people were treated and transported with possible critical injuries, and several people were treated for possible serious injuries. All other injuries appeared to be minor. All of them were transported within 1 hour. Later during the day, some passengers complained of pain and were routinely transported to hospitals, or they proceeded to hospitals on their own initiative.

1.15.4 Cabin Emergency Lighting System

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. The overhead and door light subsystem was manufactured by Gulton Industries, Inc., of Hawthorn, California, and was installed when the airplane was manufactured. The components of this subsystem consisted of four battery-charging units and nickel cadmium batteries (NICAD). The floor path and side wall exit sign lighting subsystem was manufactured by the DME corporation, Fort Lauderdale, Florida, and was installed in the accident airplane in 1993 by DME. These components were located along the right ceiling and adjacent to the 1-R through 4-R exit doors. Two complete units of logic modules and battery packs for the system were located at each right side cabin exit door.

During the on-scene investigation, a functional test of both emergency lighting systems revealed that only the floor path lighting on the left aft side of the cabin illuminated. Subsequently, both systems were disassembled on the scene, under Safety Board supervision, and no mechanical or structural anomalies were found. However, in this accident, such functional tests would not have been sufficient to detect the problem because of the short period of time that the emergency lights were illuminated.

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.

Seven of the eight DME Control Modules located in four electrically independent (output) and redundant zones were found to be functional during the evaluation. The one nonfunctional module was located on the right aft portion of the airplane. Evaluation of the lamp load indicated that the right aft zone lighting would have adequately powered and illuminated that zone of the cabin.

The Gulton cabin overhead and door emergency lighting system was disassembled and reexamined. All logic units and system charging capabilities 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. 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 engineers instrument console but not enough to actually operate the system.

The tests concluded that as a result of the 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.

1.16 Tests and Research

1.16.1 Airplane Performance Study

1.16.1.1 General Information

Data from ATC radar, weather, CVR, FDR, and information from the examination of the aircraft wreckage and the accident runway were used to develop a time history of the accident flight's motion during the approach and landing. (See figure 10 for airspeeds and altitudes during the landing sequence). Calculations were made of the crosswind component during the final 2 1/2 minutes before landing. A composite plot was developed that shows, in a graphical format, the flight control positions and airplane headings when key events occurred during the landing sequence. (See figures 11a and 11b).

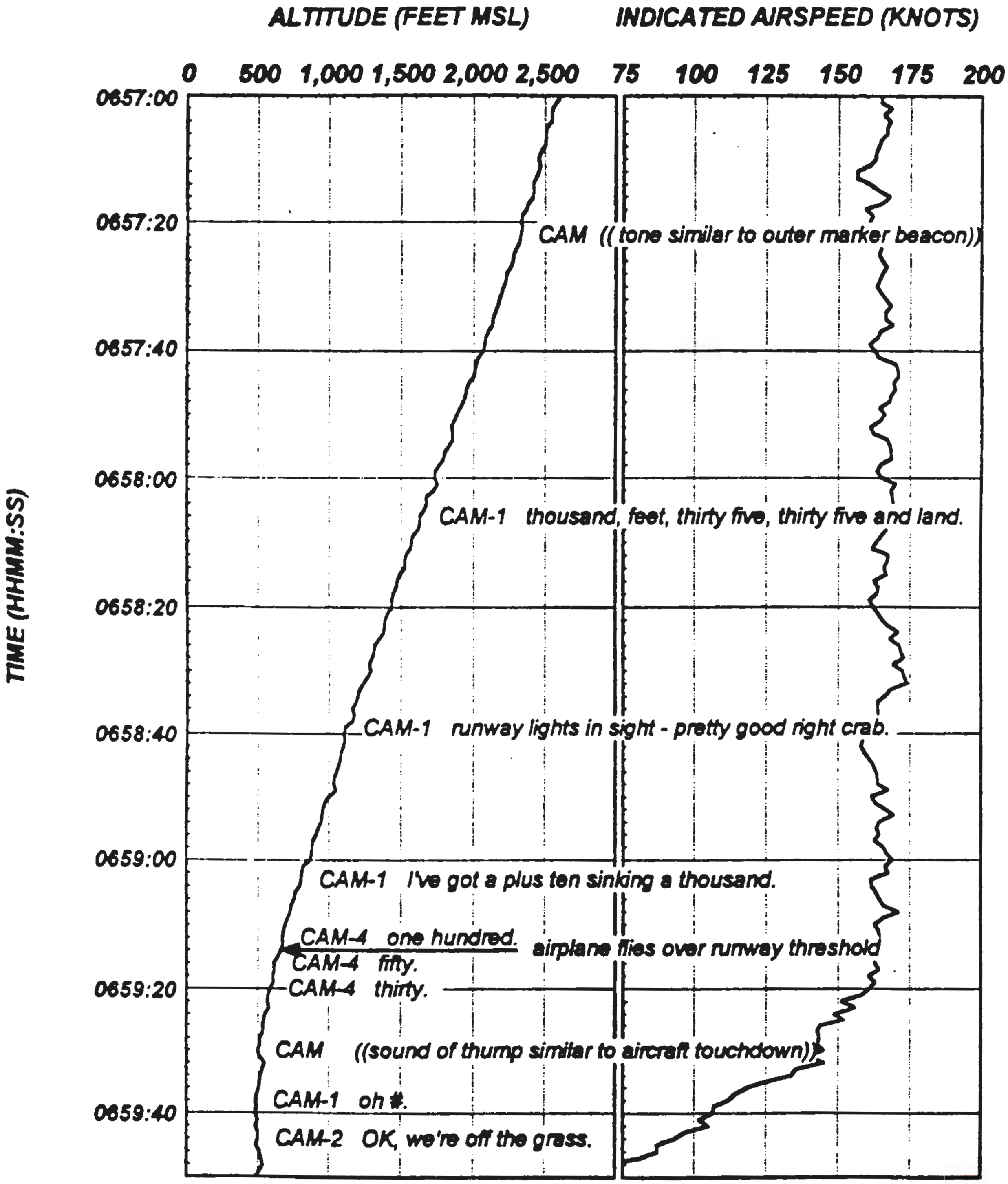

Figure 10.--Airplane airspeeds and altitudes versus time.

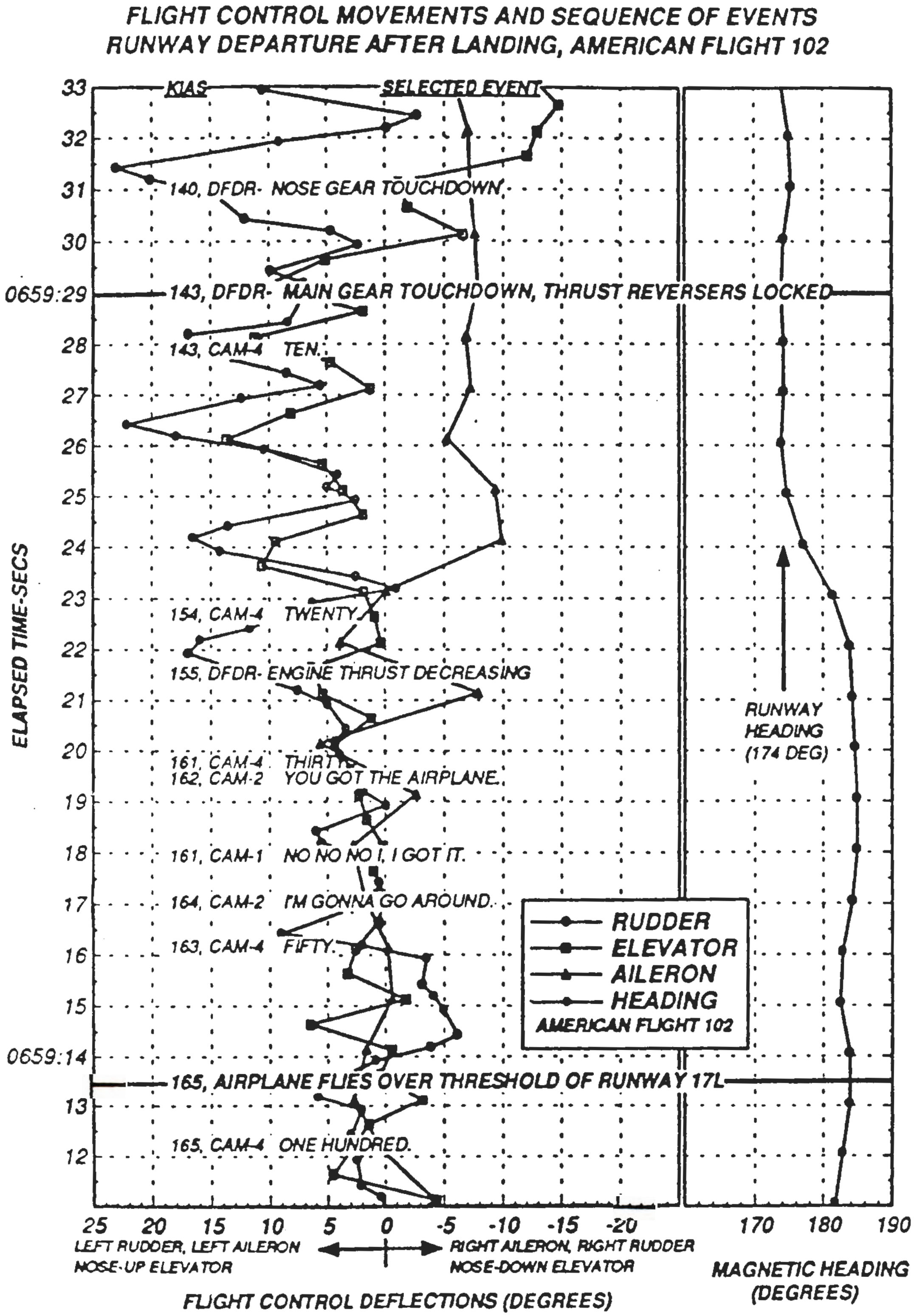

Figure 11a.--Flight control positions and airplane headings during landing sequence.

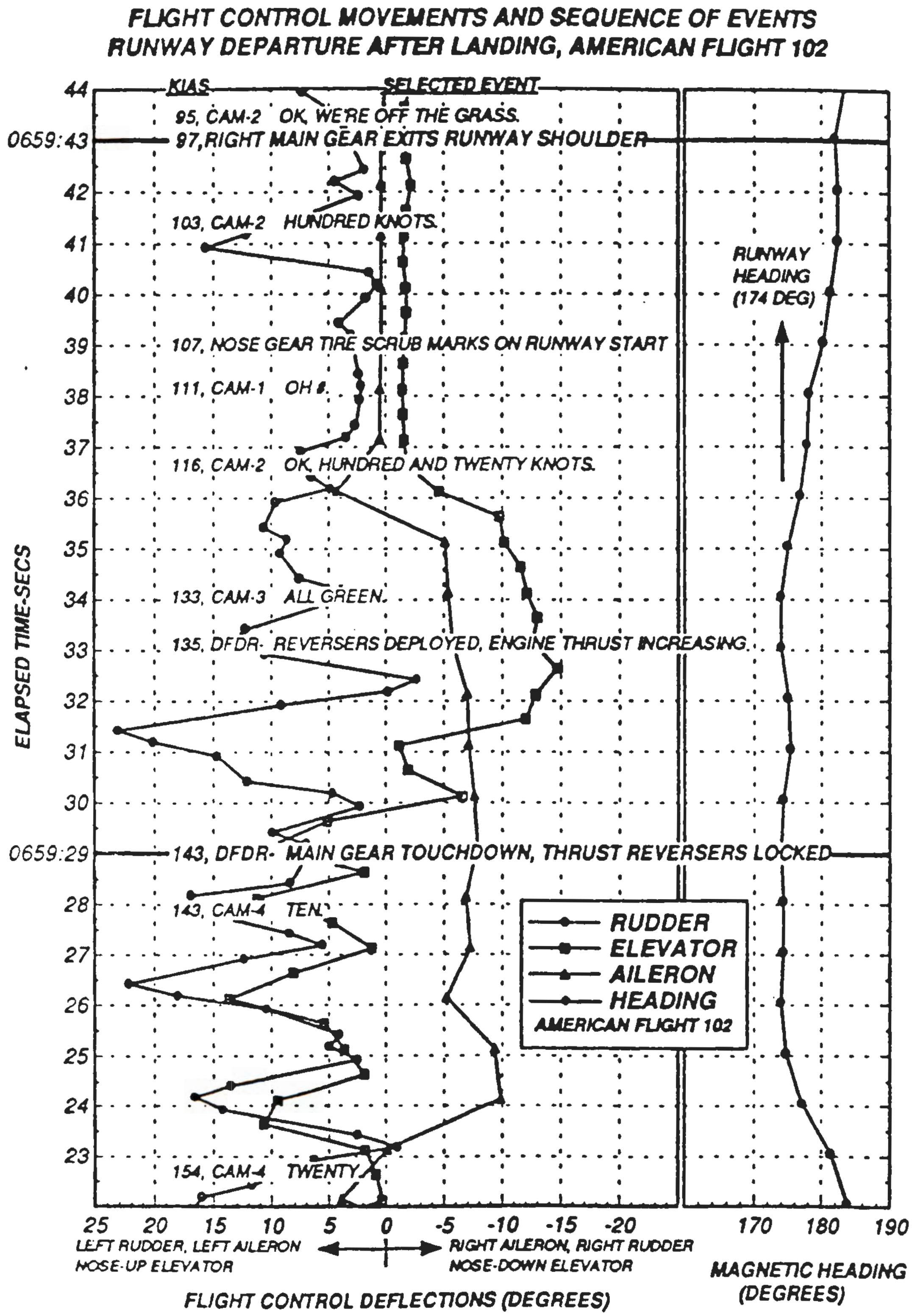

Figure 11b.--Flight control positions and airplane
headings during landing sequence.

Prior to touchdown, the airplane transitioned from a 10-degree right crab to a 2-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 17L for about 8 seconds, averaging an 8-degree ANL rudder deflection. During the 8 seconds after touchdown, the airplane decelerated to 116 knots indicated airspeed (KIAS), while the rudder was deflected on average about 8 degrees ANL, the aileron position averaged 5 degree RWD, and the elevator averaged 7 degrees airplane nose down (AND).

About 6 seconds after touchdown, the airplane heading began to move to the right of runway heading. At 7 seconds after touchdown, 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 1 second, upon which the heading stabilized for about 2 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.

1.16.1.2 Airplane Radar Data

At the time of the accident, DFW had an operable Automated Radar Terminal System (ARTS) under FAA supervision. A magnetic tape containing recorded data from the facility's computer was read out at the Safety Board's laboratory. Data were found from antenna sites at Colleyville and the U.S. Naval Air Station at Dallas (NAS Dallas). The Colleyville antenna site is about 4.6 miles from the accident site at DFW, and the NAS Dallas antenna is about 9.7 miles from the accident site. The DFW antenna was apparently not operating at the time of the accident. It did not record any primary returns for AAL102.

Radar data from the Colleyville antenna were used in the calculations. Comparisons of radar altitudes with FDR altitudes revealed that the clock times for the radar system were offset approximately 6 seconds from the FDR clock times.

Colleyville radar data were smoothed for use in approximating the winds experienced by the accident flight on final approach. These data were then interpolated to 1-second intervals for use in wind calculations that are described in the section below.

1.16.1.3 Wind Calculations

To better estimate the winds to which the airplane was subjected during the final 3 minutes of flight, FDR and radar data were examined, starting with the flight on approach at approximately 2,600 feet msl. A computer program was written to approximate the winds experienced by the accident flight during the approach. Wind velocity was calculated each second, by comparing the radar-defined flightpath to the FDR-defined flightpath, beginning at 0657:00 cdt. These calculations are a function of the accuracy of both FDR and radar data, and are not valid if the airplane is in a sideslip. FDR data were integrated to produce a no-wind flightpath. The no-wind flightpath was then compared to the actual flightpath as recorded by the radar antenna, and it was assumed that the difference between the two paths was attributable to atmospheric wind. The program compared the two flightpaths and calculated wind speed and direction.

The data show that the airplane was in a right crab during the majority of the approach. Approximately 7 seconds before touchdown, the airplane heading moved left toward runway heading, and the airplane transitioned to a sideslip attitude prior to touchdown.

There is a gap in radar coverage after AAL102 crossed the runway threshold. Therefore, it was assumed that the airplane flew a straight line between the radar return at 0659:11 and the touchdown point. The time of 0659:29 and location at 4,303 feet from the approach end of 17L for the touchdown point were calculated from FDR and data verified by ground measurements. The calculated wind directions varied between approximately 225 and 310 degrees during the final 2 1/2 minutes before touchdown (except for the final 7 seconds of data, which are assumed to be inaccurate since the airplane was in a sideslip). 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 calculated wind direction varied randomly between a quartering headwind and a quartering tailwind between 0657 and 0659. At 0659:00 cdt, AAL102 was approximately 270 feet agl, 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 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 AAL102 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 1-second after the automated voice called out "fifty" (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.

1.16.1.4 Position and Time Calculations

The winds that the airplane was subjected to during final approach were also entered into a second computer program to calculate the airplane's flightpath and ground roll every second from 0657:00 until the airplane came to rest at 0659:54. The program integrated FDR data using the calculated winds in flight and the LLWAS-recorded winds after touchdown to produce a time history of positions for the airplane. Indicated airspeeds (IAS) are not accurate at low speeds, and an estimated airspeed decrease during the period near the end of the landing ground roll was used in the program.

The airplane was on the glideslope during the approach; however, radar data ceased as the airplane crossed the runway threshold. The first tire marks found on the runway from the airplane were 4,303 feet from the beginning of 17L, with 7,085 feet of runway remaining. The FDR-derived flightpath and CVR information are consistent with touchdown occurring 4,303 feet from the beginning of the runway. The airplane's radar altimeter recorded "ten" (feet) 1.8 seconds before this point, and the sound of a thump similar to an airplane touchdown was recorded 0.7 second after this point. The calculated ground track closely approximates the measured tire erasure marks for AAL102.

AAL102 had just descended below 50 feet agl, when the first officer stated, "I'm gonna go around" at 0659:17. The captain took control of the airplane, and the sound of touchdown was heard at 0659:29.7 at 143 KIAS.

1.16.1.5 FDR and CVR Data

Microphone keying information was used to establish a time correlation between the CVR and FDR information for the accident flight. The CVR transcript provides the time of each radio transmission in central daylight time. The FDR examines whether the microphone is "on" or "off" for 1/768th of a second, once each second. Allowing for realistic variance between CVR microphone "on" segments and FDR binary data, no detectable offset (other than the normal 5-hour difference in the clocks between cdt on the CVR and utc on the FDR) was found between CVR and FDR recorded times.

After the accident, the flightcrew stated that the captain took control when he said, "No, no, no I, I got it," at 0659:17.93. At 0659:18 the airplane was 10 degrees right of runway heading. At 0659:22, when the airplane was approximately 20 feet agl, the airplane heading moved to the left, reaching the runway heading of 174 degrees in about 3 seconds. During the left heading change, the FDR recorded left rudder and right aileron inputs, and a right roll attitude, all of which are consistent with a normal sideslip maneuver in preparation for landing.

The accident flight touched down at approximately 4 degrees nose-up pitch attitude, with 2-degrees left-wing-down at 143 KIAS. Nose gear touchdown occurred approximately 2 seconds later at 0659:31. Pitch attitude remained slightly above zero after nose gear touchdown until after the airplane departed the right side of the runway. Pitch attitudes during the ground roll, with the nose gear on the runway, varied between approximately 0.3 and 1.4 degrees. The same range of pitch attitudes were found in FDR data from the previous landing of the accident airplane. The downforce on the nose gear was not recorded by the FDR, but the accident airplane's pitch attitudes during the rollout were consistent with those recorded on the previous landing.

According to FDR data, N1 speed for all three engines increased to normal reverse thrust levels shortly after touchdown. The airplane came to rest approximately 25 seconds after touchdown. The average rate of deceleration of the airplane, while it was approximately on centerline, was about 3 1/2 knots per second.

The flight tracked close to runway centerline for approximately 8 seconds after touchdown, crossing right of centerline at 0659:37, when the airplane was at 116 KIAS. Rudder and elevator positions averaged about 7.9-degrees nose left and 7.7-degrees nose down, respectively, during the first 8 seconds after touchdown. However, elevator deflection had decreased to about 1.5-degrees nose down and 2.5-degrees nose-left rudder deflection by 0659:37. The rudder was also steady at 2.5 degrees prior to the correction of the crab angle at the start of the transition.

The captain stated, "Oh [expletive]," at 0659:38, as the airplane was moving right of runway centerline. The airplane continued moving to the right until the right main landing gear exited the runway shoulder at 0659:43, at a speed of 95 KIAS. Between 0659:37 and 0659:43, rudder and elevator positions averaged about 4.6-degrees nose left and 1.8-degrees nose down. The rudder was generally at 2.5-degree ANL except for a momentary spike in rudder position during this period, described below.

1.16.1.6 Airplane Response to Flight Control Inputs

The airplane pitch attitude changes were consistent with the airplane on the runway and with changes in elevator position. Roll attitude changes of the airplane were consistent with changes in aileron position. Airplane heading values respond to changes in roll attitude and rudder position on final approach and to rudder position after touchdown. The airplane touched down at 143 KIAS and maintained a runway heading. Approximately 7 seconds and 1,800 feet after touchdown, at 118 KIAS, the rudder and elevator positions approached neutral, and the airplane heading and ground track changed to the right.

When enough friction exists between the tires and runway to allow cornering, the ground track will be fairly consistent with airplane heading. The airplane heading will lead the turn. In the case of the accident flight, FDR heading data and tire erasure marks indicate that the airplane turned right and also moved to the right of runway centerline.

At 0659:40, a spike of 12 to 15 degrees of nose-left rudder input was recorded by the FDR. The airplane heading momentarily stopped moving to the right, consistent with a normal response to left rudder input. The input was not maintained. At this time, the airplane's heading and ground track were approximately 8 degrees right of runway centerline. This track continued until the right main landing gear departed the right shoulder of the runway.

The previous landing performed by the airplane was compared with the accident landing. Rudder positions varied approximately +/-4 degrees about the neutral position during the previous landing rollout. Approximately 5 degrees of nose-down elevator was used until about 45 KIAS in the previous landing rollout.

1.16.1.7 Effect of Misconfigured Thrust Reverser Cascades on No. 2 Engine

During the application of reverse thrust, the wing engines create a nose-down pitching moment and the center engine creates a nose-up pitching moment. In the horizontal plane, the reverse thrust forces are normally symmetric, while in the vertical plane there is a slight net nose-down pitching moment. According to the engine manufacturer, a general effect of the misconfiguration of the No. 2 engine cascades would have been to reduce the weight on the nose landing gear and push the nose of the airplane to the right during the period of reverse thrust.

The FDR data show that the airplane touched down on 17L at approximately 0659:29, reached full reverse thrust by approximately 0659:36, and maintained full reverse on all engines for the remainder of the ground roll. When the airplane was developing full reverse thrust on all engines, the effect of misdirected thrust due to the two misconfigured cascades on the No. 2 engine was a change in pitching moment on the airplane of 65,000 to 72,000 foot pounds (65 to 72 kft-lbs) nose up. The change in yawing moment on the airplane was 61 to 68 kft-lbs nose right.

The effect of the two misconfigured No. 2 engine thrust reverser cascades on the controllability of the airplane in the pitch and yaw axes was determined. The available hingewise rudder deflection on the DC-10-30 is +/-23 degrees. The available elevator deflection is 16.5 degrees trailing edge down and 27 degrees trailing edge up. The rudder pedals also provide +/-10 degrees of nosewheel steering. The change in pitching and yawing moments due to the tail engine were compared with the moments provided by a fixed amount (5 percent) of elevator and rudder at various airspeeds. It was determined that the change in moments available through the use of flight controls was more than sufficient to offset the change due to the misconfigured tail engine thrust reverser at the speeds recorded by the FDR.

1.17 Additional Information

1.17.1 Flightcrew Interviews

After the accident, the members of the flightcrew were interviewed individually as part of the Safety Board's investigation. From these interviews, the approach and subsequent events are summarized as follows: When they joined the Boyds standard terminal arrival route (STAR),[16] they used the aircraft's radar to track thunderstorm activity. They saw an opening in the weather to the south of the airport that caused the captain to request a landing to the north. ATC advised that this would be disruptive to departures and that they would have to land to the south. ATC also told him that another aircraft was landing to the south ahead of him and that this aircraft had not reported any difficulties. The captain noticed that the opening in the weather to the south was filling in and agreed to land to the south on runway 17L.

Around the Bridgeport VOR at about 14 miles from the airport, they saw a brilliant flash of light and heard thunder in the cockpit which could have been associated with lightning. The flight engineer found no system malfunctions, and the cockpit instrumentation appeared to be normal. Intercepting the localizer, the CVR recorded a second lightning event that may have been lightning striking the airplane. They discussed entering the event in the aircraft logbook after arrival in DFW.

The first officer stated that he thought the weather in the area of DFW was just routine for springtime. He did ask the captain and flight engineer to be alert for indications of windshear. The visibility was reported as 6 miles, which was in excess of a 4,000 feet RVR requirement to allow the first officer to fly the approach and make the landing. The captain was performing the duties of the nonflying pilot. From the outer marker, he made the required callouts; 1000 feet, 500 feet, and thereafter for each 100 feet of altitude, giving airspeed and rate of descent.

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[16] A preplanned instrument flight rule (IFR) air traffic control arrival procedure. STARs provide transition from the en route structure to an instrument approach fix in the terminal area.

When the first officer had the runway in sight, he disconnected the autopilot but not the autothrottles. 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 that 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 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 altitude/glideslope adjustment. He was confident that the landing would be within "the desired 3,000-foot touch down zone." He said that there was no need to go around, no windshear, no airspeed, height, or alignment problem.

He 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 "weather vaned" about 5 degrees to the right. He acted "instinctively" to return to the centerline of the runway. He released the control column and used the 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 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 callouts expected of the nonflying 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 had judged the need to initiate a missed approach, the first officer replied, "I've got to trust him."

1.17.2 Douglas DC-10 Approach and Landing Procedures

In its January 1977 and September 1989 issues of *Flight Crew Newsletter*, Douglas addressed stopping the DC-10, summarized as follows:

1. Do not be afraid to delay landing. Under zero wind conditions, most runways have adequate crossfall to provide drainage under quite high rates of precipitation. It appears that drainage can be seriously affected in crosswinds above 10 knots; however, a 15- to 20-minute waiting period after a downpour is usually sufficient to drain the water.

2. Be knowledgeable of the many variables associated with landing under wet runway conditions:
   Landing weather forecast
   Aircraft weight and approach speed
   Hydroplaning speed
   Condition of tires
   Brake characteristics
   Wind effects on the aircraft on a wet runway
   Runway length and slope
   Glidepath angle

   ...and lastly remember, do not overlook or underestimate the effects of a crosswind because of its low magnitude.

3. Do not exceed 1.3 Vs + wind additives at the runway threshold.

4. Establish and maintain a stabilized approach.

5. Be prepared to go-around from the threshold.

6. Do not perform a long flare.

7. Do not allow the aircraft to drift during the flare.

8. Touchdown firmly and do not allow the aircraft to bounce.

9. If a crosswind exists, apply lateral wheel control into the wind.

10. Keep the aircraft centerline aligned with the runway centerline.

11. Antiskid braking should be applied steadily to full pedal deflection when automatic ground spoilers deploy and main wheel spinup occurs. Do not modulate brake pressure.

12. Apply maximum reverse thrust as soon as possible after main gear touchdown.

13. Be prepared to deploy ground spoilers manually if automatic deployment does not occur.

14. Get the nose of the aircraft down quickly. Do not attempt to hold the nose off for aerodynamic braking.

15. Apply forward column pressure as soon as the nosewheel is on the runway to increase weight on the nosewheel for improved steering effectiveness. Do not, however, apply excessive forward column pressure because the down elevator will unload (to some extent) the main wheels and decrease braking.

16. When the aircraft is in a skid, align the aircraft centerline with the runway centerline if you can. Get off the brakes to maximize cornering capability and bring aircraft back to runway center. If you are in a crab and cannot align aircraft centerline with runway centerline and attempted cornering is not effective, get out of reverse thrust to eliminate reverse thrust component side forces tending to push the aircraft off the side of the runway.

1.17.2.2 Handwheel Steering/Forward Pressure on the Yoke

When interviewed, the captain reported that he had tried to use the handwheel steering control to return to the runway centerline. Douglas published an All Operators Letter (AOL), dated November 6, 1986 that addresses handwheel steering control:

> The control input from the handwheel is much more sensitive than from rudder pedal steering at high speeds. Its use may result in overcontrol of nosewheel steering. Because it is difficult to judge and control the amount of handwheel input at high speeds, it is recommended that use of the handwheel be restricted to taxiing and never be used for control of the aircraft on the runway at ground speeds in excess of 15 knots.
>
> During the landing roll, should the aircraft begin moving toward the edge of the runway while at high speed, the pilot applies appropriate control inputs to stop the lateral movement and then to return to the runway centerline. If the nosewheel steering angle becomes excessive, such as through handwheel inputs or even by rudder pedal inputs on a slippery runway, the desired corrective force will be greatly decreased or even reduced to practically zero. In this situation, it may be necessary to reduce the nosewheel steering angle until steering force is regained, then cautiously reapply steering control inputs until the desired aircraft response is attained.[17]

Douglas published this information in an AOL, two flightcrew newsletters, and the DC-10 flightcrew operating manual. The Douglas precaution on the use of nosewheel steering was not included in the American Airlines "Operating Procedures" for the DC-10. However, the Douglas guidance on excessive nosewheel angles on slippery runways was included in the "Techniques" section.

In order to use the handwheel steering control, the accident captain removed his left hand from the control yoke while his right hand was occupied with engine reverse. Douglas has published information regarding the necessity for

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[17] Douglas Aircraft Company All Operators Letter, dated November 6, 1986.

forward pressure on the yoke to reduce lift and improve the steering characteristics of the nose gear in two flightcrew newsletters. Additionally, its DC-10 flightcrew operating manual contains an expanded landing roll procedures guide, which makes "nosewheel contact" a line item and emphasizes the need for forward pressure.

American Airlines states the importance of forward pressure on the yoke after touchdown in the "technique" section of its DC-10 operating manual. However, American has no procedure or technique for the pilot not flying to apply forward pressure on the yoke after touchdown. The Douglas All Operators Letter states: "The pilot not flying must apply sufficient forward pressure on the control column to maintain the nosewheel firmly on the ground for maximum directional control." Other air carriers that operate the DC-10 have made this a procedure.

1.17.2.3 Reverse Thrust

The captain stated that he did not take the engines out of reverse thrust or return to forward thrust to attempt to return to the runway centerline. Douglas, and other air carriers that operate the DC-10, have a procedure addressing the use of reverse thrust during loss of directional control on landing roll. Essentially, the procedure calls for the pilot to bring the engines out of reverse and to use forward thrust to pull the airplane back to the centerline. This procedure is considered to be a "technique" in the American Airlines DC-10 Operating Manual.

1.17.2.4 Braking

When interviewed, the flightcrew was asked if they had previous experience with maximum antiskid braking. The engineer said that he was familiar with the sound and feel of the braking cycling in antiskid braking on the DC-10.[18] He stated that he did not hear or feel the brakes cycle on the accident landing rollout.

The FDR does not record brake application. When the captain described the landing and subsequent accident, he was unable to describe his specific actions following the heading change during the landing rollout. His only reference to use of the brakes and the flight controls was that he normally did not brake until the aircraft had slowed below 100 knots and that he acted "instinctively."

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[18] Maximum antiskid braking requires full pedal deflection at 60 to 90 pounds of force.

When he was interviewed the following day, the captain made no mention of any effort to maintain the full pedal deflection.

1.17.3 American Airlines Procedures and Techniques

American Airlines' guidance on flying the DC-10 is contained in its DC-10 operating manual in two chapters entitled "Operating Procedures" and "Operating Technique," respectively. The following excerpt from the preface to the Operating Technique section explains the difference:

> A procedure is an orderly plan for doing some particular thing, and usually involves several steps. Technique is the expert manner of performing each of these steps....
>
> Proper technique is the hallmark of the professional, and a requirement for an airline crewmember.
>
> It is emphasized that the contents of this section are presented as recommended techniques, and not as regulatory-type procedures with which strict literal compliance is always required, either by the company or FAA regulations. It is recognized that, in some situations, the crew may find it necessary to modify or deviate from some of the recommendations.[19]

American Airlines did not have procedures for:

1) Holding forward pressure on the yoke after touchdown;

2) Not using the handwheel steering control at high speeds;

3) Using the elevator, aileron, and rudder after landing until the airplane decelerates below 50 knots; and

4) Coming out of reverse into forward thrust to regain directional control.

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[19] American Airlines DC-10 Operating Manual, Section 3A, page 2, Preface.

American's Operating Technique section contains the following information:

> Should the airplane begin moving toward the edge of the runway while at high speed, appropriate control inputs should be applied to stop the lateral movement and return to the runway centerline. If the nosewheel steering angle becomes excessive, because of inadvertent steering wheel inputs or even from rudder pedal inputs on a slippery runway, the desired corrective force will be greatly decreased or even reduced to practically zero. In this situation, it may be necessary to reduce the nosewheel steering angle until steering force is regained, then cautiously reapply steering control inputs until the desired aircraft response is attained.[20]

1.17.3.1 Airborne Weather Radar

There was extensive conversation between the pilots about the radar (0636:39 to 0645:51). At 0637, the captain indicated that they were 80 miles out, that he saw "yellow scud" (radar returns), and that he was "not looking at anything that even approaches red." At 0639, the first officer began to pick up red returns. Then, the captain said "...wherever the heavy stuff is, it's down low, I'm searching level right now, and uh, I wanted to see where the red is on here, and then go from there...." An unidentified voice then said "...red should be a really bad cell."

The American Airlines DC-10 operating manual classifies the colors in the radar displays as:

green -	light rainfall
yellow -	medium rainfall
red -	heavy rainfall

The color radar manufacturer's manual classifies the colors in the radar displays as:

green -	light return	rainfall rate 0.7 - 4 mm/hr
yellow -	medium return	rainfall rate 4 - 12 mm/hr

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[20] American Airlines DC-10 Operating Manual, Section 3A Operating Technique, page 13.

red - heavy return rainfall rate > than 12 mm/hr

Part 1 of American's Flight Manual contains its thunderstorm and radar policy. It does not address the color display scheme but does identify VIP levels 3 and 4 precipitation intensity as heavy and very heavy, respectively. It indicates that American considers any echo that is seen on the scope beyond 50 miles to be a "strong echo." On the CVR, the flightcrew of AAL102 described seeing echoes at 80 miles.

The flight manual defines airborne weather radar as "primarily an avoidance rather than a penetration tool." At 0641, the first officer said "I think I'm going to go through this at what about two fifty?" "Two fifty" (250 knots) is the DC-10-30's turbulence penetration speed to be used below 10,000 feet.

At 0642:23, the cockpit area microphone picked up a loud rumble that sounded like thunder. The captain described it to ATC as a "big blast of lightning" at 0642:38. The following are excerpts from the CVR transcript at 0645:

Captain: "I don't know what the # happened with this radar."

First officer: "is it not working or is it working?"

Unidentified voice: "all that line that we passed through"

Further conversation concerning the mechanical status of the airborne radar was not understandable because the volume of the radio drowned out some of the conversation during this period which was picked up by the cockpit area microphone (CAM) and recorded on the CVR.

At 0649:47, the captain asked approach control if its radar showed weather. Approach control advised that there was weather all down the final course, 15 miles on either side of the airport, and that it did not appear to be moving much. The captain stated that the final approach was a "big red area" on his scope and that they would "wait around." Approach then advised them of a DC-8 that was on final approach, 8 miles south of their position, that was experiencing a smooth ride at 3,000 feet. The captain then accepted the ILS approach to runway 17L.

The American Airlines Flight Manual provides the following guidance regarding radar:

3) Radar Procedure

a. The primary purpose of our airborne radar equipment is fixing the position of thunderstorm cells so that these areas of turbulence, and possibly hail, may be avoided. In avoiding thunderstorm cells the following cell clearance rules shall be observed.

b. When operating below 20,000 feet, aircraft may be flown through an area where radar echoes indicate a weak rainfall gradient if such action dictates that this is the best course to follow. Above 20,000 feet weak rainfall gradient areas should be avoided by 10 miles.

c. Areas where echoes indicate a steep rainfall gradient should be avoided by 20 miles at all altitudes.

American Airlines uses self-directed video tape training for airborne weather radar.

1.17.3.2 Windshear Guidance

American's operating technique section of the manual has guidance on windshear. American's list of "Identifiers of Wet Thunderstorm Microbursts" cites the following:

- Thunderstorms Forecast - Although no techniques currently exist to forecast wet microburst, crews should consider the thunderstorm forecasts contained in the terminal forecasts and severe weather advisories as a possible indication of wet microbursts.

- Visual Clues - Heavy Rain, lightning,...

  Avoidance Actions - Search for clues which may indicate the presence of severe windshear. Severe windshear has been encountered under the following conditions:

- Thunderstorm and convective clouds

- Rain

When positive indications of severe windshear exist, avoid the area by:

- In flight, divert around areas.

- On approach, initiate a go-around or hold until conditions improve.

1.17.3.3 Cockpit Resource Management (CRM) Training Program

American administers a CRM training program based upon the principles of "Authority with Participation and Assertiveness with Respect," focusing on developing a synergistic relationship between cockpit crewmembers, enhancing pilot awareness of physiological and psychological factors that affect pilot performance, and eliminating communication and attitude problems among crewmembers. All three crewmembers on AAL102 had received CRM training at American Airlines. Interviews with a CRM instructor and several captains and first officers established that the training focuses upon discussions of CRM issues present in recent major accidents and incidents.

The company does not currently integrate a CRM "practice and feedback phase" through the use of video recording equipment and crewmember critiques in its Line Oriented Flight Training (LOFT) simulator training program, with the exception of its Fokker 100 program.

1.17.3.4 Approach Procedures

For the DC-10, American's normal procedures section of the manual has the following guidance:

Basic Procedures And Crew Coordination Practices Applicable to All Instrument Approaches

After evaluating weather, wind, runway conditions, etc., the captain will specify who will fly the approach and who will make the landing. He will brief the crew on how the approach and missed approach, if necessary, will be conducted. The captain is in

> command and must take over control any time the situation requires; however, last minute changes in planned procedure should be avoided.

This section also has the DC-10 descent and landing checklists and expanded procedures for using these checklists. An approach briefing is not a line item in either of the checklists. The accident crew did not perform an approach briefing.

1.17.4 American Airlines Flightcrew Training Recordkeeping System

American Airlines used an integrated crew qualification and flight training computerized recordkeeping system. The system was approved by the FAA to meet the requirements of Federal Aviation Regulations (FAR), Part 121.683, which states, in part, "Maintain current records of each crewmember...." The FAR does not specify which training records are to be maintained.

American Airlines recordkeeping system maintains the training files of its flightcrew in a composite format. The system does not retain performance information generated during actual training, such as examination scores, and simulator instructor performance evaluations and comments. These original records were routinely disposed of for pilots who have successfully completed training, and their record of satisfactory completion is entered into the system. FAR Part 121.683 does not define "training" records and does not specify that training performance data should be maintained. No records of previous training performance for the accident flightcrew were available to Safety Board investigators, other than the record of training taken and of its satisfactory completion.

1.17.5 FAA Oversight

The FAA handbook recommends an annual training record audit. The FAA Principal Operations Inspector (POI) explained that if he were to conduct an audit, he would compare American's computer data base records to American's microfiche records. The FAA handbook recommends checking training records against an independent source, such as the FAA Oklahoma City data base. The POI had not performed an inspection of American's flightcrew training records and could not tell Safety Board investigators when such an inspection had last taken place.

2. ANALYSIS

2.1 General

The investigation found that the air traffic controllers and meteorologists were qualified, current, and properly trained.

The investigation found that the flight attendants were properly trained and qualified in accordance with applicable FARs and company requirements.

The pilots were in good general health and had proper FAA medical certificates at the time of the accident. There was no evidence of adverse medical conditions that affected the flightcrew, and there was no evidence that they were under the influence of, or impaired by, drugs or alcohol.

The flightcrew had been trained in accordance with an FAA-approved training program. The quality of the training and the procedures used by the flightcrew is discussed later is this report.

The airplane had been maintained in accordance with an FAA-approved maintenance program. Examination of the airplane's fuselage and wing structure, flight control systems, and powerplants disclosed no evidence of a malfunction that would have caused or contributed to the accident, although certain discrepancies, not considered to be a factor in the accident, were noted during the investigation.

All three thrust reversers were found fully deployed, as evidenced by jackscrew actuator positions. However, on the No. 2 engine, two of the reverser cascades were found to be improperly configured. The resultant differences in the angles of thrust from the vanes of the two misconfigured cascades would have partially changed the reverser air flow pattern or "efflux." With the No. 2 engine in reverse thrust, the airflow would have been altered from a vertical (thrusting downward) direction to a near-horizontal direction, and from an inboard direction (toward the fuselage centerline) to an outboard direction (away from the fuselage). The reduction in the vertical component of airflow would have reduced the nose-down pitching moment of the airplane and lessened the down force on the nosewheel, with the No. 2 engine in reverse thrust.

There also would have been a component of thrust vectored horizontally away from the right side of the center engine, with the engine in full reverse thrust. The evidence showed that the force in full reverse would have generated a relatively small nose-right yawing moment of approximately 1/10 the moment that could be generated by 10 degrees of rudder deflection during the turn off the runway. Therefore, there was ample rudder and elevator authority to redirect the airplane and overcome any input from the two misconfigured No. 2 engine cascades.

The brakes were found to be within service limits. Although 5 of the 20 antiskid valves tested for response to electrical signals were found out of design limits for new parts, the manufacturer stated that the mode in which the valves exceeded tolerances would have made it less likely for the affected wheels to skid. A change in pressure would only come after the pilot or pilots had released main wheel brake pressure, then reapplied pressure. The Safety Board concludes that the evidence shows that the antiskid system was functioning properly and was not considered a factor in this accident.

The two nosewheel steering cables and pulley bracket found broken in the nose landing gear compartment were caused by overload. The evidence showed that the failures were a result of the accident, not a cause. That is, the forces and damage that occurred during the collapse of the nose landing gear led to the broken components.

The broken cables fit a pattern of damage along the aft nose landing gear (NLG) compartment wall. During the accident, the NLG collapsed aft, and the bottom of the wall acted as a plow in the soil. The bent and broken bracket was dislodged in an upward direction. Mud packed under compartment protrusions, and torn and shredded insulation blankets, provided further evidence of the upward forces in the wheel well following impact. Even if the cables had not been broken as the general pattern of damage was occurring, the fuselage separation under the L-1/R-1 doors crossed the cable routing. If the cables had failed first, the pulleys and bracket would not have been damaged, nor would the cables have damaged the compartment pressure seal.

Although perpendicular scratches were seen on the NLG tires, the treads were intact and not distinctly different. If the NLG had turned to the side, one tire would have been lifted and the other would have suffered abrasion or hydroplaning. However, no reverted rubber was seen on either NLG tire.

The Auto Ground Spoiler indicator on the fault isolation panel was found in the "set" position. The Safety Board concludes that this was most likely due to fire damage to the spoiler position wiring in the left wing and not due to any malfunction of the autoground spoiler system.

This accident occurred following an instrument approach made in the presence of strong winds and rain showers resulting from thunderstorms moving across the airport at the time of the approach and landing. The first officer had elected to abandon the landing approach about 50 feet above the runway because he believed the airplane was not in a position to make a safe landing. The captain elected to take control of the airplane and land. The airplane was landed on speed and on centerline but long (4,303 feet from the approach end of 17L). However, shortly after the airplane landed, it began to drift to the right, left the runway surface, and came to rest off the runway with substantial damage to the airframe.

The Safety Board's analysis of this accident included examination of the conditions that could have caused or contributed to this event, including the decision of the flightcrew to initiate and continue the approach, and their failure to maintain the airplane on the runway after the landing. The Safety Board examined the accuracy and communication of weather information to the flightcrew by American Airlines, the NWS, and ATC, the effects of the weather conditions on the performance of the airplane, American Airlines' procedures and training for its flightcrews, and the decisions and actions by the flightcrew. The analysis also examined the postaccident events related to the emergency evacuation.

2.2 Weather Aspects

2.2.1 Weather Planning and Forecasts

Prior to departure from HNL, the flightcrew of AAL102 received weather reports indicating that about the time of their anticipated arrival at DFW, thunderstorms would be in the vicinity. The captain revealed this information when he briefed the cabincrew at HNL. There was ample opportunity before and during the approximately 8 1/2 hour flight from HNL to brief a variety of normal and abnormal procedures regarding the anticipated flight into thunderstorm conditions at the destination. There was, however, no indication either from the statements of the flightcrew or on the CVR that briefings regarding the approach and possible go-around procedures at DFW were conducted ahead of time.

The forecaster for American Airlines amended the DFW FT at 0600 to reflect expected worsening conditions at the airport. The worse conditions forecast at the arrival time of AAL102 were "occasional ceiling 600 feet overcast, visibility 1 mile, with thunderstorms and moderate rain showers." The surface wind forecast was "variable 15 knots, gusting 20 knots."

A Terminal SIGMEC for DFW was valid from 0358 to 1000 on April 14, 1993. The SIGMEC, advised, in part, occasional thunderstorms, with heavy rain, low level windshear, surface wind gusts to 40 knots, and frequent lightning expected in the vicinity of DFW by 0700.

According to American Airlines personnel, terminal SIGMECs were disseminated via ARINC immediately upon issuance and were also attached to changeover information messages, if issued within 1-hour of landing. The flight log for AAL102 indicated that receipt of the terminal SIGMEC for DFW was at 0423 on April 14, 1993. However, the SIGMEC advisory was not attached to the two changeover information messages provided to the crew at 0624 and 0646. The Safety Board believes that an extra margin of safety could be realized if pertinent Terminal SIGMECs were appended to all changeover information messages during the valid period.

American Airlines meteorologists also provided oral weather briefings to incoming shifts of company flight dispatchers. The briefings were taped so that dispatchers could review the forecasts as needed during their shifts. The 0615 weather briefing tape was not retained, and, when he was interviewed, the forecaster did not specifically recall what he said during the briefing. The Safety Board believes that American Airlines should require that pertinent briefing tapes be retained for a suitable period in the event of a future need to reconstruct the briefing.

Federal Regulations 14 CFR, Part 121.599 and 121.601, require that airline dispatchers be thoroughly familiar with reported and forecast weather, and that they provide pertinent weather information to the pilot-in-command that might affect the safety of the flight. The dispatchers responsible for AAL102 provided the flightcrew with appropriate American Airlines advisories and forecasts. A company PIREP was also sent to the crew at 0532, about 1 1/2 hours before the airplane landed at DFW.

In summary, American Airlines meteorology and flight dispatch sections correctly advised AAL102 of expected thunderstorms, moderate-to-heavy rain showers, low-level windshear, and variable surface winds, gusting 20 to 40 knots, upon arrival at DFW.

The contract weather observer at DFW accomplished two hourly and four special weather observations between 0550 and 0701 on April 14, 1993. The observations show timeliness and good quality.

DFW weather observations were disseminated via a computer, located in the weather observatory, to the Wichita Falls, Texas, Weather Service Office and then through a distribution circuit to the Fort Worth Forecast Office. The FAA provided a dedicated link from the forecast office to DFW.

On the day of the accident, the dissemination computer in the weather observatory was out of service between 0515 and 1315. As a backup, the weather observer telephoned the observations to personnel in the Fort Worth Forecast Office, who then typed them into a communications computer. Postaccident investigation found that the 0635 special observation was disseminated at 0637, the 0639 special observation was disseminated at 0643, and the 0650 hourly observation was disseminated at 0656.

Delays in transmission of the surface weather observations were not a factor in the accident. However, a concern remains that critical weather observations could be unacceptably delayed when communications circuits are down. Moreover, it is possible that in some circumstances, the weather observer would not know that his observations did not ultimately reach ATC personnel. The implementation of the Automatic Surface Observing System (ASOS) should relieve these concerns.

The NWS FT prepared by the Fort Worth Forecast Office, which was valid at the time of the accident, called for prevailing visual flight rules (VFR) conditions, with occasional thunderstorms and moderate rain showers. In addition, the FT advised of a chance of severe thunderstorms, ceiling of 800 feet obscured, visibility 1 mile in heavy rain showers, hail and wind gusts to 50 knots. According to NWS guidelines, no amendment was required.

The forecast office also issued local airport advisories for DFW, as required. No advisories were issued or required during the morning of April 14, 1993.

The NSSFC followed NWS guidelines in issuing convective SIGMETs 44C and 45C, at 0555, April 14, 1993, and Convective SIGMET 48C at 0655.

2.2.2 Movement of Thunderstorms Across DFW

During the final approach of AAL102, cloud bases north of DFW were, from the evidence, likely 1,000 to 2,000 feet broken to overcast. The UND Doppler radar at 0650:23 showed an area of radar echoes up to and including VIP level 4 intensity, northwest through north of the airport. Cockpit communications and sounds similar to windshield wipers, recorded on the CVR, indicated that AAL102 was in and out of thunderstorms and rain showers during most of its approach. The flightcrew reported runway lights in sight, at 0658:14, and the airplane touched down on 17L at 0659:29.

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 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 7 miles west of 17L. The UND Doppler radar 0.5-degree tilt scan[19] at 0650:23 showed that the line was slightly west of the airport complex. The LLWAS west sensor went into sector alert at 0653:25, as the line traversed that area.

Radar returns from the UND radar 0.5-degree tilt scan 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 -4 echoes were just west of 18R.

The runway visual range (RVR) sensor for 17L was located midway between 17R and 17L, approximately 1,000 feet south of the thresholds. According to the NWS recording, the RVR began a marked decrease around 0659 and stabilized between 0700 and 0701. This decrease in runway visibility is consistent

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[19] At 0.5-degree antenna elevation, the height of the center of the radar beam was about 1,200 feet to 1,400 feet msl over the airport.

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 17R, later stated:

> The aircraft [AAL102] appeared to be in the normal attitude and altitude for landing as he crossed the runway threshold.[20] The rain had just picked up to a more moderate to almost heavy level as I watched him for a very short time.

An airfield operations assistant officer was parked on the south taxiway J at about 0655. In a letter to the Safety Board, he stated, "Precipitation had been variable with light moderate and heavy rain. Visibility was poor...."

The NWS rain gauge was located about 1/4 mile east of 17L, approximately opposite the location where AAL102 came to rest. According to the recorder and NWS observers, the rain showers began to increase at the gauge and in the vicinity of the Delta Air Lines hangar around 0658, and heavy rain showers began at those locations about 0700. Delta Air Lines mechanics located at the hangar reported that, about 0700, the rain was "heavy and constant...blowing in sheets to the east across the ramp."

The evidence suggests that the line of rain showers and thunderstorms probably started in the vicinity of the south end of 17L a little after 0657, becoming heavier 1 to 2 minutes later. While this timing is generally consistent with the reduced RVR readings at the north end of 17L, it would seem to indicate that the leading edge of the heavier precipitation was slightly farther east, in the vicinity of the southern portion of the runway. ASR-9 radar data between 0659 and 0700 confirms a slight north-northwest to south-southeast orientation to the line traversing the airport. Finally, an advected UND 3-D radar plot prepared by MIT/Lincoln Laboratories for 0659:04 indicates heavier radar echoes just to the west of the northern end of 17L. At the southern end of the runway, the plot indicates that cells at that time were slightly to the east of the runway. The UND Doppler radar accomplished a 0.5-degree tilt scan at 0701:56. Radar returns showed predominately equivalent VIP level-3 radar returns along and east of 17L.

In summary, the evidence shows that a line of moderate to heavy rain showers and thunderstorms was crossing runway 17L as AAL102 was landing. The

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[20] AAL102 crossed the runway threshold about 0659:11.

flightcrew of AAL102 should have had sufficient information to realize that this was occurring at the time of the landing.

2.2.3 Centerfield Anemometer Wind Reports From 0656 to 0701

The FAA centerfield anemometer (CFA) was approximately 1,450 feet east of the centerline of 17L, and the NWS anemometer was approximately 50 feet south and 10 feet east of the CFA. The elevation of both instruments was about 20 feet agl. CFA-measured winds were normally collected at 10-second intervals, with the output recorded as a running weighted 7- to 10-second average. By international convention, a 2-minute average wind was computed and supplied to landing and departing aircraft. A gust meter at the CFA provided a 1-second average of the highest winds in a 10-second period. A gust was noted on the display in the tower whenever it equaled or exceeded the 2-minute average speed by 10 knots or greater. The NWS anemometer displayed instantaneous winds at the weather office and maintained a gust recording in the office. Wind directions from the NWS anemometer were not recorded or archived.

An initial comparison of the NWS gust recorder and the FAA CFA data revealed an apparent discrepancy in the timing of the strong wind gusts passing over their locations. The NWS showed a peak gust of 33 knots at 0700, while the CFA indicated a gust to 32 knots between 0700:55 and 0701:05. Since the FAA LLWAS computer clock was found to be accurate within 2 seconds of the WWV (call letters for the U.S. Government time standard broadcast station), the LLWAS winds were used in lieu of the NWS gust recorder. A detailed correlation of wind speeds between the two sensors showed that the NWS gust recorder was probably about 1-minute slow around the time of the accident.

The ATC tower controller gave AAL102 a report of "wind calm," at 0656:39. The 2-minute data showed that calm winds were displayed in the tower until 0658:25. The CFA 2-minute average wind speed then began gradually increasing, and, at 0658:55, the CFA wind speed was reported as 290 degrees magnetic at 4 knots, gusting to 14 knots. The tower CFA display at the time of touchdown was 300 degrees magnetic at 7 knots.

The 10-second CFA LLWAS data showed a near-calm wind at 0656:39, and a wind speed of 5 knots at 0658:05. The wind speed then steadily increased, and, at touchdown, the 10-second data reported the wind to be 302 degrees magnetic at 14 knots. The 10-second average wind speed reached a peak of 25 knots at 0701:25. A gust of 25 knots was recorded between 0700:45 and 0700:55, and a maximum gust of 32 knots was recorded during the following 10 seconds. The computed average cross-track wind speed increased to about 20 knots at 0700:55 and to 24 knots during the following 10 seconds. The gust to 32 knots, recorded between 0700:55 and 0701:05, yielded a maximum cross-track wind of 31 knots.

2.2.4 Winds Affecting AAL102

It is impossible to determine the exact magnitude and direction of the wind during the period the airplane was on the runway. However, the data do allow for a reasonable estimate of the wind conditions experienced by the airplane.

Using an eastward translation of the line of showers and thunderstorms of 23 knots, winds measured at the CFA would have passed over 17L about 37 seconds earlier. Since the airplane touched down at 0659:29, the CFA 10-second average wind from 0700:05 was considered appropriate for the time of touchdown. That wind was reported to be 295 degrees magnetic, at 16 knots. Ten seconds later at 0700:15, the CFA 10-second average wind was reported to be 282 degrees magnetic, at 16 knots. No gusts were reported during the above 20-second period; however, the wind could have gusted to 21 knots without triggering the CFA gust meter. The computed CFA cross-track winds at 0700:05 and 0700:15 were approximately 14 knots and 15 knots, respectively.

The 10-second wind for 0659:35 from the northeast LLWAS sensor (located about 7,300 feet due north of the touchdown point) was 275 degrees magnetic at 14 knots. That wind was consistent with the estimated touchdown wind mentioned in the previous paragraph. The strongest wind speed reported by the northeast LLWAS sensor was 25 knots at 0700:25.

Based on witness statements, radar data, and weather information, a wind surge was associated with the line of showers and thunderstorms moving across the airport. At the time of touchdown, the Safety Board believes that the leading edge of the line of heavier showers and thunderstorms was located in the vicinity of 17L. It is likely that the wind gusts of 25 to 32 knots, which occurred about 0701 at the CFA, did not affect the airplane. However, based on the meteorological data, the Safety Board could not rule out that the airplane experienced similar wind speed surges while on the runway.

2.2.5 LLWAS System Testing

The Safety Board supervised examination and testing of the LLWAS to determine if the system functioned properly at the time of the accident. FAA maintenance technicians performed evaluations of the system on April 15 and 16, 1993, and again on May 6, 1993. The evaluations revealed that some of the potentiometer outputs of the west, northwest, and centerfield wind sensors were "out-of-tolerance."

Subsequently, the three suspect out-of-tolerance anemometers were shipped to the manufacturer for further examination under Safety Board supervision. Additional factory tests on June 7, 1993, showed that the centerfield sensor outputs were within tolerance and that the northwest sensor outputs were only slightly outside the established limits. The west sensor outputs were substantially out-of-tolerance, which caused the manufacturer to surmise that the sensor might have been damaged by a transient input. The manufacturer stated that the centerfield and northwest sensors were unlikely to have contributed significant errors into the system.

Although three anemometers failed to meet published calibration standards, postaccident evaluations revealed that the wind speed and direction outputs of the individual sensors were not significantly in error and did not seriously impact the windshear alert algorithm.

2.2.6 Windshear Algorithm

The LLWAS II algorithm, in place at DFW at the time of the accident, had a modest capability to detect wind field divergence. However, the algorithm relied mainly on comparing each sensor wind with the mean network wind and issuing a windshear sector alert when a predetermined threshold was reached.

On April 14, 1993, the system issued a windshear alert from 0653:25 to 0655:35 for the west sensor. No other sensors alerted as the line of showers and thunderstorms traversed the airport complex. No divergent windshear was indicated.

2.3 Air Traffic Control

Air traffic control, specifically the Fort Worth Center and the two DFW approach controllers, kept the accident flight and other flights updated regarding current weather on approach to DFW. They answered requests for weather information, and provided clearances to deviate around weather cells. The accident flightcrew requested and was granted two such clearances during the approach. Although the controllers neglected to advise the pilot of an ATIS update, the procedures used by the controllers were otherwise in accordance with the FAA Air Traffic Control handbook, Order 7110.65, and local orders. Additionally, although the controllers were not able to accommodate all requests by the flight during its arrival sequence, and the flight did not receive a windshear advisory that was relevant to its situation, these events resulted from operational and procedural constraints and did not contribute to the accident. The events are discussed below.

At 0643:09, the Feeder West controller at the Dallas/Fort Worth TRACON received the request to land in the opposite direction made by the flightcrew of AAL102 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 requested by AAL102, occur at DFW, airport operations, arrivals, and departures, must be stopped at nearby airports, such as Dallas Love Field, NAS Dallas, Addison Field, and Meacham Field. 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 that unless an emergency condition exists, opposite direction approaches[21] will not be conducted. Furthermore, the weather conditions at the time of the request did not warrant a runway change. Therefore, because of the combination of the operational impact on the surrounding airports, and the local order, the controller appropriately denied the opposite direction arrival request from the flightcrew of AAL102.

At 0650:23, the Arrival 2 controller instructed the flightcrew of AAL102 to turn southbound toward the airport, although there was precipitation depicted in that area on the controller's radar display. The captain of AAL102 stated, "Ah I don't think we're going to be able to do that that's ah pretty big red area on our scope ah it's about ninety degrees and that's about what we're looking at ah

[21] Approaches opposite its established flow of arriving and departing flights.

we're going to have to just go out I guess and wait around to see what's going on here." It is noteworthy that the controller's radar display does not indicate the various intensities of precipitation, as does the pilot's display. The controller then issued a pilot report which had been received from a pilot of a preceding DC-8 which was on approach to 18R. The report indicated that the ride was "smooth." Based on this information, the flightcrew of AAL102 elected to turn inbound and subsequently complied with the controller's amended instructions.

At 0656:36, the flightcrew of AAL102 made initial contact with the local controller. The controller stated, "American one oh two heavy regional tower runway one seven left cleared to land wind calm." Although a windshear 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 windshear alert, a windshear 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 windshear advisory was not broadcast until after the accident had occurred.

Although the flightcrew of AAL102 did not receive the windshear 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 AAL102 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 5 knots on short final.

Despite the availability of an ATIS, the information may not be immediately available because of the time required to record and review the revised ATIS broadcast. Even if a recording were broadcast in a timely fashion, pilots normally would not monitor the ATIS while they were on final approach because of high workload. Because pilots rely on controllers to issue pertinent weather information, such as windshear alerts, in a timely fashion, the Safety Board believes that the ATC handbook should be amended to require controllers to continue to verbally broadcast windshear 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 windshear was not a factor in this accident, the rapidly changing weather conditions occurring at the airport might have been more apparent to the flightcrew of AAL102 if a timely windshear advisory had been made.

There is no requirement for tower controllers to continually display or relay information from LLWAS wind sensors other than the one located at the centerfield site. In the tower cab, centerfield wind information is always displayed because of the requirement for controllers to issue the wind direction and speed from this sensor. Wind information from the LLWAS wind sensors is displayed only when a windshear alert condition exists or if the controller selects a particular sensor for display of its information. This is accomplished by pressing the sensor button for that specific site.

During the approach of AAL102, when the controller issued "wind calm" in the clearance to land at 0656:39, the west wind sensor indicated 270 degrees at 16 knots. The difference in the west wind sensor and the network mean wind was not enough to trigger a windshear alert. This information, however, would have been important to the flightcrew because it indicated the highly variable nature of the wind at the airport. If the flightcrew had had this additional information, it could have assisted them in their decision to land or to execute a missed approach. Although the lack of wind information from the west sensor is not considered to be a contributing factor in this specific accident, the Safety Board believes that providing such wind sensor information to flightcrews would be a safety improvement in the ATC system.

In summary, the Safety Board concludes that ATC services were provided in accordance with established procedures and were not causal to the accident.

2.4 Flightcrew Actions During Approach and Landing

2.4.1 General

By the time the airplane was on final approach for landing, the flightcrew had already undergone a series of weather-related difficulties and decisions, including two possible lightning strikes, two requests by the captain to DFW approach control for vectors around weather cells, which were accepted, and requests to Fort Worth Center and DFW approach control to land to the north, which were denied. Then, about 50 feet agl, the first officer stated that he was "gonna go around." The captain said, "No, no, no I, I got it." The first officer said, "you got the airplane." The actual transfer of control probably took place about 40 feet agl. The captain's decision at that low altitude to assume control and land the airplane certainly was within his authority; however, it left him with virtually no time to communicate with the first officer or flight engineer, or to assess conditions affecting the airplane, including wind direction and velocity, rain, rate of descent, speed and runway alignment. By overruling the first officer's decision to abort the landing, the captain committed the airplane to landing long on a rain and crosswind-swept runway.

2.4.2 Pilot Actions and Company Procedures

During the Safety Board's interviews of the flightcrew, the first officer indicated that he elected to go around because he believed the airplane was "high" and that too much nose-down control input would be needed to make the landing. The captain stated that he took control of the airplane because he thought that the first officer was having difficulty aligning the airplane with the runway.

The investigation determined that the airplane touched down, on the runway centerline, about 4,303 feet from the approach end of 17L.[22] The Airman's Information Manual defines the first 3,000 feet of runway, beginning at the threshold, as the "touchdown zone." The recommended touchdown point is 1,000 feet from the approach end of the runway. When interviewed, the captain stated that he was confident that his landing was "within the desired first 3,000 feet."

The FDR indicates that the reversers were deployed and thrust was increasing about 4 seconds after touchdown. The reverse thrust level was approximately 83 to 85 percent N1 (or turbine speed) on all three engines; thrust on engine Nos. 1 and 3 was symmetrical. Immediately after touchdown, the captain applied forward pressure to assist in holding the nosewheel down on the runway. Analysis of the FDR data indicate a negative or down elevator, resulting in aerodynamically nose-down forces, during about the first 7 seconds after touchdown. Immediately thereafter, the elevator position went to a near neutral or in-trail position and showed virtually no movement for approximately 12 seconds, until about the time the airplane departed the south side of taxiway 3S. The Safety Board believes that when the elevator went to a neutral or in-trail position, the captain moved his left hand from the yoke to place it on the tiller (handwheel) to commence nosewheel steering.

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[22]The runway touchdown point is derived from radar data, calculations, and tire marks.

The captain said that after touchdown the airplane "weathervaned" about 5 degrees to the right. It would be expected that if an airplane "weathervaned" and the tires were hydroplaning, the airplane's nose would turn into the wind and the airplane would track downwind, or left of runway centerline. The investigation found that while the airplane's nose turned to the right, most likely due to the right cross wind acting upon the vertical stabilizer, the airplane did not track downwind, or to the left. Rather, it tracked into the direction the nose was pointing, until, as the tire marks show, the airplane tracked off the right side of the runway. Therefore, the direction of the airplane track off the right side of the runway indicates that the main landing gear tires had enough friction to allow cornering and therefore were not hydroplaning. During this same time period, the FDR indicates that there was little input into the flight controls to maintain the airplane on the runway. For example, the FDR indicates that below 118 knots there was very little input into the rudder which was capable of 23 degrees of travel from center. Also, there was virtually no input into the elevator or ailerons.

The captain stated that he acted "instinctively" to get back to the centerline of the runway. He stated that when the airplane did not respond, "there was nothing we could do but hang on."

The FDR shows that after touchdown, below 120 knots, the rudder remained near a neutral position, except for a momentary deflection of 15 degrees, about 11 seconds after touchdown. The rudder remained near neutral until the airplane departed the runway. Both the rudder pedals and the tiller (handwheel), provide nose gear steering. The movement of the rudder pedals provides corresponding deflection of the nosewheel up to 10 degrees either side of neutral. Movement of the handwheel or tiller steering control will override the rudder pedal control and provides up to 68 degrees of deflection, either side of neutral. The intended use of the handwheel is to make turns at low speeds.

DAC 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, two flightcrew 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 nonflying pilot to apply forward pressure on the yoke after touchdown.

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 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 contains an "Expanded Landing Roll Procedures Guide," which cites nosewheel-to-runway contact as a line item and emphasizes the need for forward pressure. The recommendation states:

> The pilot not flying must apply sufficient forward pressure on the control column to maintain the nosewheel firmly on the ground for maximum directional control.

For about 7 seconds, about 1-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 the postaccident 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 Technique section of American Airlines DC-10 Operating Manual, Section 3A, does discuss the possibility of the airplane "...moving toward the edge of the runway while at high speed...." However, it 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 nonflying pilot to hold forward pressure on the yoke, is considered ineffective. Further, the technique could lead one to believe that the use of the 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 understands that certain aspects of air carrier line flying involve the use of "techniques" that are not necessarily procedural in nature. However, 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 nonstandard 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 flightcrew actions that are expected to be used are properly included in the Procedures section of the manual.

In postaccident interviews, the flightcrew was asked if they had previous experience with maximum antiskid braking. The flight engineer stated that he was familiar with the sound and feel of the brakes cycling in antiskid braking on the DC-10. He stated that he did not hear or feel the brakes cycle during the landing rollout.

The FDR does not record brake application. However, when the captain described the landing and rollout, he stated that he normally did not brake until the aircraft had slowed below 100 knots. Maximum antiskid braking requires full pedal deflection at 60 to 90 pounds of force. The captain's discussion of acting "instinctively" did not mention full pedal deflection.

2.4.3 Landing Briefing

Safety Board investigators were unable to find specific American Airlines operations policy on when and where a captain should brief specific procedures, emergency or otherwise. There is a requirement that the captain brief the approach and, if appropriate, possible missed approach procedures.[23] However, there is no specific policy regarding such a briefing if the captain were to take over the airplane during the approach. A reasonably opportune time to brief significant procedures with the flightcrew is prior to the beginning of the approach. Understandably, all possible procedures cannot be briefed for every approach; however, prior to the beginning of the airplane's approach into DFW, no briefings on approach, landing, or go around procedures, emergency or otherwise, were conducted.

Without an approach briefing, the flightcrew must fall back upon standardized operational training. After the captain countermanded his 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.

When American Airlines line 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,

[23]Reference American Airlines Operators Manual on the duties of a captain in briefing the flightcrew prior to approach and landing.

especially during emergencies, when their input into the flight controls may be needed.

2.5 Flightcrew Decision-Making

The Safety Board examined the actions and decisions of the captain and the first officer upon their arrival into the DFW terminal environment to determine the effect, if any, such performance may have had on the accident. The evidence indicates that the captain and the first officer were aware of and were prepared for the possibility of encountering severe weather on the approach into DFW. The weather information that the crew received in HNL called for adverse weather upon their arrival into the DFW. Center and arrival controllers gave the crew updates on the weather, including a real time identification of storm cells lying over the final approach path that the arrival controller saw on his radar scope. Moreover, the CVR indicates that the crew had numerous discussions about the weather, and added airspeed, as appropriate, to mitigate against the likelihood of encountering windshear.

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 AAL102 proceeded to the ILS approach to 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 17L, this condition was not inherently unsafe. The DC-8, which had landed on 18R about 4 minutes before AAL102, had reported a "smooth ride" that had been passed by an approach controller to AAL102. Also, on approach to 17L behind AAL102, an SA-340 captain, who flew a missed approach beginning about 600 feet agl, reported that he experienced light to moderate turbulence during the approach and no windshear activity.

The captain of AAL102 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 to go 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 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 this 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 lead the Safety Board to believe that the captain might have been fatigued to some extent. Even though the circumstances surrounding the flightcrew'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.

2.6 AAL Pilot Training Program and Recordkeeping

The Safety Board attempted to obtain information about the quality of the past training and checking performance of the flightcrew of AAL102 from American Airlines, but was unable to do so because of the lack of detailed information in the records. The FAA-approved recordkeeping system only provided information on when pilots completed required actions such as flight checks. Their performance on the 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 flightcrew on AAL102 was an aberration or was consistent with a performance decrement.

The Safety Board was concerned to learn that American Airlines did not maintain individual pilot training files in any more detail than pass/fail records. Although this recordkeeping might have satisfied minimal training, oversight, and regulatory requirements, it restricts the airline's ability to monitor the long-term training, performance, and personal history of its individual pilots and prevents it from tailoring or modifying training for its pilots. Without adequate recordkeeping, not only was the Safety Board at a disadvantage in establishing the quality of the training received by the accident flightcrew, but American Airlines and the FAA were equally disadvantaged in assessing the effectiveness of the training program.

The FAA DC-10 program manager for American Airlines, FAA Inspectors, and American Airlines instructor, check, and line pilots were interviewed regarding the pilot training records system. The FAA program manager said that American Airlines was conducting training and keeping records properly, doing things as "we do," and that he expressed no need for the operator to keep more detailed training records, specifically those on pilot performance in simulator training, and passed or failed check rides.

The American Airlines simulator check captain stated that he looked at written performance records of pilots prior to the check. However, he did not express an extensive interest in their written training records because he wanted to give the checks with no preconceived notions regarding the pilots. He also stated that after examining the training evaluations of pilots, he tore them up. Thus, the basic training records, specifically those that would differentiate one pilot from another in performance or capability, were kept in the form of a "Pass" or "Fail" record. Nevertheless, the check captain showed interest in keeping records of reasons why a pilot had failed a check ride. However, written evaluations for pilots who had completed training and check flights were not retained.

The FAA's principal operations inspector (POI) for American Airlines stated he believed that checking the operator's computer recordkeeping of pilot training records against the FAA's own American Airlines-related microfiche records was an adequate means for inspecting such records. The FAA handbook recommends the checking of an operator's training records against an independent source, such as the FAA's Oklahoma City data base. However, during the interviews, the POI stated that he had never performed a records inspection on American Airlines training records and that he could not recall when such an inspection of the operator had last been accomplished. The Safety Board believes more emphasis should be placed on the examination of pilot training procedures and records.

The Safety Board's investigation included formal depositions of American Airlines line, training, and check captains, including captains who worked at training management positions. When investigators asked questions relative to corporate policies, operational practices, and performance history of the accident flightcrew, the general responses were in agreement with the actions of the accident flightcrew. The investigation found no evidence that the operator had previously identified any adverse performance characteristics in training or operational difficulties for the flightcrew.

In the past, the Safety Board has urged the FAA to ensure that airlines examine their maintenance and inspection programs to determine if trends exist that might suggest possible difficulties with a particular aircraft, or with particular maintenance practice. In fact, there are specific regulations governing airline maintenance quality assurance programs. The Safety Board believes that the quality of the training and checking of flightcrews operating the aircraft is equally as important as the quality of an aircraft maintenance program.

At the time of the accident, American 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 recordkeeping 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 flightcrew 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 flightcrew 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. Therefore, the Safety Board urges the FAA to review the recordkeeping systems of airlines operating under FAR 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.

2.7 Survival Factors and Airport Fire and Rescue

The cabin crewmembers performed in a professional manner in assisting 189 passengers, a high percentage of which were of retirement age, off the airplane. The evacuation was complicated and difficult. The cabin emergency lighting, by witness accounts, worked, at best, only temporarily in the forward coach cabin and not at all in the rear coach cabin. The result was a darkened cabin after the airplane came to rest. Furthermore, because the nose gear and left main landing gear were fractured, the airplane came to rest in an approximately 10-degree left wing down and slight nose-down pitch attitude. Consequently, as a result of this fuselage attitude, the emergency evacuation slides, for the two right rear cabin exits, were deployed at nearly a vertical angle.

A fire was apparent outside the aft left side of the cabin, providing a glow into the otherwise dark aft cabin. Cabin crewmembers and many passengers later stated that all of them knew of the urgency of evacuating the airplane as quickly as possible, and several persons later described a deliberate attempt by nearly everyone to remain calm. Nevertheless, some passengers were injured as they fell to the base of 3- and 4-R slides and became stuck in the mud as others fell on top of them. A flight attendant made a self-described difficult decision to exit his station at 3-R, and walk out onto the right wing to try to see why there was a holdup of passengers on the wing at the top of the 3-R slide. When he looked down and saw the steepness of the slide and some of the elderly who seemed to nearly fall down the vertical slide, he made the decision to direct the remaining passengers back into the cabin, although he knew that there were flames out the aft left cabin windows, and to move them forward to another exit.

The Safety Board finds these actions exemplary. As a result of the actions of the cabin crewmembers, all persons exited the airplane, and there were only two serious fracture injuries.

DFW airport fire department personnel estimated that they arrived at the airplane around 0701, about 1 minute from the time the airplane came to rest, with persons still coming out of the cabin. Their performance in responding to the accident scene was well within the established guidelines and permitted rapid extinguishing of the fire on the left side of the airplane.

Several flight attendants and passengers said that during the emergency evacuation they did not see cabin emergency lights illuminate. The aft coach cabin was described as extremely dark or black. Two DFW fire fighters, who conducted the postevacuation cabin search, stated that they had to use the emergency flashlights that were located in the cockpit.

The Safety Board conducted a functional test of the emergency lighting system on the airplane on April 16, 1993. The floor path lighting illuminated on the left side of the aft section of the cabin, but no other cabin emergency lights illuminated.

Both emergency lighting subsystems were independent of each other, and they linked together at the emergency light switches in the cockpit and at the 1-L flight attendant's station. The entire cabin emergency lighting system is designed to activate automatically whenever the airplane's electrical system is shut down or when the engine fire suppression system is activated. The system-activating cockpit switch was found by investigators in the "standby" position, and the switch at the 1-L flight attendant station was found in the "off" position.

No deficiencies were found in either the subsystem or in the components on the airplane. The cockpit and 1-L flight attendant activation switches were found functional. In addition, voltage and impedance tests conducted on the wiring of each subsystem indicated no deficiencies.

Additional testing was done under Safety Board supervision on both subsystems at the facilities of their manufacturers. This inspection and testing determined that the Gulton systems battery pack had been reassembled improperly during maintenance. There was no evidence of improper assembly by the manufacturer. The individual battery packs (constituting 24 batteries for each of the four battery charging units) are required by maintenance scheduling to be replaced in the same sequence as they were previously installed on the airplane. Three of the four battery packs were found to have been configured improperly. With the improper configuration, enough electrical power would have been provided to indicate an "up system" in battery tests but not enough power to energize the emergency lights in the actual emergency. Upon receiving this information, American Airlines issued an Engineering Service Order and initiated an inspection of battery stores in all airplanes that might have been affected by the configuration.

2.8 Landing Runway Surface Conditions

It is apparent that the surface texture of 17L-35R had deteriorated with use, or as a result of high levels of jet traffic and weather-related erosion. FAA guidance, as stated in FAA Advisory Circular (AC) 150/5320-12B, addresses runway wear. Although, by definition, "maintenance planning" for this runway was called for, the friction levels of the majority of the runway fell within acceptable levels for airplane operations. Furthermore, as described below, there is no evidence that the airplane entered hydroplaning on the runway or that traction was significantly reduced because of the condition of the runway.

The investigation found a buildup of rubber at the approach end of 17L that showed a coefficient of friction below the FAA minimum standard. According to airport records, for the past 3 years, rubber removal was conducted at 4- and 8-month intervals. There was an average of 261 landings on 17L each day. FAA guidance suggests a rubber removal frequency of every 2 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. 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 FAA provides guidance in advisory circulars for runway friction measurement and runway maintenance. However, there is no formal requirement for FAA oversight of airports regularly performing friction measurements. In addition, there are no formal requirements for the FAA to regularly inspect certificated airports to ensure that they have adequate friction measurement or, if necessary, rubber removal programs.

The Safety Board has addressed the subject of runway friction since 1973 when Safety Recommendation A-74-119 was issued to the FAA to:

> Amend appropriate regulations and procedures to establish an alerting service to advise pilots of hydroplaning probabilities before and during the landing approach. Such an advisory system would entail (1) A runway slipperiness rating and runway contamination monitoring program; and (2) The use of measuring devices and associated charts to correlate rainfall, wind direction, and velocity, with runway gradient and water depth on the runway surface.

Safety Recommendation A-74-119 was superseded by the recommendations issued with the accident report on the January 23, 1982, World Airways accident at the Boston-Logan Airport. The applicable recommendations in the Boston-Logan World Airways report were superseded by the recommendations in the report on the October 25, 1986, accident at the Charlotte-Douglas airport--specifically A-87-110.

In all, 19 safety recommendations have been issued regarding runway friction and friction measurement.

As a result of the Safety Board investigation of the Piedmont Airlines Boeing 737 accident at Charlotte-Douglas International Airport, North Carolina, on October 25, 1986, the Safety Board issued Safety Recommendation A-87-110 which recommended that the FAA:

> During annual inspections of full certificate airports, emphasize the identification of deficient runway conditions and use approved friction measuring devices to measure the dry runway coefficients of friction. Encourage the airport operator to correct (or provide appropriate notice to users) runway conditions that do not meet criteria recommended in advisory circular 150/5320-12A.

Following previous correspondence, on December 12, 1992, the FAA replied that it agreed with the safety recommendation and has revised AC 150/5320-12B to include guidance and procedures for the design and construction of skid-resistant pavement, pavement evaluation with or without friction equipment, and maintenance and high skid-resistant pavements. As a result of that letter, on March 26, 1993, the Safety Board classified Safety Recommendation A-87-110 as "Closed--Acceptable Action."

However, as a result of the investigation of the accident involving AAL102, the Safety Board believes 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 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. 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 (ACMs) 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.

The Safety Board is aware that due to budgetary constraints, airport inspection resources are limited and workloads are heavy, and thus additional responsibilities, such as overseeing friction measurement programs, may be burdensome. A number of aviation safety workforce positions, such as air traffic controllers, flight standards inspectors, and flight service staff are categorized in special emphasis workforce positions, which provide for minimum staffing levels and hiring priorities to ensure that safety is not compromised. The Safety Board believes that airport certification and safety inspectors are also critical to aviation safety, and that the FAA should provide special emphasis status to such positions.

2.9 Evaluation of Tire Marks and Tire Traction

The touchdown point on 17L was about 4,303 feet from the approach end of the runway. Initially, the tire marks were characterized by very brief black rubber marks. The runway marks and subsequent off-runway marks in the soft soil and on high speed taxiway 3S were consistent with the spacing of the airplane's landing gear tires and led to their positions on the resting airplane.

The airplane's tire marks, where it crossed high speed taxiway 3S, were black. The position of the marks, with the nose gear tire marks to the right of the center gear tire marks, indicates that the airplane was skidding as it crossed the taxiway. Traverse scuff marks found on some of the tires also indicated that they had been subjected to a skid. The offset between the tire marks and the nose gear and center gear indicates that the airplane was in nearly a 10-degree yaw as it skidded across high speed taxiway 3S.

There are three basic forms of tire hydroplaning: viscous, dynamic, and reverted-rubber. Viscous hydroplaning occurs when a tire is unable to penetrate a thin film of fluid. It is characterized by reduced friction between the tires and the runway surface.

Dynamic hydroplaning occurs when standing water on a runway acts to lift the tire off the runway. The major conditions required to cause dynamic hydroplaning are a ground speed greater than the tire dynamic hydroplaning speed, standing water, and poor runway surface microtexture. Although the accident airplane's ground speed was greater than the dynamic hydroplaning speed (9 times the square root of p where "p" equals tire pressure in pounds per square inch), and the runway surface microtexture was fairly low (but acceptable), the grooves in the runway should have channeled away the standing water, as would the tire treads. Although one, and perhaps two of the tires on the left main landing gear were found to have excessive tread wear, the Safety Board does not believe that the condition of the tires contributed to the loss of airplane directional control or to a condition of dynamic tire hydroplaning.

In the case of reverted-rubber hydroplaning, a film of water between the tire and the runway is heated into steam. This high heat leaves a clean path on the runway and reverts the portions of the tire or tires in contact with the steam into a "gummy" rubber mixture. There was no evidence of reverted rubber or overheat on any of the tires on the airplane, nor was there reverted rubber on the runway.

The Safety Board believes that the tire marks noted on the runway were not caused by hydroplaning, but were instead erasure marks on the wet runway. There were a large number of similar marks on the runway surface from other landing airplanes that were not hydroplaning. Furthermore, if hydroplaning had occurred, tire traction would have been lost and the airplane would not have tracked up wind in the direction that it was pointed, when it weathervaned to the right. Rather, it would have drifted toward the left side of the runway.

3. CONCLUSIONS

3.1 Findings

1. The airplane was certificated, equipped, and maintained (with the exception of the two misconfigured reverse thrust cascades on the No. 2 engine) in accordance with Federal Aviation Regulations and approved procedures.

2. The airplane was within its weight and balance limitations.

3. The flightcrew was properly certificated and had received the proper rest to perform their respective duties, in accordance with Federal Aviation Regulations.

4. The American Airlines flightcrew training recording procedures and records met FAA minimum standards and indicated that the pilots were qualified. However, the records were inadequate to use for trend analysis or evaluation of an individual's performance during training.

5. Although air traffic control was not a factor in this accident, because of procedural shortcomings, windshear advisory information was not provided to the flightcrew in a timely fashion.

6. The practice of displaying only the centerfield wind on the low level windshear alert system limited the amount of information the controller had available to him to issue to the flightcrew.

7. The LLWAS system operated within acceptable limits at the time of the accident.

8. NWS and American Airlines weather information provided to the flightcrew of AAL102 was timely and substantially accurate.

9. At touchdown, flight 102 was subjected to cross-track winds of about 15 knots that may have been increasing, with gusts about 5 knots above the steady winds.

10. The wind gusts of 25 to 32 knots recorded on the centerfield anemometer were not a factor in the accident; however, wind speed surges of similar strength could not be ruled out entirely based on meteorological data.

11. No microbursts or hazardous low level windshears affected the airplane at the time of the landing.

12. A line of moderate to heavy showers and thunderstorms was crossing runway 17L as AAL102 touched down.

13. The captain failed to compensate for moderate crosswinds from the right, allowing the airplane to weathervane and drift off the right side of the runway with minimal rudder commands, inappropriate tiller nosewheel steering commands, and lack of forward pressure on the control column.

14. The evacuation of the passengers, although made difficult by the fire and the nose-down left roll final resting attitude of the airplane, in mud, was handled in an expeditious and professional manner.

15. The emergency lighting did not operate properly because the emergency overhead lighting system battery packs were found to be out of sequence. This condition resulted in enough electrical power to indicate that the system was fully charged on the flight engineer's console but insufficient power to operate the overhead emergency lighting system for a specified 5 minutes. The manufacturer's instructions did not describe the importance of properly sequencing the batteries in each pack.

16. Runway 17L-35R was worn to a "maintenance planning" level. However, the majority of the runway's coefficient of friction was found to be within prescribed advisory circular guidelines.

17. There is inadequate FAA oversight of the runway friction measurement at U.S. airports.

18. The emergency response of the DFW ARFF was exceptionally good.

19. There was no evidence of hydroplaning on the runway or reverted rubber on the airplane's tires.

20. The broken nose landing gear steering cables were a result of the accident. They were not broken before the collapse of the nose landing gear.

21. Two of 32 reverser cascades on the center or No. 2 engine were found not to be in the proper configuration. The calculated misdirected force could be counteracted by about 1 degree of rudder deflection.

3.2 Probable Cause

The National Transportation Safety Board determines 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.

4. RECOMMENDATIONS

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

--to the Federal Aviation Administration:

Review the pilot training recordkeeping systems of airlines operated under FAR Parts 121 and 135 to determine the quality of information contained therein, and require the airlines to maintain appropriate information on the quality of pilot performance in training and checking programs. (Class II, Priority Action) (A-94-24)

Amend the ATC handbook, 7110.65, Chapter 3, "Airport Traffic Control - Terminal," Section 1, General: paragraph 3-8, "Low Level Windshear Advisories," to state that tower controllers should issue the LLWAS advisory, "Low Level Windshear Advisories in Effect," whether or not the facility is equipped with an ATIS. The advisory should continue to be transmitted by ATC, relative to all runways in operation at the airport, until either the information is confirmed to be on the ATIS, or the prescribed 20-minute time limit from the time of the alert has expired. (Class II, Priority Action) (A-94-25)

Revise ATC handbook, 7110.65, Chapter 3, "Airport Traffic Control - Terminal," Section 1, General: paragraph 3-8, "Low Level Windshear Advisories," to require controllers to select for display all sensors on the LLWAS when adverse weather conditions, such as thunderstorms, are forecast or present in the terminal area to improve controller and pilot perception of wind conditions affecting the entire airport. (Class II, Priority Action) (A-94-26)

Require the manufacturers of rechargeable batteries to provide specific maintenance instructions and recommended care practices. (Class II, Priority Action) (A-94-27)

Issue an Advisory Circular that provides proper maintenance instructions to aviation battery maintenance and repair facilities. (Class II, Priority Action) (A-94-28)

Require all 14 CFR Part 139 airports to perform runway friction tests regularly. (Class II, Priority Action) (A-94-29)

Provide FAA certification and safety inspectors with the training and resources necessary to oversee airport runway friction measurement programs. (Class II, Priority Action) (A-93-30)

Place airport certification and safety inspectors on the special emphasis workforce list. (Class II, Priority Action) (A-94-31)

--to Dallas/Fort Worth International Airport:

Monitor surface friction on all operational runways on a more frequent basis, including the buildup of rubber on all runways, and perform rubber removal operations as required, in accordance with FAA Advisory Circular 150/5320-12B. (Class II, Priority Action) (A-94-32)

-- to American Airlines, Inc.:

Review the guidelines for developing, implementing, reinforcing, and assessing CRM training programs for flight crewmembers, as contained in FAA Advisory Circular 120-51A, and ensure that the CRM program conforms to the guidance contained therein. (Class II, Priority Action) (A-94-33)

Examine the maintenance procedures and practices that resulted in the misconfiguring of two reverse thrust cascades on the No. 2 engine of N139AA. Determine if this is a single incident, or a more common procedural or maintenance practice error and make the appropriate changes. (Class II, Priority Action) (A-94-34)

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

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Member

John Hammerschmidt
Member

James E. Hall
Member

February 14, 1994

5. APPENDIXES

APPENDIX A

INVESTIGATION AND HEARING

1. Investigation

The National Transportation Board was notified of the accident about 0900 eastern daylight time, April 14, 1993. An investigative team was dispatched, arriving about 1530 cdt at DFW.

Investigation groups were formed for: Airport Fire and Rescue, Aircraft Performance, Aircraft Structures, Aircraft Systems, Cockpit Voice Recorder, Flight Data Recorder, Human Performance, Powerplants, Maintenance Records, Metallurgy, Operations, and Survival Factors.

Parties to the investigation included: The Federal Aviation Administration, Aircraft Braking Systems Corporation, Allied Pilots Association, American Airlines, Association of Professional Flight Attendants, Dallas/Fort Worth International Airport, Flight Dispatchers, Meteorologists, and Operations Specialists Union, General Electric, McDonnell Douglas, and the National Air Traffic Controllers Association.

2. Public Hearing

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

APPENDIX B

PERSONNEL INFORMATION

Flightcrew Background

The Captain

The captain, age 59, was born on April 27, 1934. He was hired by American Airlines on August 1, 1966, as a first officer on the BAC-111. He was transferred from that position to fly as a navigator on the Boeing B-707, where he flew on Pacific Ocean routes for American Airlines for about 2 years during the Vietnam War. He then progressed from the position of Boeing B-727 flight engineer, to first officer, to captain. He then flew for a short time as a captain on the McDonnell Douglas MD-80, and then became a captain on the DC-10. Records indicate that at the time of the accident, he had flown about 12,562 total hours for American Airlines, 555 of which were in the DC-10.

The captain holds Airline Transport Pilot certificate No. 1478746, with the rating of airplane multi-engine land, and type ratings in the DC-9, DC-10, B-727, and commercial privileges for airplane single engine land, and B-337. Additionally the captain holds Flight Navigator certificate No. 1746479. His FAA First Class Medical approval was issued on March 9, 1993, and bore the limitation: "Must have available glasses for near vision." He had no record of an accident, incident, or violation.

The captain began training on the DC-10 in November 1991. His instructor gave him an additional simulator training period, beyond the programmed number of periods prior to the simulator check flight. He was type rated in the DC-10 on December 10, 1991, by an American Airlines FAA Aircrew Program Designee. He was trained and qualified for international flights in April 1992. This training also served as his last line-required check.

The captain's last recurrent training and proficiency check were in December 1992. All of the American Airlines training records were kept in a computer data base. The data base contained the dates that the training was completed, and indicated whether the pilot passed or failed the check. There is no qualitative information regarding performance in these records, or whether a maneuver had to be repeated.

The First Officer

The first officer, age 40, was born on September 5, 1952. He was hired by American Airlines in September 1986, as a Boeing B-727 Flight Engineer. He progressed to the position of B-727 first officer, and then to DC-10 first officer. Records indicate that at the time of the accident, he had accrued about 4,454 total flying hours for American Airlines, about 376 of which were as a first officer in the DC-10.

The first officer holds Commercial Pilot certificate No. 585406734, with the ratings of airplane single and multi-engine land. In addition, he holds Flight Engineer certificate No. 585406734, with a turbojet rating. His First Class Medical approval was issued on October 23, 1992, and bore no limitation. He had no record of an accident, incident, or violation.

The first officer began training in the DC-10 in June 1992. He pointed out in an interview, as part of the Safety Board's investigation, that an additional simulator period, prior to the check, was necessary to train the pilot that he was paired with during training to proficiency, and that he did not require the extra period. The next required recurrent training period for the first officer was July 1993.

The Flight Engineer

The flight engineer, age 60, was born on September 29, 1932. He was hired by American Airlines in October 1955 as an aircraft mechanic. He progressed to become a professional flight engineer in the Douglas DC-6/7, Lockheed L-188, Boeing B-707 and -727, and DC-10. American Airlines records indicate that he was qualified in the DC-10 in November 1985, and, at the time of the accident, accrued about 4,800 flight hours in the DC-10.

He holds Flight Engineer certificate No. 1209924, with ratings in reciprocating engine, turbopropeller, and turbojet airplanes. In addition, he holds Airframe and Powerplant Mechanic certificate No. 1209924. His Second Class Medical approval was issued on March 23, 1993, and bore the limitation, "Must have available glasses for near vision." He is not a licensed pilot. He has no record of an accident, incident, or violation.

Flightcrew 72-Hour History

The captain had been off duty for an 11-day period prior to being notified of the April 12 to 14, 1993, DFW-HNL-DFW trip. He was at home, on a reserve status, when he was called, about 1730 cdt, on Sunday, April 11, 1993, to notify him of the flight. He slept for about 8 hours and reported for duty at DFW at 0920 cdt, April 12, 1993. He flew as captain on flight 123 from DFW to HNL. The first officer and flight engineer were the same for both the DFW to HNL leg of the trip and the return (accident) leg from HNL to DFW. The flight arrived at HNL at 1416 Hawaiian Standard Time (hast) or 1916 cst. The captain later stated that prior to this trip he had not been paired with the first officer. However, several years earlier, he had been paired with the flight engineer while flying the B-727.

The captain checked into his hotel room and subsequently ate a meal. He walked in the vicinity of the hotel, and watched television in his room before retiring for the night at 1700 hast (2200 cst). He stated that he slept well. He awoke at 0630 hast (1130 cdt) on April 13, 1993, had coffee and ate breakfast, walked, and spent time at the hotel swimming pool. He took a nap between 1300 and 1515 (1800 cdt to 2015 cdt), and then met his crew and proceeded to the airport, reporting for duty at 1750 (2250 cdt). The captain stated that he was not tired during the return flight to DFW.

The first officer stated that he had been off duty for 6 days prior to being notified on April 11, 1993, while at home on reserve status, of the trip from DFW to HNL to DFW. He had a normal night's sleep, at home, and reported for duty at DFW at 0810 cdt, April 12, 1993. He stated that he had not previously flown with either the accident captain or flight engineer.

Upon completion of the flight from DFW to HNL, the first officer checked into his hotel room, then went shopping, ate dinner, and spent time in the room, making a telephone call and watching television. He stated that he retired for the night at 2200 hast, April 12, 1993 (0300 cdt, April 13), and arose at 0600 hast (1100 cdt) April 13, 1993. He took a morning walk and spent time reading in his room until 1100 hast (1600 cdt). He ate lunch, and then took a nap between 1200 and 1600 hast (1700 to 2100 cdt). He met the other members of the crew and reported for duty at HNL at 1750 hast (2250 cdt), April 13, 1993. He stated that he had felt tired during the accident flight and had taken naps briefly twice to "perk up." (The captain, when interviewed, also noted that the first officer had twice taken oxygen to refresh on the flight from HNL to DFW.)

The flight engineer had previously bid the April 12 to 14, 1993, DFW to HNL to DFW trip, and was scheduled for it. On April 11, 1993, he slept at his home between 2030 and 0645 cdt, and reported for duty at DFW at 0840 cdt, April 12, 1993.

He arrived at the hotel in HNL with the other members of the crew, checked into his room, ate a meal, and retired at 2000 hast, April 12, 1993 (0100 cdt, April 13). He slept until 0300 hast (0800 cdt), April 13, 1993. He took a walk in a park near the hotel during the morning hours and then napped between 1300 and 1600 hast (1800 to 2100 cdt), prior to meeting with the crew and reporting for duty at HNL at 1750 hast (2250 cdt).

APPENDIX C

COCKPIT VOICE RECORDER TRANSCRIPT

LEGEND

CAM	Cockpit area microphone voice or sound source
RDO	Radio transmission from accident aircraft
INT	Transmissions over aircraft interphone system
PA	Transmissions over aircraft public address system
-1	Voice identified as Captain (PIC)
-2	Voice identified as First Officer.
-3	Voice identified as Flight Engineer
-4	Voice identified as cockpit mechanical voice
-?	Voice unidentified
CTR-1	Radio transmission from Ft. Worth air traffic center
ATIS-1	Radio transmission from DFW ATIS
APR-1	Radio transmission from 1st DFW approach controller
APR-2	Radio transmission from 2nd DFW approach controller
217HL	Radio transmission from aircraft 217 HL
AAMT	Transmissions from DFW 3E maintenance
TWR-1	Radio transmission from DFW Control Tower
GND-1	Radio transmission from DFW Ground Control
*	Unintelligible word
@	Non pertinent word
#	Expletive
%	Break in continuity
( )	Questionable insertion
(( ))	Editorial insertion
- - -	Pause

Note: Times are expressed in central daylight time (CDT).

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
START OF RECORDING			
START OF TRANSCRIPT			
0629:46 **CAM-3**	uh, a whole bunch of sigmets are out.		
0629:50 **CAM-2**	OK, I'll **.		
0629:53 **CAM-?**	I'll be ****.		
0629:57 **PA-1**	uh, good morning folks, Captain Kruslyak again, uh, we've begun our descent now into the Dallas Ft. Worth area. we're presently uh, a hundred and uh, thirty five miles to the west of the airport. uh, we've been in and out of a little bit of bumpy air for the last uh, fifty miles or so. uh, aircraft up ahead of us tells us that as we get into the clouds and down below 'em into the lower altitudes, it's going to be bumpy. so uh, I'm gonna ask out flight attendants to go ahead and round everything up at this time and uh, take your seats, and, just as a precaution. our uh, radar is showing numerous * uh, areas of rain showers around the Dallas Ft. Worth area so from uh, here on in we'll be doing uh, a little bit of deviating uh, radar is working very well, so we can kinda pick our path through these cells that are up ahead of us here, shouldn't be any particular problem other than some bumpy air every once in a while. nothin' dangerous just uh, more of a nuisance than anything else. right now it looks like we oughta be landing ina uh, just about twenty five to thirty minutes from now. the weather at the airport is good uh, there are, several layers of clouds starting at about three thousand feet above the ground, and uh, visibility is seven miles with uh, just some light rain in progress at, at the present time. temperature is sixty seven degrees.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
0631:36 **CAM-2**	couple of bulbs burned out here, so I'm gonna to test this real quick.		
0631:39 **CAM-?**	ya, I think that's co-pilot's red side .		
0631:46 **CAM-2**	* I saw green.		
0631:47 **CAM-1**	did ya?		
0631:54 **CAM-?**	looks like we're gonna be taking about a, 'bout three left course correction here *** another sixty miles or so.		
0632:06 **CAM-1**	(are you lookin' at that one about a hundred miles) ***		
0632:12 **CAM-2**	yes sir.		
0632:23 **CAM-3**	** twelve miles **		
0632:27 **CAM-2**	what was the winds? one eighty at what?		
0632:28 **CAM-3**	one eighty at seven. --- you all ready for some numbers?		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
0632:35 **CAM-1**	uh, yeah.		
0632:37 **CAM-3**	OK. the top. -- two thirty one, one ninety nine, one sixty four, thirty five flaps, one forty six. and Charlie.		
0632:56 **CAM-?**	***		
0632:57 **CAM-?**	**		
		0633:08 **CTR-1**	* one zero two, contact Ft. Worth center, one two seven point niner five.
		0633:13 **RDO-1**	twenty seven ninety five, thanks for your help. --- Ft. Worth center, American one oh two heavy out of two eight two four zero.
		0633:30 **CTR-2**	American one oh two heavy, roger. --- American one oh two heavy, cleared uh, Dallas/Ft. Worth cleared direct Bridgeport Boyds Two arrival.
		0633:34 **RDO-1**	OK uh, direct Bridgeport Boyds two arrival and uh, we're gonna wait 'til we get a little bit closer and see what it looks like on our radar, do, uh, maybe do some deviation there.

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
		0633:46 CTR-2	they have a uh, twin engine prop penetrating the weather uh, about twenty two north of uh, Bridgeport. I'll try to get a report out of him. he's at seventeen and I'll get right back with you.
		0633:57 RDO-2	uh OK, is there a lot of traffic coming into DFW at this hour?
		0634:01 CTR-2	say again please. I was uh, on another radio.
		0634:03 RDO-1	yeah, is there a lot of uh, traffic coming into DFW at this hour?
		0634:07 CTR-2	uh, no sir, there is not, uh. matter of fact, I'm not indicating anybody on final right now.
		0634:13 RDO-1	OK, I was just wondering uh, just looking at it, it looks like there is at least a remote possibility that you might be able to come in from the south and land to the north but uh, we'll keep an eye on it, huh?
		0634:28 CTR-2	OK, I don't know if they're gonna uh, I can check with them uh, was that a request or uh, have a quick wind uh, approach uh, north landing you mean?
		0634:41 RDO-1	well yea, but uh, let's wait 'til we get a little closer and look at it. the radar at this range is uh, is not really as accurate as it is when we get in uh, oh forty fifty miles away (er).

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
		0634:59 CTR-2	American one oh two, roger. American one oh two, descend and maintain one zero thousand, ten thousand, Dallas/Ft. Worth altimeter two niner five one.
		0635:07 RDO-1	on down to one zero thousand, American one oh two heavy.
		0635:24 CTR-2	two one seven Hotel Lima, what are your uh, flight conditions?
		0635:26 217HL	oh we've got light uh, moderate rain here and some uh, light chop.
		0635:32 CTR-2	American one oh two uh, moderate chop uh, seventeen thousand the aircraft at your ten o'clock about uh, seventy miles uh, penetrating weather moderate light to moderate rain.
		0635:44 RDO-1	OK, thank you.
		0635:54 RDO-3	three E maintenance. American one zero two.
		0635:56 AAMT	this is huh, this is maintenance, go ahead.
0635:58 CAM-?	*		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
		0635:59 **RDO-3**	uh, American one zero, two, aircraft uh one thirty nine uh, we've got just a couple of minor cabin items and uh, our right uh, gear uh, indicating uh, light capsule, the lower half of it's burned out 'n, that's it.
		0636:15 **AAMT**	OK, sir, you're cutting out, I didn't get your aircraft number or your gate assignment.
		0636:20 **RDO-3**	OH, uh, it's aircraft one three nine, gate twenty nine.
		0636:28 **AAMT**	one thirty nine, gate twenty nine, you have a g ---
		0636:32 **RDO-3**	OK thank you, American one oh two.
0636:39 **CAM-2**	** it's raining that stuff doesn't look that bad **		
0636:46 **CAM-1**	eighty three miles from the airport, on our nose --		
0636:57 **CAM-2**	looks like if we jog around to the left, *** an opening.		
0637:00 **CAM-1**	which opening *****?		
0637:04 **CAM-2**	** twenty degrees?		
0637:05 **CAM-1**	well yea, I'm looking, look on your eighty mile scope, -- uh, we're eighty miles out right now. you see that space that that 'bout seventy eight miles from here?		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
0637:19 **CAM-2**	*		
0637:21 **CAM-1**	you're looking at yellow scud, you're not looking at anything that even approaches red, so and it's kinda centrally located. then you've got that area there, and then you've got another area, at the eighty mile point there. we'll look at it when we get a little bit closer and see what the best ***		
0637:39 **CAM-2**	is that ***?		
0637:40 **CAM-1**	I think right now 'bout that eighty five mile or seventy five mile point, you can just about go right in there with nothing more than some bumpy air. ***		
0637:55 **CAM-3**	uh, you want to carry some engine heat uh, Ken down through there?		
0637:58 **CAM-1**	yea, whenever we need it.		
0637:59 **CAM-3**	*		
0638:00 **CAM**	((sound of three clicks))		
0638:03 **CAM-?**	***		
0638:08 **CAM-?**	(we've got about seventy two miles) ***		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
0638:17 **CAM-?**	** twenty nine sixty ***		
0638:21 **CAM**	**		
0638:26 **CAM-1**	uh, call * and make sure they're all sitting down back there, would ya?		
0638:36 **CAM-?**	alright.		
0638:38 **CAM-3**	** are you all down **		
0638:46 **CAM-2**	I can't tell now ***		
0639:53 **CAM-1**	* you're picking up the red aren't you?		
0639:54 **CAM-2**	yep.		
0639:54 **CAM-1**	OK, that's what I'm doing I'm trying to, whatever the stuff is, wherever the heavy stuff is, it's down low, I'm searching level right now, and uh, I wanted to see where the red is on here, and then go from there. right now, we're sixty miles from the airport on our uh, ten degrees to the right. ****		
0640:18 **CAM-?**	** red should be a really bad cell.		
0640:22 **CAM-1**	well, I'm searching low right now. gettin' up to where we're looking at ***		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
0640:46 **CAM-1**	that's really what we're looking at right there.		
		0640:48 **CTR-2**	American one oh two, radio check.
		0640:51 **RDO-1**	you're loud and clear.
		0640:52 **CTR-2**	'kay.
0641:01 **CAM-2**	* I think I'm goin' to go through this at what about, two fifty?		
0641:03 **CAM-1**	yea, I'd, I'd go ahead.		
0641:20 **CAM-2**	one oh eight outbound.		
0641:22 **CAM-1**	say what?		
0641:23 **CAM-2**	one oh eight's the outbound course ** Bridgeport.		
0641:27 **CAM-?**	** ((concurrent with previous statement))		
0641:39 **CAM-2**	out of eleven for ten and it's armed.		
0641:40 **CAM**	((sound of alert horn similar to altitude alert))		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
0641:43 **CAM-?**	***		
		0642:08 **RDO-1**	are you gettin' any movement on this stuff uh, American one oh two?
		0642:12 **CTR-2**	American one oh two uh, no sir, let me check uh, with people were here all night. not of any significance, American one oh two.
0642:23 **CAM**	((sound of loud rumble))		
0642:24 **CAM-?**	#, that was a good one.((concurrent with following transmission))		
		0642:28 **RDO-1**	say it again?
		0642:29 **CTR-2**	not of any significance uh, it's pretty much uh, static.
		0642:33 **RDO-1**	OK.
		0642:37 **CTR-2**	how's the ride so far?
		0642:38 **RDO-1**	well, it's been good so far, we just had a big blast of lightning and.
0642:47 **CAM-3**	everything appears to be functioning ****		

INTRA-COCKPIT COMMUNICATION TIME & SOURCE	INTRA-COCKPIT COMMUNICATION CONTENT	AIR-GROUND COMMUNICATION TIME & SOURCE	AIR-GROUND COMMUNICATION CONTENT
		0642:51 CTR-2	uh, you say you took a big blast or you say uh, see a lot of lightning.
		0642:54 RDO-1	ah, just one one big shot of lightning, we didn't take it though uh, I don't suppose there is any chance of uh, landing to the north, huh?
		0643:03 CTR-2	uh, I doubt it but I will forward that request.
		0643:05 RDO-2	yeah, we're going to have to make a decision here in just a few miles.
		0643:26 CTR-2	OK. ---- American one oh two contact Regional approach, American one oh two, descend and maintain niner thousand, contact Regional approach one two five point eight, they do have your request.
		0643:33 RDO-1	twenty five eight, down to nine thousand, American uh, one oh two.
0643:37 CAM-2	nine thousand set and arrned.		
0643:38 CAM-1	what's your, what's your?		
0643:39 CAM-3	Charlie. --- altimeters baro?		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
		0643:41 RDO-1	uh, approach, American, one oh two heavy, Charlie uh, descending through ten to nine.
0643:47 CAM-1	I'm going to go to over override and air start.		
0643:52 CAM-?	(*** check right ignition loop)		
		0643:52 APR-1	(was there) American one zero two heavy calling approach?
		0643:54 RDO-1	yes uh, we're descending from ten to nine, did you get our request for lan uh, possibility of landing to the north?
		0643:58 APR-1	American one zero two heavy, I have your request, right now we're uh, checking upstairs. they've got quite a few departures lined up to takeoff southbound so I wouldn't uh, count on three six. now you can plan on a uh, south landing and if we do get a north landing I'll let you know. you can descend and maintain five thousand. did you have information Echo?
0644:05 CAM	((sound of alert horn similar to altitude alert, concurrent with previous transmission.))		
		0644:14 RDO-1	yeah, we've got Echo, uh standby, we'll get, never, disregard, we're getting, uh we're gonna have to go around to the left then uh, to deviate around this stuff, we're gonna have to go about uh, oh, fifty degrees or so to the left.

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
		0644:26 **APR-1**	one five, fifteen degrees or five zero, fifty?
		0644:29 **RDO-1**	five zero.
		0644:33 **APR-1**	American one zero two heavy, roger, yeah you can deviate as necessary. you want to turn to a heading of zero five zero, is that it?
		0644:35 **RDO-3**	((starts concurrent with previous transmission and next five statements or transmissions)) DFW airport arrival information ECHO. the one one three five Zulu special. measured ceiling one thousand four hundred overcast. visibility two and one half, thunderstorms rain showers and fog. temperature, six seven, dew point six five. wind two two zero at six, altimeter two niner four eight. thunderstorms in all quadrants, moving northeast. frequent lightning in clouds, cloud to cloud, cloud to ground. pressure's falling rapidly. attention all aircraft, convective sigmet four one central, four two central , four four central and four five central affects the DFW area. ILS runway one seven left, one eight right approaches in progress. aircraft arriving over Bridgeport or Acton can expect one eight right. aircraft arriving over Blue Ridge * can expect runway one seven left. notice to airmen. runway one seven right threshold displaced four hundred and twenty feet. runway one seven right glideslope is out of service. read back all runway hold short instructions. advise approach control you have Echo.

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
		0644:39 **RDO-1**	negative, it'll be a heading of about uh, zero seven five or so.
		0644:44 **APR-1**	American one zero two heavy roger, you can deviate as necessary.
		0644:47 **RDO-1**	thank you.
0645:10 **CAM-?**	** yeah that's heavy **		
0645:10 **CAM-?**	everything's high now.		
0645:31 **CAM-1**	I don't know what the # happened with this radar.		
0645:51 **CAM-2**	*** (is it not working or is it working?)		
0645:54 **CAM-?**	all that line that we passed through **		
0646:02 **CAM-?**	** right straight down **		
0646:24 **CAM-3**	** --- OK -- Echo, fourteen hundred overcast, two and a half miles visibility, uh, winds, two two zero at six, uh, twenty nine forty eight, lightning cloud to cloud, cloud to ground, uh, thunderstorms moving northeast and pressure falling rapidly.		
0646:49 **CAM-1**	OK. --- * twenty five to the right, twenty eight miles, twenty twenty eight **		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
0647:06 **CAM-2**	verification		
0647:07 **CAM-3**	uh, they're giving (now) an altimeter now of twenty nine forty eight.		
0647:11 **CAM-?**	**		
0647:13 **CAM-1**	forty eight OK,		
0647:14 **CAM-?**	I don't dis ***		
0647:17 **CAM-1**	OK, how we doing on our altitude?		
0647:18 **CAM-2**	we're cleared to five thousand.		
0647:21 **CAM-?**	***		
		0647:23 **APR-1**	American one zero two heavy, descend and maintain three thousand.
		0647:26 **RDO-1**	down to three, American one oh two heavy.
0647:41 **CAM-1**	why don't we go ahead and get'er on down and we'll have a better choice at getting down below this stuff.		
0647:45 **CAM-2**	I'm going to slow down and, and **		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
		0647:58 **APR-1**	* everyone landing at DFW, the weather now is measured ceiling one thousand four hundred overcast, visibility two and one half, thunderstorms rain showers, fog, wind one four zero at one one, altimeter two niner four niner, and uh, expect south landing.
0648:25 **CAM-3**	thrust computer?		
0648:29 **CAM-2**	set go-around.		
0648:30 **CAM-3**	OK, altimeters?		
0648:33 **CAM-1**	uuuh, let's see, whata we got, twenty eight?		
0648:37 **CAM-3**	the conversion is twenty eight, eighty four.		
0648:41 **CAM-1**	eighty four, OK.		
0648:42 **CAM-2**	eighty four set.		
		0648:45 **APR-1**	American one zero two heavy, contact approach now on one three two point one.
		0648:49 **RDO-1**	thirty two one, goodday.
0648:50 **CAM-2**	** one fifty heading. that was one fifty heading.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
0648:54 **CAM-1**	one fifty heading or one oh two?		
0648:57 **CAM-2**	he said one fifty heading.		
		0648:59 **RDO-1**	who was that last transmission for?
		0649:02 **APR-1**	go ahead?
		0649:04 **RDO-1**	uh who was the last transmission for?
		0649:05 **APR-1**	American one zero two heavy.
		0649:07 **RDO-1**	say it again, the frequency?
		0649:09 **APR-1**	one three two point one.
		0649:10 **RDO-1**	thirty two one.
0649:12 **CAM-2**	she said one fifty.		
		0649:15 **RDO-1**	approach, American one oh two heavy we're uh, out of four for three.
0649:23 **CAM**	((sound of horn similar to altitude alert.))		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
		0649:27 **APR-2**	American one zero two heavy, expect ILS runway one seven left, localizer frequency one uh, one zero point three.
		0649:34 **RDO-1**	one one zero three OK uh, how's it look on your scope for gettin' in there?
		0649:41 **APR-2**	American one zero two heavy, when able, fly heading one three zero.
		0649:47 **RDO-1**	OK, one three zero. how's it look coming down final on your radar?
		0649:51 **APR-2**	well uh, I show an area of weather at, at fifteen miles either side of DFW airport proceeding uh, straight north uh fifteen miles on uh, each side uh, for about thirty miles.
		0650:09 **RDO-1**	OK, can you uh, give us a good heading then to come in on?
		0650:10 **APR-2**	uh, well I can give you a good heading to intercept the localizer but there's weather all down the final is what I'm saying there's I don't see any openings on the final of I see a weather area all the way down the final.
		0650:18 **RDO-1**	OK uh, and is this stuff moving?

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
		0650:21 **APR-2**	uh, does does not appear to be moving uh, much if any American one zero two heavy if able, turn right heading one five zero and join the runway one seven left localizer.
0650:31 **CAM**	((sound of three clicks))		
		0650:33 **RDO-1**	uuh. I don't think we're goin' to be able to do that that's uh, that's a pretty big red area on our scope uh, about ninety degrees and that's about what we're looking at. uh, we're gonna have to, just go out I guess and wait around to see what's goin' on here.
		0650:46 **APR-2**	American one zero two heavy, eight miles south of you's a heavy DC-8 at three thousand joining uh, the final's uh, reporting a smooth ride at three.
		0650:54 **RDO-1**	oh, OK, eight miles south of us?
		0650:56 **APR-2**	uh, about eight nine miles south, straight south of you.
		0650:59 **RDO-1**	OK uh, we'll head down that way then and uh, worse comes to worse we'll go out from there.
		0651:04 **APR-2**	OK, one zero two heavy, turn right heading two zero zero and intercept the runway one seven left localizer.

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
		0651:10 **RDO-1**	right to two hundred and intercept the localizer.
0651:13 **CAM-2**	right to two hundred. OK, (checks)		
0651:17 **CAM-?**	yeah **		
0651:18 **CAM-2**	uh, slats extend please.		
0651:19 **CAM**	((sound of two clicks))		
0651:28 **CAM-2**	slowin' to two ten.		
0651:31 **CAM-?**	yeah.		
		0651:31 **APR-2**	*an one zero two heavy, would you like to slow down?
		0651:32 **RDO-1**	yeah, we're gonna bring 'er way back.
		0651:33 **APR-2**	OK.
0651:34 **CAM-?**	**		
0651:36 **CAM-1**	go ahead and and slow the thing on down uh		
0651:40 **CAM-2**	flaps ten degrees.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
0651:43 **CAM**	((sound of three clicks))		
0651:46 **CAM**	((sound of horn similar to landing gear warning horn))		
0651:48 **CAM-3**	flight instruments and bugs?		
0651:54 **PA-1**	uh, flight attendants uh, prepare for landing. we're gonna be on the ground uh, in just about uh, about five six minutes from now and it uh, could be bumpy from here on in so just if you would, stay in your seats please.		
0651:58 **CAM-2**	flaps fifteen, please. ((concurrent with previous PA-1))		
0652:02 **CAM**	((sound of horn similar to landing gear warning horn concurrent with PA-1))		
0652:09 **CAM-3**	flight instruments and bugs?		
0652:10 **CAM-1**	uuuh, they're set and cross checked, let's see ten three?		
0652:20 **CAM-2**	one ten three. -- don't have **		
0652:22 **CAM**	((sound of horn similar to landing gear warning horn))		
0652:26 **CAM-1**	this is for the left runway, right?		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
0652:28 **CAM-2**	one seven left.		
0652:29 **CAM-1**	*** I mean one *, one, seven		
0652:32 **CAM-?**	(identified)		
		0652:40 **APR-2**	American one zero two heavy, you're uh, one two miles from the outer marker, maintain three thousand 'til established on localizer, cleared ILS runway one seven left approach.
		0652:49 **RDO-1**	we're cleared for the one seven left uh, ILS approach, American uh, one oh two heavy.
0652:58 **CAM-2**	if anybody sees anything that looks like windshear, let me know.		
0653:01 **CAM-1**	yeah, don't be afraid to carry an extra ten to fifteen knots on final, and then slow down when we get close.		
0653:08 **CAM-2**	that's what I'll do.		
0653:12 **CAM-1**	*** we oughta be getting out of this stuff, most of this stuff (looks) high here.		
0653:20 **CAM-?**	****		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
		0653:20 **APR-2**	American one zero two heavy, uuh, say your flight conditions.
		0653:24 **RDO-1**	uh, we're in the clouds it's uh, just uh, little ripple, in uh, pretty good size rain out here.
0653:31 **CAM-2**	flaps twenty two please.		
0653:32 **CAM**	((sound of click))		
0653:42 **CAM-2**	* do you think that was a lightning strike, or was that just uh ---		
0653:46 **CAM-1**	uh, it's hard to tell, we probably oughta go ahead and tell 'em that ----		
0653:50 **CAM-3**	it's a possibility.		
0653:51 **CAM-1**	yeah. --- I've been hit twice and that's what it looks like.		
0653:53 **CAM-?**	yeah.		
0653:54 **CAM-?**	**		
0653:55 **CAM-?**	I've never been hit. I've seen things like that before but it's * hard to tell.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
0654:35 **CAM-1**	** identified. --- yeah, localizer's comin' alive.		
0655:08 **CAM-1**	I don't think this is going to be any problem **		
0655:17 **CAM-2**	about a * fifteen knot variation. -- it's all hooked up right now.		
0655:31 **CAM-1**	uh, gettin' a pretty good spike on the airspeed.		
		0655:36.95 **RDO-1**	anda, American one oh two heavy, in our position here, we're gettin' about a ten to fifteen knots uh, fluctuation on our airspeed.
0655:43 **CAM**	((sound of horn similar to landing gear horn concurrent with pervious transmission))		
		0655:45 **APR-2**	was that gain or a loss?
		0655:47 **RDO-1**	uh, that's mostly a gain.
		0655:50 **APR-2**	American one zero two heavy, roger.
0655:53 **CAM-2**	landing gear down. --- add fifteen knots to one forty six.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
		0656:01 **APR-2**	((concurrent with previous statement and two following statements)) American one zero two heavy, * I just got a report from the heavy DC-8 that landed on runway one eight right, reported a plus or, minus uh, one zero knots at the outer marker and a plus or minus uh, five or a minus five, excuse me, at a, or at the, uh, on short final for one eight right.
0656:17 **CAM**	((sound of clank))		
0656:18 **CAM-?**	four green no red. ((concurrent with previous transmission))		
		0656:18 **RDO-1**	OK, thank you.
		0656:20 **APR-2**	American one zero two heavy, how's your ride now?
		0656:22 **RDO-1**	well we're gettin' uh, light an occasionally moderate chop.
		0656:26 **APR-2**	American one zero two heavy, contact tower now, one two six point five five.
		0656:28 **RDO-1**	twenty six fifty five, good night, thanks for your help.
0656:33 **CAM-2**	gear's down four green.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
		0656:35 **RDO-1**	tower, American one oh two heavy, nine and a half out for one seven left.
0656:38 **CAM-3**	anti-skid, checked and on.		
		0656:39 **TWR-1**	American one zero two heavy Regional tower, * one seven left, cleared to land, wind calm.
		0656:42 **RDO-1**	cleared to land, one seven left, American one oh two heavy.
0656:48 **CAM-3**	spoiler handle?		
0656:49 **CAM-1**	armed. ((sound of click and thud))		
0656:50 **CAM-2**	flaps thirty five, please. ((sound of click)) --- I'm goin' to maintain one sixty for my final speed.		
0656:59 **CAM-1**	that'll be good. --- if you need the wipers, just holler for the wipers, if you need Dave ***		
0657:03 **CAM-2**	never mind. ((concurrent with previous statement))		
0657:11 **CAM-3**	flight guidance system and radios.		
0657:13 **CAM-1**	uh, they're, they're set.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
0657:21.50 **CAM**	((sound of intermittent audio tone similar to outer marker beacon))		
0657:23 **CAM-2**	marker seventeen * ((concurrent with following statement))		
0657:27 **CAM-1**	marker seventeen hundred.		
0657:49 **CAM-2**	need the wipers for a few seconds **		
0657:50 **CAM-1**	alright definitely.		
0657:52 **CAM-2**	go ahead.		
0657:54 **CAM-1**	we're goin' to clean those windshields off.		
0657:57 **CAM**	((sound similar to windshield wipers))		
0658:06 **CAM-1**	thousand, feet, thirty five, thirty five and land.		
0658:11 **CAM-3**	before landing checklist complete.		
0658:12 **CAM-?**	*		
0658:14 **CAM-1**	(there's) runway lights are in sight, we're goin' to lose them in a second here.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
0658:38 **CAM-3**	OK, there's five hundred.		
0658:39 **CAM-1**	runway lights in sight. ---- pretty good right crab.		
0658:45 **CAM-1**	there's uh, five hundred now, and plus about ten. -- there's four hundred.		
0658:53 **CAM-4**	traffic.		
0658:55 **CAM-1**	three hundred.		
0658:59.15 **CAM-1**	there's two hundred.		
0659:03.19 **CAM-1**	I've got a plus ten sinking a thousand.		
0659:05.92 **CAM-1**	there's one hundred.		
0659:12.21 **CAM-4**	one hundred.		
0659:16.16 **CAM-4**	fifty.		
0659:17.03 **CAM-2**	I'm gonna go around.		
0659:17.93 **CAM-1**	no no no I, I got it.		
0659:19.45 **CAM-2**	you got the airplane.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
0659:19.76 **CAM-4**	thirty. ((concurrent with last word in previous statement))		
0659:22.68 **CAM-4**	twenty.		
0659:27.88 **CAM-4**	ten.		
0659:29.73 **CAM**	((sound of thump similar to aircraft touchdown))		
0659:31.63 **CAM**	((sound of another thump))		
0659:33.69 **CAM-?**	**		
0659:34.05 **CAM-3**	all green.		
0659:36.64 **CAM-2**	OK, hundred and twenty knots.		
0659:38.15 **CAM-1**	oh #.		
0659:41.40 **CAM-2**	hundred knots.		
0659:43.44 **CAM-2**	OK, we're off the grass.		
0659:45.54 **CAM-2**	eighty knots.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
0659:48.01 **CAM-?**	gosh darn.		
0659:50.20 **CAM**	((sound of horn))		
0659:53.09 **CAM-?**	#		
0659:53.09 **CAM-1**	emergency evacuation.		
0659:54.45 **CAM**	((sound of continuous horn))		
		0659:56.91 **RDO-2**	evacuate? -- alright tower uh, American one zero two, we entered a slide uh --
0700:04.23 **CAM**	((sound of warbling horn similar to evacuation horn))		
		0700:07 **RDO-2**	-- and we're evacuating.
0700:09 **CAM-1**	OK, check list.		
0700:13 **CAM-3**	evacuation check list.		
0700:15 **CAM-?**	##		
0700:15 **CAM-?**	easy victor, easy victor, easy victor.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
0700:15 **CAM-3**	sound evacuation, call the tower?		
0700:18 **CAM-3**	outflow valve?		
0700:19 **CAM-2**	tower's already been called. ((concurrent with previous statement))		
0700:21 **CAM-3**	outflow valve check spoiler handle full forward.		
0700:22 **CAM-?**	closed. ((concurrent with the word "check" above))		
0700:23 **CAM-?**	it's open.		
0700:24 **CAM-3**	spoiler handle?		
0700:25 **CAM-1**	full forward.		
0700:27 **CAM-3**	brakes parked?		
0700:28 **CAM-1**	checked.		
0700:29 **CAM-3**	fuel levers?		
0700:30 **CAM-?**	fuel levers off.		
0700:32 **CAM-?**	***		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
0700:32 CAM-3	power switch on?		
0700:34 CAM-1	spoiler handle won't stay closed.		

END of RECORDING

END of TRANSCRIPT

APPENDIX D

DFW TOWER/TRACON TRANSCRIPT

U.S. Department of Transportation
Federal Aviation Administration

Memorandum

Dallas-Fort Worth Tower/TRACON
P. O. Box 610368
DFW Airport, TX 75261

Subject **INFORMATION:** Transcription concerning the accident involving AAL102 Heavy DC10 on April 14, 1993 at 1200 UTC

Date April 28, 1993

From Dallas-Fort Worth Tower/TRACON

Reply to Attn of

To This transcription covers the time period from April 14, 1993, 1138 UTC to April 14, 1993, 1208 UTC.

Agencies making transmissions	Abbreviations
American Airlines Flight 102	AAL102
Delta Airlines Flight 1438	DAL1438
Simmons Aviation	SYM730
Simmons Aviation	SYM874
Martinaire	MRA657
Executive Flight	EXE101
D10 Feeder West Position TRACON	FW
D10 Arrival Radar Two Position TRACON	AR2
D10 Dallas North Position TRACON	DN
D10 Meacham North Position TRACON	MN
D10 Departure Radar One TRACON	DR1
DFW Local Control East TOWER	LCE
DFW Local Control West TOWER	LCW
Fort Worth Center ARTCC	ZFW
Airport Operations Vehicle	Port 110
Unknown	UNKN

I hereby certify that the following is a true transcription of the recorded conversations pertaining to the subject Aircraft Accident :

Robert T. Allen
Quality Assurance Specialist
April 28, 1993

(1138)		
(1139)		
(1140)		
(1141)		
(1142)		
(1143)		
1143:05	ZFW	Feeder West on the ten
1143:08	FW	Feeder West
1143:09	ZFW	American one o two would ah has ah requested a north landing three five or three six your control
1143:18	FW	Thank you PM
1143:37	AAL102	Approach American one o two heavy charlie descending from ten to nine
1143:46	FW	Was that American one zero two heavy calling approach
1143:48	AAL102	Yes were descending from ten nine did you get our request for land possible to the landing to the north
1143:55	FW	American one zero two heavy I have your request right now we are ah checking upstairs they've got quite a few departures lined up to take off south bound so I wouldn't count on three six for now you can plan on ah a south landing and if we do get a north landing I'll let you know you can descend and maintain five thousand did you have information echo
(1144)		
1144:12	AAL102	Yeah we got echo
1144:14	AAL102	Stand by disregard we're going we're going to have to go around to the left and ah to deviate around this stuff we're going to have to go around fifty degrees or so to the left

1144:20	FW	One five fifteen degrees or five zero fifty
1144:21	AAL102	Five zero
1144:31	FW	American one zero two heavy roger you can deviate if necessary you want to turn to a heading of zero five zero is that it
1144:37	AAL102	Negative it would be a heading of about zero seven five or so
1144:42	FW	American one zero two heavy roger you can deviate as necessary
1144:44	AAL102	Thank you
(1145)		
1145:44	ZFW	Feeder West Acton ten
1145:47	FW	Feeder West
1145:49	ZFW	Simmons seven thirty says he needs that heading for about another eight miles on a zero eight zero heading to join your approval
1145:55	FW	That's fine with me but that's Meacham's airspace
1145:57	ZFW	Yeah I'll point him out to Meacham
1145:58	FW	Ok thank you
1145:59	ZFW	MY
(1146)		
(1147)		
1147:12	MN	Meacham's

1147:14	FW	This is feeder west point out ten miles west of Denton American one zero two heavy descending to three
1147:16	UNKN	(unintelligible)
1147:22	FW	American one zero two heavy descend and maintain three thousand
1147:24	AAL102	Down to three American one o two heavy
1147:39	ZFW	Feeder West ten
1147:42	FW	Feeder West
1147:45	ZFW	Meacham South is watchin Simmons seven thirty and I gave him a hundred heading to join when he can
1147:46	FW	Thats fine
1147:47	SYM730	Good morning Regional approach Simmons Seven three zero is with you five thousand the last ATIS we got was Delta
1147:55	FW	For everyone landing at DFW the weather now is measured ceiling one thousand four hundred overcast visibility two and one half thunderstorms rain showers fog wind one four zero at one one altimeter two niner four niner and ah expect south landing
(1148) 1148:14	SYM730	Simmons seven thirties with yeah at five grand
1148:17	FW	Simmons seven thirty regional approach roger
1148:43	FW	American one zero two heavy contact approach now on one three two point one
1148:46	AAL102	Thirty two one good day

1148:55	AAL102	Who was that last transmission for
1148:59	FW	Go ahead
(1149) 1149:03	AAL102	Who was the last transmission for
1149:05	FW	American one zero two heavy
1149:06	AAL102	Say it again the frequency
1149:07	FW	One three two point one
1149:09	AAL102	Thirty two one
1149:26	AR2	American one zero two heavy expect ILS runway one seven left localizer frequency one one zero point three
1149:32	AAL102	One one zero three
1149:40	AR2	American one zero two heavy when able fly heading one three zero
1149:46	AAL102	OK one three zero hows it look comin down final on your radar
1149:48	AR2	Well I I show an area of weather at about fifteen miles either side of DFW airport proceeding ah straight north ah fifteen miles on ah each side ah for about thirty miles
(1150) 1150:05	AAL102	OK can you ah give us a good heading then to come in on

1150:07	AR2	Well I can give you a good heading to intercept the localizer but there's weather all down the final is what I'm saying there's I don't see any openings on the final I see a weather area all the way down the final
1150:16	AAL102	OK and ah is this stuff movin
1150:23	AR2	Ah does does not appear to be moving ah much if any American one zero two heavy if able turn right heading one five zero and join the runway one seven left localizer
1150:30	AAL102	Ah I don't think we're going to be able to do that that's ah pretty big red area on our scope ah it's about ninety degrees and that's about what we're looking at ah we're goin to have to just go out I guess and wait around to see what's goin on here
1150:45	AR2	American one zero two heavy eight miles south of you the heavy DC eight at three thousand join ah the finals ah reporting a smooth ride at three
1150:54	AAL102	O OK eight miles south of us
1150:56	AR2	Yes sir about eight nine miles south straight south of you
1151:00	AAL102	OK we'll head down that way then and ah we're just going to (unintelligible) out from there
1151:05	AR2	OK American one zero two heavy turn right heading two zero zero and intercept the runway one seven left localizer
1151:08	AAL102	Right to two hundred intercept the localizer
1151:14	DN	Dallas North

1151:19	AR2	Ah this is AR1 point out American one o two heavy finally decided he would turn south he's at three thousand feet join he gonna try the localizer for one seven
1151:24	DN	OK point out observed
1151:25	AR2	MJ
1151:27	AR2	American one zero two heavy would you like to slow down
1151:30	AAL102	Yeah we're gonna bring it way back
1151:31	AR2	OK
(1152) 1152:39	AR2	American one zero two heavy your ah one two miles from the outer marker maintain three thousand until established on the localizer cleared ILS runway one seven left approach
1152:47	AAL102	We're cleared for the one seven left ILS approach American ah one o two heavy
(1152) 1152:55	LCW	Local West
1152:59	AR2	This is AR2 any complaints with Emery zero two two heavy on the final
(1153) 1153:01	LCW	Not yet and I'm tryin to get a report (unintelligible)
1153:03	AR2	OK thanks
1153:04	AR2	MJ

1153:21	AR2	American one zero two heavy ah say your flight conditions
1153:24	AAL102	Ah we're in the clouds it's ah just a little ah ripple and ah pretty good size rain out here
(1154)		
(1155)		
1155:26	SYM730	Hello regional approach Simmons seven thirty is with you descending four for three
1155:31	AR2	Simmons seven thirty regional approach good morning expect ILS runway one eight right
1155:34	SYM730	One eight right for seven thirty thank you
1155:38	AAL102	And ah American one o two heavy in our positions here we're getting about ah ten to fifteen knot ah fluctuation on our airspeed
1155:45	AR2	Gain or a loss
1155:47	AAL102	Ah it's it's mostly a gain
1155:50	AR2	American one zero two heavy roger
1155:51	AR2	Go ahead override
1155:53	LCW	Plus or minus ten at by the outer marker and ah plus or minus five right short final
1155:57	AR2	Thank you a DC eight
1155:58	LCW	GY
(1156)		

1156:02	AR2	American one zero two heavy I just I just got a report from the heavy DC eight that landed on runway one eight right reported a plus or minus one zero knots at the outer marker and a plus or minus ah five minus five excuse me at ah at the ah short final for one eight right
1156:18	AAL102	OK thank you
1156:21	AR2	American one zero two heavy how's your ride now
1156:24	AAL102	O we're getting ah light and occasionally moderate chop
1156:25	AR2	American one zero two heavy contact tower now one two six point point five five
1156:28	AAL102	Twenty six fifty five good night thanks for your help
1156:30	AR2	Your welcome
1156:36	AAL102	Tower American ah one o two heavy nine and a half out for one seven left
1156:39	LCE	American one zero two heavy regional tower runway one seven left cleared to land wind calm
1156:44	AAL102	Cleared to land one seven left American one o two heavy
(1157)		
1157:22	SYM874	Regional tower Simmons eight seventy four is with you ILS one seven left
1157:27	LCE	Simmons eight seventy four regional tower number two cleared to land runway one seven left wind calm caution wake turbulence following a heavy DC ten

1157:34	SYM874	OK cleared to land ah one seven left Simmons eight seventy four
(1158) 1158:31	DAL1438	And Delta fourteen thirty eights ready
1158:33	LCE	Delta fourteen thirty eight runway one seven right taxi into position and hold
1158:38	DAL1438	Ah position and hold Delta fourteen thirty eight
1158:45	UNKN	And Delta fourteen thirty eight which way are you heading
1158:46	DAL1438	Goin north
1158:53	UNKN	Can you give a PIREP ah to departure some way we'd appreciate it
1158:57	DAL1438	We will
(1159) 1159:05	LCE	Exec one zero one runway one three left taxi into position and hold
1159:07	EXE101	Position and hold Exec one o one
1159:25	LCE	Delta fourteen thirty eight change your departure frequency that will be one one eight point five five
1159:30	DAL1438	Eighteen ah fifty five
1159:36	DAL1438	It looked clear out ah to the west now
1159:40	LCE	I'm sorry say again

1159:43	DAL1438	Ah does it look ah clear out to the west for fourteen thirty eight
1159:45	LCE	I'm not painting anything on radar they got ah weather reduction ah kicked in on our radar so I'm not showing anything and up here in the tower it looks ah heavy rain everywhere
1159:58	DAL1438	OK on our radar it looked pretty heavy out to the east and up to the north but ah turning south on the runway here it ah it doesn't look too bad out to the west
(1200) 1200:07	LCE	OK what are you saying you'd like to do
1200:09	DAL1438	Like to go west
1200:11	LCE	Give me a heading
1200:15	DAL1438	O about two forty initially and then we'll work our way around
1200:18	LCE	Alright standby
1200:20	LCE	American one zero two heavy cross runway one seven right
1200:28	LCE	American one zero two heavy
1200:34	LCE	American one zero two heavy

1200:41	LCE	Simmons eight seventy four go around climb and maintain two thousand
1200:45	SYM874	Eight seventy four
1200:50	LCE	American one zero two heavy can you hear
1200:53	LCE	OK we're calling the equipment we can see a fire in the vicinity of your aircraft we can't tell where it's coming from but we do see flames from the tower cab
(1201)		
1201:15	DR1	From forty east of McAlester to forty south south west of McAlester
1201:33	DR1	Possible in the Texas portion
1201:36	DR1	DR one
1201:38	LCE	Local east handoff over the airport Simmons eight seventy four ah go around we got a aircraft on fire on runway one seven left an the runway is unusable at this time he's ah heading ah runway heading two thousand
1201:40	Port 110	Regional tower Port one ten
1201:48	DR1	Alright this is DR1 your calling OK
1201:50	LCE	Yeah
1201:50	DR1	OK (unintelligible)
1201:50	SYM874	Tower eight seventy four you want us over to ah departure

1201:53	LCE	Simmons eight seventy four fly heading one seven zero and contact departure one one eight point five five
1201:58	SYM874	Seven one eighteen five T five
(1202)		
1202:05	Port 110	Regional tower port one ten
1202:08	LCE	Port one ten we're showing everything closed down on the east side of the airport aircraft is on fire on runway one seven left DC ten American one zero two heavy is the call sign
1202:20	Port 110	Roger the airport is closed clear the bridges
1202:23	LCE	Roger
(1203)		
(1204)		
1204:23	LCE	Exec one zero one and Delta fourteen thirty eight I'm not gonna be able to let you go and it's gonna be a little while if you want go ahead and shut down in position that's fine with me I don't have any estimate as to when we'll get you goin again
1204:38	DAL1438	Ah fourteen thirty eight roger
1204:40	EXE101	Exec one 0 one
1204:43	UNKN	seven ninety eight
(1205)		
(1206)		
(1207)		

1207:24	LCE	Attention all aircraft convective SIGMET forty eight central valid until thirteen fifty five ZULU from forty miles east of McAlester to forty miles south southwest of McAlester to twenty miles south of Waco to thirty miles west northwest of San Antonio line of severe thunderstorms twenty miles wide moving from two seven zero at two five tops above flight level four five zero tornadoes hail to three inches wind gust to seventy knots possible

End of Transcript

APPENDIX E

ANTISKID SYSTEM

The accident airplane's antiskid system components, including components found between the airplane and high speed taxiway 3S, were removed from the accident site and tested at the manufacturer, Aircraft Braking Systems, under Safety Board supervision. There were no faults found with the wheel speed transducers used for antiskid and the deployment of the spoilers, or with the antiskid system control box.

The operator's DC-10-30 Maintenance Manual shows that the airplane was equipped with 20 antiskid pressure control valves, mounted in 6 manifolds. Each valve controlled half of the brake assembly for each main landing gear wheel. Testing found that 16 of the valves responded to electrical signal applications, signal step changes, and signal releases. One valve was found inoperative, and three were found with damaged or missing motor caps, which prevented their testing. Five of the 16 valves were found to be out of tolerance in electro-hydraulic tests. Test personnel from the system manufacturer noted that each of the five out-of-tolerance valves would "make it less likely for the affected wheel to skid." Three of the remaining valves were not able to be tested, and one valve, when tested, resulted in no response. The valve, which did not respond to test stimulus, had been removed from the center gear manifold and was found in the "pressure released" condition. System manufacturer engineers stated that failure in the "pressure released" condition should prevent pressurization of the brake half controlled by that valve. The hydraulic fuses in each manifold passed acceptance test criteria.

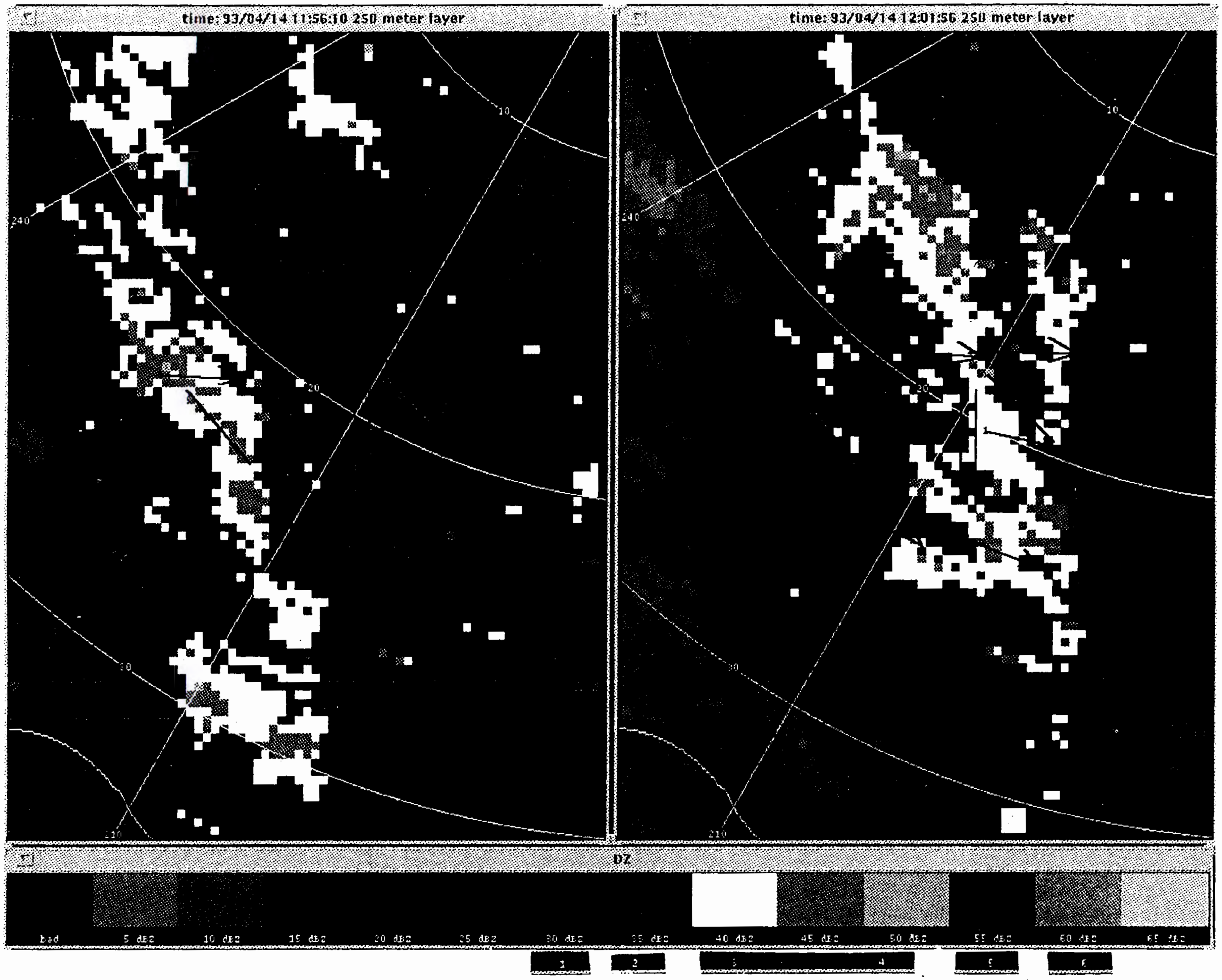
The antiskid control system manufacturer had previously recognized a possibility of corrosion of the control wiring within the hydraulic manifolds. Aircraft Braking System issued a Service Letter (DC-10-10-SL-9 and DC-10-30/40-SL-8), dated March 15, 1979, which stated that corrosion, uncorrected, could result in the antiskid built-in test equipment (BITE) identifying an inappropriate valve circuit malfunction. They noted that loss of a wire could diminish pressure release to the associated half of a wheel brake on the affected main landing gear (left, centerline, or right). When antiskid manifold, S/N 71-104, was disassembled, the connector and connector wiring were found corroded. However, the electronic control unit had not identified and stored fault information from the system BITE.

The airplane wiring diagram showed use of an air-ground sensing circuit in the airframe antiskid wiring. The mechanical and electrical portions of the circuit functioned according to design when inspected after the accident.

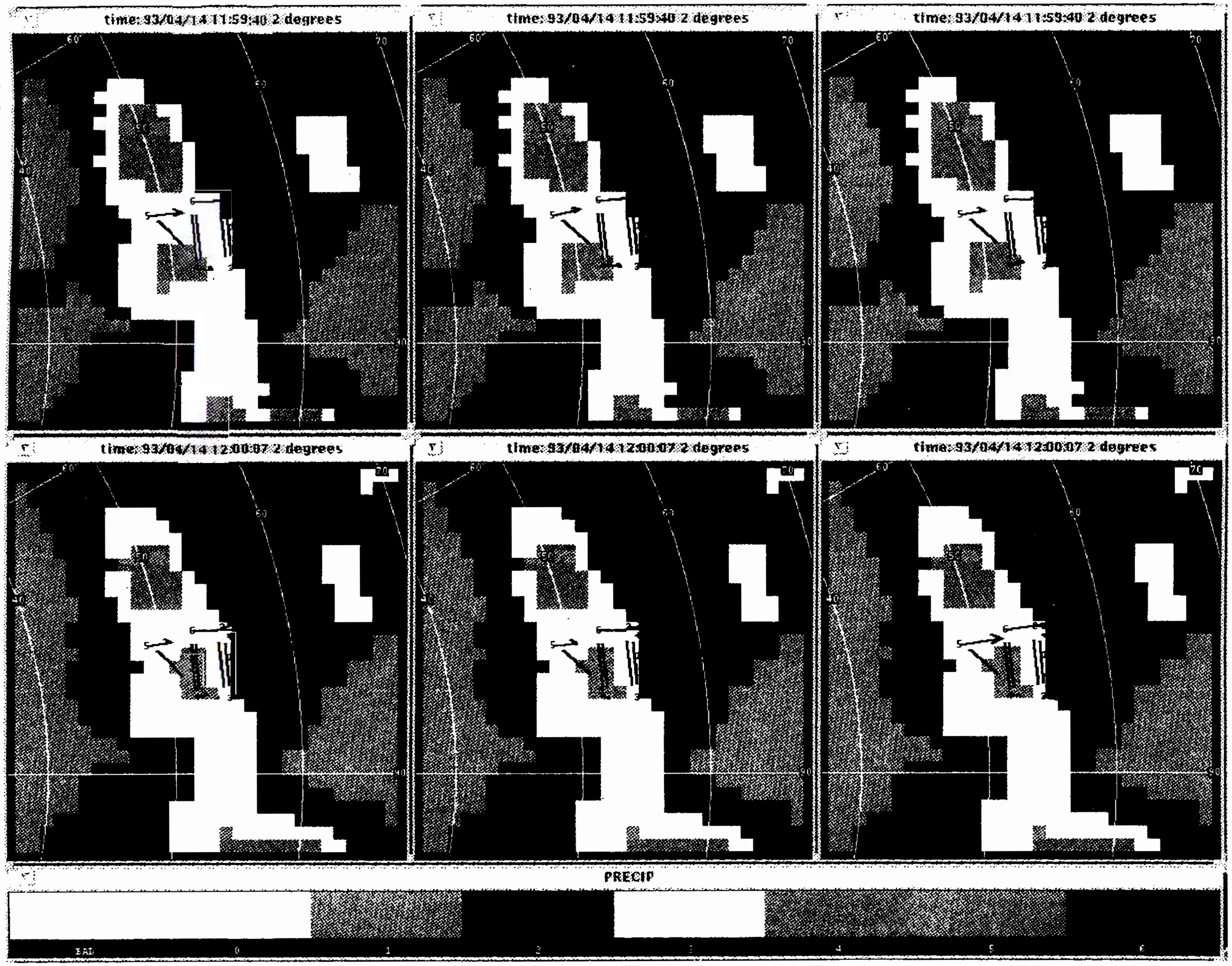
APPENDIX F

SELECTED WEATHER RADAR DATA

Advected 3-D Doppler Radar 39 dBZ Isosurface for 0659



Doppler Radar Data for 0656:10 and 0701:56
VIP Levels 1 & 2 = Shades of Green; VIP Levels 3 & 4 = Shades of Yellow;
VIP Levels 5 & 6 = Shades of Red; Arrows Indicate LLWAS Wind Vectors



ASR-9 Weather Radar Images for 0659:40 and 0700:07 Depicting Weather Echoes of 1 - 6 Intensity Levels. VIP Levels 1 & 2 = Shades of Green; VIP Levels 3 & 4 = Shades of Yellow; VIP Levels 5 & 6 = Shades of Red; Arrows Indicate LLWAS Wind Vectors at 10-Second Intervals

*U.S. G.P.O.:1994-300-644:80021