Runway excursion, USAir Inc., Flight 183, McDonnell Douglas DC9-31, N964VJ, Detroit Metropolitan Airport,Detroit, Michigan, June 13, 1984

Micro-summary: **This Douglas DC-9-31 landed late and slid off the runway during a landing in foul weather.**

Event Date: **1984-06-13 at 2056 EDT**

Investigative Body: **National Transportation Safety Board (NTSB), USA**

Investigative Body's Web Site: **http://www.ntsb.gov/**

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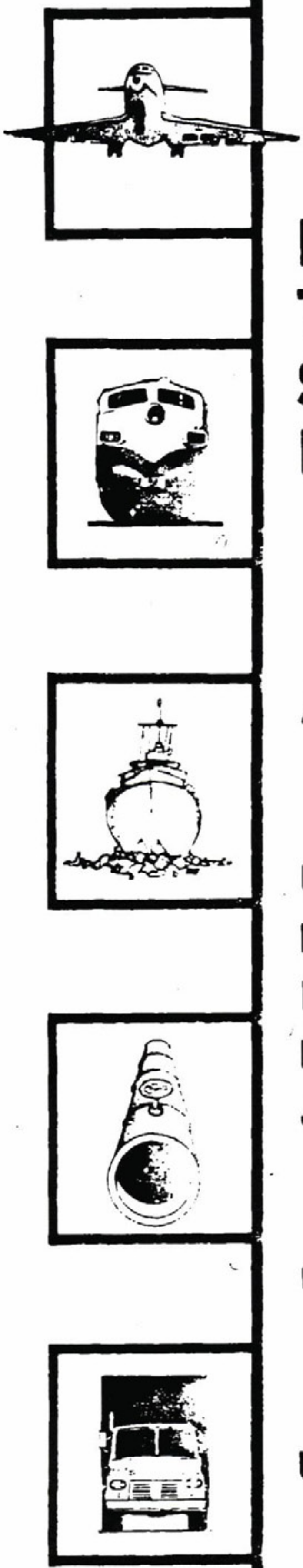

NATIONAL TRANSPORTATION SAFETY BOARD

WASHINGTON, D.C. 20594

AIRCRAFT ACCIDENT REPORT

US AIR, INC., FLIGHT 183
McDONNELL DOUGLAS DC9-31, N964VJ
DETROIT METROPOLITAN AIRPORT
DETROIT, MICHIGAN
JUNE 13, 1984

NTSB/AAR-85/01

UNITED STATES GOVERNMENT

CONTENTS

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AIRCRAFT ACCIDENT REPORT

Adopted: March 5, 1985

USAIR INC., FLIGHT 183 McDONNELL DOUGLAS DC9-31, N964VJ DETROIT METROPOLITAN AIRPORT DETROIT, MICHIGAN JUNE 13, 1984

SYNOPSIS

On June 13, 1984, USAir, Inc., Flight 183, a McDonnell Douglas DC9-31, N964VJ, with 5 crewmembers and 51 passengers aboard, encountered turbulence, hail, and heavy rain as it was making an instrument landing system approach to runway 21R at the Detroit Metropolitan Airport, Detroit, Michigan. The captain lost sight of the approach light system and started a missed approach. The airplane would not climb, according to the captain, and flew through the thunderstorm between 100 and 200 feet above the ground. As the airplane flew out of the rain and hail shaft, the captain saw the runway. He believed that ground contact was imminent, so he ordered the first officer to extend the landing gear as he reduced engine thrust and attempted to land the airplane. The airplane landed on the runway about 2,500 feet beyond the threshold of runway 21R before the landing gear was extended fully. The airplane skidded about 3,800 feet before sliding into the grass on the left side of the runway. The crew and passengers were evacuated with only minor injuries. The airplane was damaged substantially.

The weather at the time of the accident was, in part, ceiling 3,000 feet broken, visibility 1/4 mile, thunderstorm with heavy rain showers and 3/4-inch hail, wind 300 degrees at 20 knots gusting to 32 knots. The Low Level Wind Shear Alert System had indicated wind shear alerts in three of the airport quadrants.

The National Transportation Safety Board determines that the probable cause of the accident was inadequate cockpit coordination and management which resulted in the captain's inappropriate decision to continue the instrument approach into known thunderstorm activity where the airplane encountered severe wind shear. The failure of air traffic control personnel at the airport to provide additional available weather information deprived the flightcrew of information which may have enhanced their decisionmaking process.

1. FACTUAL INFORMATION

1.1 History of the Flight

On June 13, 1984, the flightcrew for USAir, Inc., Flight 183, a McDonnell Douglas DC9-31, N964VJ, a regularly scheduled passenger flight from Bradley International Airport, Hartford, Connecticut, to Detroit, Michigan, reported to the USAir operations office at the airport. The flightcrew consisted of the captain, the first officer, and three flight attendants. The captain received the dispatch package, which had been prepared by the dispatcher in the USAir System Control office in Pittsburgh, Pennsylvania, and then transmitted to Hartford. The dispatch package included weather information, flight plan route data, SIGMET 1/ data, flightcrew advisories, and other pertinent information. The captain checked the NOTAM 2/ and the first officer prepared the flight plan. The weather information indicated that the 1400 3/ weather at Detroit was, in part, 4,500 feet scattered clouds, 30,000 feet thin broken clouds, visibility 6 miles with haze, and the wind 250 degrees at 8 knots.

The weather information advised of a cold front extending from Toronto, Canada, southwest over Detroit to west-central Illinois and of a low-pressure system extending eastward from Toronto to central New Hampshire. The weather information advised of "quite a few scattered afternoon and evening air mass thunderstorms, possibly severe at times, over the entire Gulf Coast, Central Plains, Great Lakes area, northern Ohio Valley and northern New York and New England all along the slow moving front." The flightcrew stated that the weather forecast indicated to them a possibility of thunderstorms at Flight 183's scheduled arrival time in Detroit.

Flight 183 departed the airport gate with 50 passengers and 1 infant aboard at 1525 and was cleared for takeoff on runway 33 at 1537. Shortly after takeoff, the captain asked for and received a route deviation from the Boston Air Route Traffic Control Center (ARTCC) in order to avoid thunderstorms which had developed along the proposed flight route. The flight was cleared to Flight Level (FL) 310 4/ by the Boston ARTCC for the en route portion of the flight.

Flight 183 was cleared to descend to FL 240 by the Cleveland ARTCC, and finally was cleared to descend to 8,000 feet. The flightcrew used the onboard weather radar during the entire flight. They stated that scattered thunderstorm cells were detected when Flight 183 was about 90 to 100 miles from Detroit. Most of the thunderstorm activity was west of the airport. The Detroit Metropolitan Airport Automatic Terminal Information Service (ATIS) 5/ was tuned by the captain during the descent, and information "Charlie" was noted. Information "Charlie" stated, in part, that the weather conditions at Detroit were 4,500 feet scattered clouds, visibility 7 miles, wind 280 degrees at 13 knots, and that instrument landing system (ILS) approaches were in effect for runways 21 left and right.

As Flight 183 approached Detroit, the flightcrew observed two thunderstorm cells near the airport--one about 7 miles in diameter west of Detroit over Willow Run Airport (10 miles west of Detroit Metropolitan Airport) and one southwest of the Detroit airport. Both cells were moving generally east and northeast. The captain stated that his observations of the data from the RCA AVQ-20, black-and-white weather radar in the cockpit were not consistent with the ATIS information, since Flight 183 was encountering broken rather than scattered cloud conditions.

1/ Significant Meteorological Information.
2/ Notices to Airmen.
3/ All times herein are eastern daylight time based on the 24-hour clock.
4/ Flight level is a level constant atmospheric pressure related to a reference datum of 29.92 inches of mercury. Altitudes above 18,000 feet are referred to as flight levels. All altitudes herein are altitude above mean sea level, unless otherwise noted.
5/ Prerecorded weather and airport information broadcast continually to provide landing and takeoff information to pilots.

At 1646:23, Flight 183 contacted the East Arrival Radar controller at the Detroit airport, who initially vectored the flight for landing on runway 21L. At 1647:59, Flight 183 was cleared to descend to 6,000 feet. At 1649:38, the controller stated "USAir 183, left to 240 degrees join 21 right" The first officer confirmed a heading of 240 degrees and runway 21 right. At 1649:43, the controller stated "That's runway 21 right for USAir 183," and the first officer again confirmed the transmission.

Flight 183 encountered broken cloud layers at 8,000 feet. At 1650:24, the controller instructed Flight 183 to descend to 3,000 feet, and at 1650:44, the flight was cleared to continue the descent to 2,600 feet. The airplane remained in the clouds although the flightcrew occasionally observed the ground. The flightcrew continued to observe thunderstorm cells on the weather radar, which was set on the 30-mile range. The flightcrew said that the cell to the west of the airport produced the strongest return, and the weather radar was "contouring" the cell. The cockpit voice recorder (CVR) indicated that at 1651:28, the flightcrew discussed the thunderstorm, and the captain stated "yeah, ten miles from the airport**." 6/ At 1651:28, the controller stated, "Attention all aircraft inbound to Metro. Metro visibility is 2 miles." The captain stated that he recalled hearing the transmission, and he said that he was prepared for a full instrument approach to the airport. He said that he was aware that the weather at the airport was deteriorating, even though the ATIS information did not reflect the poor weather conditions.

At 1651:51, the controller transmitted, "USAir 183 6 miles from Scofi, maintain three 'til Nesbi, reduce and maintain 170 to the marker, cleared to the ILS 21 left -- correction, that's the ILS 21 right USAir 183." The first officer transmitted, "Roger, 170 and back down to three USAir 183," simultaneously with the final portion of the controller's instruction. As a result, the final portion of the controller's transmission, "correction, that's the ILS 21 right USAir 183," was not heard in the cockpit. At 1651:59, the captain ordered the flaps to 15 degrees, and at 1652:21, the landing gear was extended.

At 1652:17, Learjet N103CF, which was en route from Toronto to Detroit and following Flight 183 in the traffic sequence, contacted Detroit approach control and asked the East Arrival Radar controller if there had been any changes to the weather which were not contained in ATIS information "Charlie." At 1652:43, as the flightcrew of Flight 183 was completing the final landing checklist, the controller replied to Learjet N103CF, "3 CF thunderstorm in progress, descend and maintain 6,000." At 1652:51, the pilot of Learjet N103CF replied, "We have Charlie, yes, and we're looking at the thunderstorm here." The flightcrew of Flight 183 testified later that they heard the discussion about the thunderstorm. The captain stated that he assumed the discussion related to weather at the airport, but, since Learjet N103CF was landing on runway 21L, the information did not apply to runway 21R. The first officer stated that he could not determine the location of the thunderstorm from the discussion.

At 1653:48, the flightcrew of Flight 183 discussed the missed approach procedure for runway 21R. The first officer mentioned the thunderstorm at Willow Run Airport, which was along the route of the missed approach procedure. At 1653:54, as the flightcrew was discussing the published missed approach procedure, the controller announced that the visibility at the airport was 1 mile.

6/ The asterisks indicate unintelligible words.

At 1654:00, the airplane passed the outer marker, and the first officer verified the crossing altitude. The captain stated that he did not monitor the weather radar once the airplane was inside the outer marker. The first officer stated that he observed cells on the weather radar once the airplane was inside the outer marker but that he did not consider the cells an impediment to landing. The first officer said that he adjusted the weather radar to observe the cell activity, but did not give the radar a high priority because he also was occupied with other before-landing duties. At 1654:23, the captain stated, "Smell the rain," and the first officer responded, "yep, got lightning in it too."

The flightcrew changed from the East Arrival Radar controller frequency to the tower local control frequency about 1654:27, and part of a transmission by the local controller was heard in the cockpit. The first two words of the transmission, "Center field" were blocked by another transmission and were not received by the flightcrew, who only heard "winds are 320 degrees at 26, peak gusts 36, north boundary winds 270 degrees at 16, east boundary winds 310 degrees at 8, south boundary winds 290 degrees at 22." The flightcrew stated that they recalled the transmission but did not consider it to be a wind shear alert. The captain said that the transmission indicated to him rapidly shifting winds at the airport, while the first officer believed that it was additional wind data. The captain stated that he had never heard wind information given in this format and that the words "wind shear alert" would have had a different meaning to him.

At 1654:34, the captain stated, "It's going to get choppier than # 7/ here in a minute." At 1654:48, the captain remarked, "I'll betcha it is, it's right on the end of the # runway." At 1654:50, the first officer transmitted, "Tower USAir 183 is with you for the right side." The local controller cleared Flight 183 to land.

At 1655:03, the first officer stated "out of a thousand" and positioned the flaps to 50 degrees. The flightcrew said that about that time they were clear of the clouds, and had begun to encounter rain. At 1655:04, the captain asked that the windshield wipers be turned on. At the same time, the local controller transmitted, "wind check, centerfield wind 320 degrees at 27, east boundary wind 320 degrees at 9, the north boundary wind 260 degrees at 13." As soon as Flight 183 was clear of the clouds, the flightcrew observed a low gray-white layer of clouds which covered the airport. The clouds and associated rain lay on the localizer course to runway 21R. At 1655:13, the first officer said that he had the approach lights in sight. Both pilots said they saw the approach lights but not the runway lights.

At 1655:29, Frontier Airlines Flight 214, a Boeing 737 that was making an ILS approach to Runway 21L, transmitted on the local control frequency, "Frontier 214 going around." The transmission was repeated at 1655:35. Although the flightcrew of Flight 183 stated that they did not hear Frontier 214's go-around transmissions, the transmissions were recorded on Flight 183's CVR. The local controller stated that, shortly before Frontier 214 started its go-around, she had observed that the airport visibility had dropped to 1/4 mile because of rain. However, she did not inform the airplanes on the tower local control frequency of the reduced visibility.

At 1655:34, the first officer remarked, "Outta 500 feet speed is plus 15," and 2 seconds later he said, "Sinking eight no flags." At 1655:40, the first officer said "Runway ** approach lights in sight." At 1655:56, the local controller announced, "Twenty one left Northwest 736 cleared to land, centerfield wind 320 degrees at 28 peak gusts 40 correction 42." At 1655:59, the captain told the first officer, "ask 'em if they got the runway lights on, I can't get a word in edgewise."

7/ The symbol "#" indicates nonpertinent word(s).

The captain stated that he turned on rain repellent in addition to the windshield wipers. As the airplane continued to descend on the glide slope, it entered the low-lying clouds about 350 feet above the ground. The captain said that until that point in the instrument approach no conditions had been encountered which caused him to consider a missed approach. He said that he was aware that the surface winds might exceed the DC9-31 crosswind landing limitation, but believed that he still had time to make a final landing decision. The first officer stated that the instrument approach was "standard" to that point. Both pilots stated that they expected rain but not a thunderstorm upon reaching decision height. 8/ As the airplane entered the low clouds, Flight 183 immediately encountered heavy rain, hail, and turbulence. The onset of the rain and hail was recorded on the cockpit voice recorder at 1656:05. The noise of the rain and hail continued until 1656:16 and overrode other sounds in the cockpit during that time period.

At 1656:05, the first officer transmitted, "Tower, USAir 183 turn the runway light onto the left side please." He later stated that he was not confused about the landing runway, but simply made a mistake when asking for the runway lights. The captain stated that as soon as the airplane entered the clouds and encountered the rain and hail, he lost sight of the runway environment and that he immediately started a missed approach. He stated that he disengaged the autopilot from the coupled instrument approach mode, advanced the thrust levers to the mechanical stops, and rotated the airplane to the 15-degree nose-up attitude indicated by the flight director command bars. He said that he observed a positive rate of climb and then ordered the flaps repositioned to 15 degrees and the landing gear raised. He verified the flap setting at 15 degrees. He stated that the only difficulty with the missed approach procedure was the excessive control wheel force required to rotate the airplane to a 15-degree nose-up attitude.

The captain stated that the indicated airspeed increased to about 140 knots from about 133 knots and that the acceleration was normal for the conditions. The first officer recalled that the airspeed increased to 135 knots. The flightcrew recalled that shortly after the initial climb began on the missed approach, the rate of climb slowed and stopped and the airspeed started to decrease; as the airspeed decreased, the airplane began to descend. At 1656:16, a sound similar to the middle marker was heard on the CVR, and at 1656:17, a ground proximity warning horn sounded. At 1656:22, the first officer transmitted "USAir 183 missed approach." The captain stated that upon passing the middle marker, the airplane flew out of the rain and hail shaft and he saw the runway. He stated that he believed that the airplane was still descending and that the airspeed had decreased to about 119 knots.

At 1656:24, the captain, believing that contact with the runway was imminent, ordered, "Down the gear, down the gear." At 1656:26, a sound similar to that of a stickshaker was recorded on the CVR. 9/ The stickshaker sound lasted 1 second. At 1656:26, the captain again ordered, "Down the gear." The captain stated that when he ordered the landing gear lowered, he pushed the nose over to insure a level touchdown, and he pulled the thrust levers back to reduce power. The sound of impact was recorded on the CVR at 1656:29. The CVR ran until 1656:47.

8/ Height at which a decision must be made during an ILS to either continue the approach or to execute a missed approach.

9/ As a warning to the pilot, the stickshaker activates when the indicated airspeed approaches stall speed.

The airplane landed with the landing gear partially extended about 2,500 feet beyond the threshold of runway 21R, which is 10,500 feet long. The captain stated that after touchdown he applied reverse thrust. The airplane skidded about 3,800 feet on the runway before sliding into the grass on the left side of the runway.

After the airplane came to a stop, the captain opened the cockpit door as the first officer completed the shutdown of the engines. The captain assisted in the evacuation of the airplane.

The flight attendants and several passengers later told Safety Board investigators that the flight was routine until the airplane suddenly encountered severe turbulence, rain, and hail. The flight attendants and passengers reported that they were shaken vertically and laterally during the approach although all reported that their seatbelts and/or harnesses were fastened snugly. They said that the contact with the runway followed an engine power increase. The contact was described as a "big jolt" and a "very hard landing." They recalled a bounce and numerous less severe bumps following the initial impact as the airplane slid along the runway. The flight attendants and passengers evacuated the airplane immediately with no significant problems. The accident occurred during the hours of daylight at coordinates 42°13'42" N latitude and 83°21'06" W longitude.

The captain of Frontier Airlines Flight 214, who initiated a go-around about 1655:29, said that he visually observed thunderstorm buildup when he was about 100 miles west of Detroit. The cells started to appear on the airborne weather radar when he was about 75 miles from Detroit. The first radar observations were of a line of small cells which were yellow on the color airborne weather radar. 10/ As the airplane was vectored for an ILS approach to runway 21L, he observed that a cell west of the airport was depicted as red on the radar, which indicated a more severe storm. He believed the center of the cell was 3 or 4 miles west of the airport. He was given the surface winds by the local controller at 1652:57, and he recalled that the winds suggested to him a crosswind problem. He heard also a transmission that the visibility at the airport was 1 mile. He stated that he understood the content of the wind data transmission, but he did not expect to receive wind data in the format they were presented. He understood that the wind data were derived from the Low Level Wind Shear Alert System (LLWAS).

The captain said that as Frontier 214 broke out of the clouds inside the outer marker, he saw the runway. There were clouds and rain obscuring the west side of the airport. He believed that the weather conditions were worse for runway 21R than runway 21L. He saw two lightning strikes and observed precipitation returns on the airborne weather radar. He said that he started a missed approach about 250 to 300 feet above the ground when he encountered heavy rain and turbulence. He said he encountered extremely heavy rain and severe turbulence but no hail during the missed approach, and that the indicated airspeed fluctuated about 10 knots on either side of his missed approach speed.

10/ Most color airborne weather radar depicts weather returns in three colors: a light precipitation return is amber, a moderate precipitation return is yellow, and a heavy precipitation return is red.

Northwest Orient Airlines Flight 736, en route from Washington, D.C., to Detroit, was sequenced in the traffic pattern to follow Frontier 214 onto runway 21L. The captain said that he was aware of the forecast for thunderstorms at Detroit before departing Washington. He stated that he observed cells west of Detroit when he was about 150 miles from Detroit. About 15 miles from the airport, he could determine that the weather associated with the thunderstorms still was west of the airport. As the airplane turned inbound to runway 21L, he noted that the cell immediately west had moved closer to the airport. He said that he continued the approach because he believed the cells to the west and southwest might not be a factor. However, he observed one cell at the airport or adjacent to the ILS approach course. He was concerned about gust fronts from the cells and listened for wind reports from the local controller. He was aware that the wind data were derived from the LLWAS, and he considered the wind information a wind shear alert. However, he stated that the delivery of the data was so rapid that he was not able to assimilate the various wind directions or velocities.

Northwest 736 contacted the local controller at 1655:14. The captain stated that the communications on the frequency were "heavy" and that there was "a little bit of confusion." For example, Northwest 736 was lined up for runway 21L, but the local controller cleared it for runway 21R. As he listened on the local control frequency, he heard Frontier 214 go around. He said that this event, coupled with the reported winds, made him decide to go around. The go-around was started at an altitude of about 900 feet above the ground. He encountered turbulence and heavy rain on the go-around, but the weather conditions did not cause problems. He never encountered hail, nor had he been told of the existence of hail at the airport.

The captain of Learjet N103CF, which was to follow Northwest 736 onto runway 21L, used the airplane's color radar to identify a cell near the Detroit airport when he was about 80 miles away. He used the capabilities of the radar and the map overlay feature of his navigation system to pinpoint precisely the location of the cell west of the airport. He observed also other cells west and southwest of the airport.

Twenty-five miles from the airport, the captain of Learjet N103CF noted that one cell was about 1 mile west of the airport, with several smaller cells to the west and southwest. The closest cell was, in his opinion, influencing "the entire airport or a great majority of the airport." He recalled that the cell passed over the northern part of the airport. The color of the cell on the weather radar was red with a very sharp rain gradient. He believed he made the observation about 1654 or 1655.

The captain of Learjet N103CF contacted approach control and was told that there was a thunderstorm at the airport. He then heard a transmission that the tower visibility at the airport was 1/4 mile. He started a missed approach before reaching the outer marker.

1.2 Injuries to Persons

Injuries	Crew	Passengers	Other	Total
Fatal	0	0	0	0
Serious	0	0	0	0
Minor	3	7	0	10
None	2	44	0	46
Total	5	51 1/	0	56

1/ One uninjured passenger was a nonticketed infant.

1.3 Damage to Airplane

The airplane sustained substantial damage.

1.4 Other Damage

None.

1.5 Personnel Information

The flightcrew was certificated and qualified for the flight in accordance with applicable Federal Aviation Administration (FAA) regulations. The flight attendants were qualified and trained in accordance with regulations. The air traffic controllers were qualified in accordance with FAA orders. (See appendix B.)

1.6 Aircraft Information

The airplane, a McDonnell Douglas DC9-31, N964VJ, was operated by USAir, Inc. The airplane was maintained in accordance with applicable regulations. The takeoff gross weight, the landing gross weight, and the center of gravity were within the acceptable ranges.

There was 21,500 pounds of jet fuel on board the airplane before it departed Hartford. Based on the fuel burnoff from takeoff until arrival at Detroit, there was about 12,500 pounds of fuel on board when the accident occurred. The airplane was powered by two JT8D-7B engines manufactured by Pratt and Whitney Aircraft Group. (See appendix C.)

1.7 Meteorological Information

The weather information for the Detroit Metropolitan Airport from 1300, June 13 through the time of the accident was generated by the National Weather Service (NWS) employees on duty at the NWS station located on the east side of the airport. One employee, the Duty Observer, made weather observations and disseminated the weather data locally and over the NWS weather circuits. The second employee was a weather radar specialist.

The 24-hour terminal forecast issued by the NWS for the Detroit Metropolitan Airport from 1300 June 13 to 1300 June 14 was:

> Clouds 4,000 feet scattered, 10,000 feet scattered, ceiling 25,000 feet broken, wind 210 degrees 10 knots, occasionally ceiling 4,000 feet broken. Chance of ceiling 2,500 feet overcast, visibility 3 miles in thunderstorms with light rain showers. After 1500 ceiling 4,500 feet broken, 10,000 feet broken, 25,000 feet overcast, wind 220 degrees 10 knots, chance of ceiling 2,500 feet broken, visibility 3 miles in thunderstorms with light rain showers. After 0500; VFR [visual flight rules]

The 1300 NWS surface weather map showed a stationary front about 120 miles southwest of Detroit, extending northeast from Kansas into central Michigan. The front then continued eastward to Maine. There was no significant pressure gradient associated with the front.

The Center Weather Service meteorologist in the Cleveland ARTCC was responsible for transmitting significant weather information to certain airports and approach control facilities within his area of observation, which included the Detroit Metropolitan Airport. He observed convective buildups in the southwest part of Michigan and issued a Meteorological Impact Statement (MIS) at 1615. The MIS stated, in part: "Developing scattered to broken area of Level 3-4 thunderstorms in Southern Michigan-Northern Indiana-Southern Lake Michigan area moving eastward at 25-30 knots. Maximum tops 40,000 feet to 45,000 feet." The MIS was transmitted on the Service A system and was received at the Detroit NWS station and the air traffic control facility at the Detroit Metropolitan Airport. He continued to observe the area west of Detroit from 1630 until 1700 by calling up the weather radarscope at the local NWS station. He stated that he did not observe any movement and development of cell activity near the airport. He stated that ground clutter precluded observation of the cells near the airport, and he did not see a cell move in from the west. He said that he believed that there was only one cell involved in the accident, and that the cell developed rapidly in the immediate vicinity of the airport.

The NWS station at the airport had a WSR-74S weather radar unit. The weather radar specialist and the Duty Observer, who also was a qualified weather radar observer, stated that ground clutter hinders the capability of the radar unit to observe convective activity within 15 to 25 miles of the airport. At 1615, the weather radar specialist observed Level 3 and 4 cells to the south and west of the airport and coordinated a severe weather call with local authorities. He did not observe the development of a cell in the immediate vicinity of the airport, since the ground clutter pattern precluded accurate observations within 20 miles of the airport. The radar overlay from the radar unit showed Video Integrator Processor (VIP) 11/ Level 3 cells about 40 miles west of the airport at 1630. The cells were moving from 260 degrees at 30 knots. The radar overlay showed Level 4 cells immediately northeast and southwest of the airport at 1730.

11/ VIP Levels

	Echo intensity	Rainfall rate (in/hr)	Indication
1	weak	.2 (light)	Light to moderate turbulence
2	moderate	.2-1.1 (moderate)	is possible with lightning.
3	strong	1.1-2.2 (heavy)	Severe turbulence possible, lightning.
4	very strong	2.2-4.5 (very heavy)	Severe turbulence likely, lightning.
5	intense	4.5-7.1 (intense)	Severe turbulence, lightning, organized wind gusts.
6	extreme	7.1 (extreme)	Severe turbulence, large hail, lightning, extensive wind gusts and turbulence.

Surface weather observations for the Detroit Metropolitan Airport, made by the NWS employees, were as follows for the times indicated:

> Time--1352; type--surface aviation; clouds--4,500 feet scattered, 30,000 feet thin broken; visibility—6 miles; weather—haze; temperature--85° F; dewpoint—70° F; wind—250 degrees 8 knots; altimeter--30.00 inches.
>
> Time—1555; type—surface aviation; clouds—4,500 feet scattered, 30,000 feet thin broken; visibility--7 miles; weather--none; temperature--92° F; dewpoint—66° F; wind—250 degrees 15 knots; altimeter—29.95 inches.
>
> Time--1636; type—special; ceiling—estimated 4,500 feet broken, 16,000 feet broken; visibility—6 miles; weather--thunderstorm and haze; wind--280 degrees 12 knots; altimeter--29.91 inches; remarks--thunderstorms began 1635, 3 miles west moving east occasional lightning in clouds and cloud to ground.
>
> Time—1650; type—record special; ceiling—estimated 3,000 feet broken; 16,000 feet broken, 30,000 feet overcast; visibility—1/4 miles; weather—thunderstorm with heavy rain showers and hail; temperature--82° F; dewpoint—68° F; wind 300 degrees 20 knots, gusting to 32 knots; altimeter—29.92 inches; remarks--thunderstorms began 1635, overhead moving east, occasional lightning in cloud and cloud to ground, rain began 1643, hail began 1650, runway 3L visual range 6,000 feet plus, hail stones 3/4 inches.
>
> Time—1725; type—special; ceiling--estimated 3,000 feet broken, 10,000 feet broken, 30,000 feet overcast; visibility--4 miles; weather--thunderstorm with light rain showers; wind--040 degrees 10 knots; altimeter—29.92 inches; remarks--thunderstorms east moving east, occasional lightning in cloud and cloud to ground, hail ended 1653.

The Duty Observer stated that he made a special observation at 1636 because he visually observed a thunderstorm about 3 miles west of the airport. He recalled that the cell had developed rapidly and had moved west to east. He said that it was a "very localized storm," and he described the cell's rapid development as "almost explosive." He said that as he began to make the 1650 record observation, the weather situation deteriorated rapidly. The rain became heavy, and 1/2-inch hail began to fall. The visibility fell from 2 miles to 1/4 mile, and the hail increased in size to 3/4 inch. He stated that the rapidly deteriorating weather conditions between 1648 and 1652 caused him to revise the first observation. Consequently, although he began to record the observation at 1650, he did not finish until 1655. The record special was entered on the electrowriter at 1656.

Information was transmitted on the electrowriter for use in the air traffic control tower, the NWS station at the airport, and other locations at the airport; the following messages were sent during the period before the accident:

- [The 1636 special observation.]

- Detroit, June 13, 1653, tower visibility 1 mile.

- Detroit, record special, 1650, ceiling estimated 3,000 broken, 16,000 broken, 30,000 overcast, visibility 2 miles in thunderstorm with moderate rain showers.

- Detroit, June 13, 1653, tower visibility 1/4 mile.

- Detroit, 1650, ceiling estimated 3,000 broken, 16,000 broken, 30,000 overcast visibility 1/4 mile in thunderstorm with heavy rainshowers and hail, barometer 1012.7 millibars, temperature 82° F, dew point 68° F, wind 300° 20 knots gusting to 32 knots, altimeter 28.92 inches, thunderstorm began 2035, overhead moving east, occasional lightning cloud to cloud and cloud to ground, rain began 1643, hail began 1650.

The runway visual range (RVR) recorded by the NWS for runway 3R did not go below 6,000 feet between 1630 and 1730. The recorded rainfall between 1640 and 1650 was 0.08 inch. The heaviest rainfall was between 1645 and 1650.

1.8 Aids to Navigation

Runway 21R is served by an instrument landing system (ILS) approach procedure. The ILS provides glide slope and localizer guidance to the flightcrew. The outer marker is 5.1 nautical miles from the runway threshold. The middle marker is 0.6 nautical mile from the runway threshold. An airplane should cross the outer marker at an altitude of 2,260 feet. The threshold crossing height is 60 feet. Decision height is 837 feet (200 feet above the runway), and the elevation of the runway threshold is 637 feet. Visibility minima for the ILS runway 21R is 1/2 mile or 2,400 RVR.

1.9 Communications

There were no known radio communications difficulties.

1.10 Aerodrome Information

The Detroit Metropolitan Wayne County Airport, elevation 639 feet, is located southwest of Detroit, Michigan. The airport is certificated for commercial operations in accordance with 14 CFR Part 139, Subpart D.

The landing area consists of four runways: 3L/21R, 3C/21C, 3R/21L, and 9/27. (See figure 1.) Runway 21R is 10,500 feet long and 200 feet wide, with a grooved concrete surface. Runway 21R has high-intensity runway edge lights, runway centerline lights, and a high-intensity approach light system with sequenced flashing lights.

Runway 3R/21L and 3L/21R each have three transmissometers located along the sides of the runway at each end and in the middle to provide RVR information to the tower. RVR information from the transmissometers was not recorded except from the transmissometer on the approach end of Runway 3R. The NWS receives RVR information from a separate transmissometer located on the approach end of runway 3R.

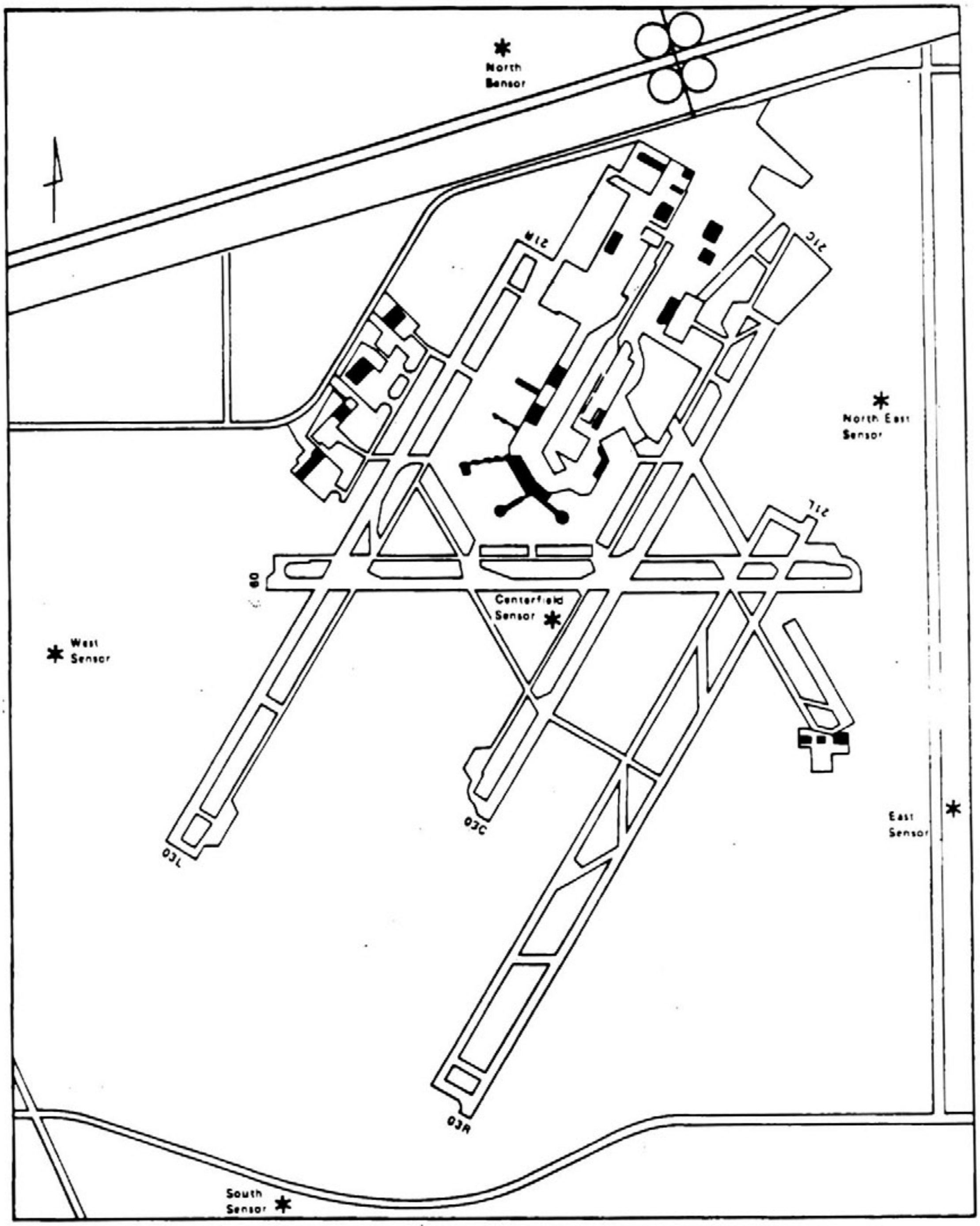

Figure 1.--Airport diagram/low level wind shear alert system.

1.11 Flight Recorders

The airplane was equipped with a Sundstrand digital flight data recorder (DFDR), model UFDR-FWUS, serial No. 1309, and a Sundstrand V-557 cockpit voice recorder (CVR), serial No. 2535. Both recorders were removed from the airplane after the accident and brought to the Safety Board's Audio Laboratory for processing and readout.

Cockpit Voice Recorder.--The CVR casing was undamaged in the accident. Two problems were noted in the transcription of the audio tape. First, the cockpit speaker volume was positioned at a high level, so the output of the speakers obscured some flightcrew conversation. Second, the microphone channel input was high, which overloaded the electronics of the recording system. Three problems resulted in a distortion of the audio on the CVR tape. However, after the tape was adjusted to the proper speed and the audio signal was filtered as required, the transcription of the CVR tape was completed with no difficulty. The entire CVR tape was reviewed by the CVR group, and the final 7 minutes 21 seconds were transcribed. (See appendix D.)

Digital Flight Data Recorder.--The recording medium of the Sundstrand model UFDR-FWUS is a 1/4-inch magnetic tape. Altitude, airspeed, heading, and microphone keyings are recorded in a digital format at the frequency of one sample per second. Vertical acceleration also is recorded in a digital format but is sampled 12 times per second.

The flight recorder was undamaged and in working order. The data recovered from the recorder indicated that it operated normally during the flight of Flight 183, and that it stopped at 1656:31. However, the vertical acceleration values were invalid since the vertical acceleration sensor had failed before the start of Flight 183. (As a result of the accident investigation, USAir revised the DFDR test procedure for the accelerometer on August 2, 1984. The accelerometer is now checked at values of 1 "g", 0 "g", and -1 "g.")

The static pressure transducer was tested to evaluate the accuracy of the altitude information. The Sunstrand Corporation assisted in the calibration of the recorder. The tests and calibration showed that the recorder met FAA tolerances for altitude data.

The data from 1651:36 to 1656:31 was extracted from the recorder and analyzed during the accident investigation. (See appendix E.)

1.12 Wreckage and Impact Information

The damage to the airplane was limited to the fuselage and the wings as a result of the impact with the runway and the subsequent skidding on the runway and the sod adjacent to the runway.

There was no damage to the radome. The forward-most damage evident on the fuselage was a dent in the skin panel from fuselage station (FS) 37 to FS 55. The skin on the underside of the fuselage was dented, scraped, buckled, and torn in various places, from FS 37 to FS 996.

The nose gear doorframe and the nose gear doors were damaged. The left and right main landing gear doors and door jambs were torn from the attach points. The nose landing gear was up and undamaged except for the water spray deflector shield which had separated from the gear assembly. The main landing gears were unlocked in the wheel wells. The landing gear handle in the cockpit was in the down position. Both landing gears extended and locked in the down position when the airplane was raised. The left main landing gear outboard wheel was damaged on the outboard rim.

The hydraulic lines in the left and right main wheel wells were damaged. The right wheel well hydraulic system reservoir was separated from the mount and was empty. The left wheel well hydraulic system reservoir was not damaged and contained hydraulic fluid. The landing gear selector valve was damaged.

There was no damage to the left or right engine pylons. Neither engine was damaged. Mud was found in the right engine inlet and on the fan blades, the exhaust duct, and the tailpipe. Both thrust reversers were found stowed and free of damage. Both engines rotated freely.

There was no scraping or damage to the trailing edges of the main wing flap panels. The wing flap hinge fairings were broken at the support mounts. The right flap hinges at FS 164 and FS 253 were ground down perpendicular to the longitudinal axis of the airplane. The left flap hinges at FS 164 and FS 267 exhibited similar grinding. The flap position transmitter and the followup rods had separated from the left and right flap hinges when the flap hinges were ground down during the slide on the runway. The followup rods remained inside the flap hinge fairings. The flaps could be moved freely by moving the disengaged followup rods. The wing flaps were extended 11 1/2 inches measured at the inboard flap panel-to-fuselage wing fillet.

The lower surfaces of the fibreglass left and right fuselage fairings were damaged. The fuselage fairings are attached to the wing flap panels and fit into the lower part of the fuselage at the wing root. The damage to the sailboat fairings was aligned with the bottom of the fuselage when the wing flaps were extended about 15 degrees.

The leading edge slats were extended fully.

The flap handle and the slat handle were in the 15-degree position in the cockpit.

The airspeed bugs were found at 118 knots.

1.13 Medical and Pathological Information

There was no evidence of preexisting medical conditions which affected the performance of the flightcrew.

Three crewmembers and seven passengers received minor injuries during the evacuation. These injuries included mild contusions, abrasions, muscle strains, and back pain.

1.14 Fire

There was no fire.

1.15 Survival Aspects

The impact and postcrash events were survivable. The impact and decelerative forces transmitted through the restraint systems were within the limits of human tolerance. There was no intrusion into the structure of the cabin or the cockpit. There were no failures of the seats or the restraint systems.

Emergency Response.--An airport firefighter observed Flight 183 contact the runway and slide into the grass. He shouted to other crash/fire/rescue (CFR) personnel as he opened the overhead station door. A CFR sergeant notified the control tower and the airport police of the accident by radio. Seven CFR personnel responded to the accident in four firetrucks and two ambulances. The first vehicles reached the accident site within 1 minute of notification. Most passengers had evacuated the airplane by the time the first CFR vehicles arrived at the accident site. The airplane was checked for fuel leaks while two emergency medical technicians assisted the injured passengers. Four injured passengers were taken to a local hospital in an airport ambulance.

Evacuation.--The captain exited the cockpit through the cockpit door immediately after the airplane stopped sliding. The "A" flight attendant started to open the main (left) passenger door, but the captain proceeded to open the door. The evacuation chute deployed and opened automatically. The "C" flight attendant opened the forward (right) galley door and the evacuation chute operated properly. The four cabin window exits were opened by passengers. Most passengers were seated toward the front of the cabin so the "B" flight attendant, seated in the rear of the cabin, did not open the tailcone exit.

No debris or loose equipment blocked the aisles during the evacuation except for two hand-carried suit bags which fell into the aisle and were removed by the forward flight attendants. The evacuation through the two forward exits was completed without difficulty. Initially the evacuation slide from the forward galley door was blown toward the front of the airplane by the strong surface winds. However, the first two male passengers to exit held the slide in place. About half of the passengers and the flightcrew exited through the two forward exits.

The remaining passengers exited rapidly through the four cabin window exits. However, some problems were encountered from several seatback trays which had loose latches and would not stay closed. Additionally, the passengers who had opened the window exits placed them in the seats, and the following passengers had to climb over the window exits and the armrests.

The flight attendants observed that several passengers carried hand baggage during the evacuation, and that many passengers attempted to secure personal belongings before they left the airplane. The flight attendants used forceful, direct commands to order the passengers to leave immediately. Flight attendants and passengers described the evacuation as orderly, rapid, and free of panic. The entire evacuation was completed in about 80 seconds.

Many passengers complained that there was no transportation to take them from the accident site to the terminal until about 30 minutes after the evacuation was completed.

The one infant on board was held in his mother's lap during the accident.

1.16 Tests and Research

1.16.1 Airplane Performance

The analysis of the airplane's performance was based on information from the CVR, the UFDR, the broadcast winds at the airport, and the DC9-31 performance manual. Because the LLWAS readings were not recorded, the wind information available from other sources was insufficient to adequately describe the wind field associated with the thunderstorm or to develop a wind model by which the magnitude of the wind shear could be measured. Because of the lack of vertical "g" information due to a sensor malfunction in the UFDR, vertical acceleration and angle of attack information could not be determined. A correlation of the UFDR and the CVR data was made to align events associated with the flight path of the airplane with the sequence of recorded cockpit conversations.

The final approach configuration of Flight 183 was: flaps--50 degrees, slats--extended, landing gear--down, landing gross weight--82,500 pounds (estimate), Vref--118 knots. Based on the broadcast winds, the north boundary wind of 260 degrees at 13 knots produced a 9-knot headwind component for Flight 183 at 1655:04. At 1655:56, the centerfield wind of 320 degrees at 28 knots gusts to 42 knots resulted in an 8- to 13-knot tailwind.

The UFDR data indicated that the ILS approach to runway 21R was stabilized before reaching decision height, and that the indicated airspeed was between 133 knots and 138 knots. About 1656:05, the CVR recorded the sounds of hail and rain, which masked all flightcrew conversation in the cockpit. Therefore, it was not possible to determine the precise moment that the missed approach was started, or when the landing gear and flaps were raised. However, by 1656:09, 4 seconds after the encounter with the rain and hail, the indicated airspeed increased to 143 knots. The altitude data indicated that the airplane was leveled off about 100 to 200 feet above the ground and maintained this altitude for about 16 seconds.

The sound of hail stopped abruptly at 1656:16, as the airplane crossed the middle marker. At this time the indicated airspeed had decreased to 127 knots. The altitude remained constant for about 5 additional seconds as the recorded indicated airspeed decreased further to about 119 knots at 1656:21 when the altitude data showed a descent to the runway. At the point that the altitude data first indicated a descent, the recorded indicated airspeed was about 119 knots. The recorded indicated airspeed moved rapidly to 133 knots at 1656:23 and then fluctuated between 128 knots and 137 knots for the next 6 seconds until impact at 1656:29.

The theoretical performance data indicated that a DC9-31 weighing the same as the accident airplane and at the same density altitude should achieve a 15-degree pitch attitude as it accelerates through 135 knots indicated airspeed with a rate of climb of 1,375 feet per minute in a zero wind condition. The maximum achievable rate of climb was calculated to be 2,700 feet per minute, if the airplane was in a 21.6-degree pitch attitude, at a constant 135 knots, also in a zero wind condition.

The airplane's level flight acceleration in the go-around mode at 135 knots was calculated to be about 3.9 knots per second in a zero wind condition.

The following are the stall speeds for unaccelerated flight (Vs1g) and the stickshaker speeds (Vss) for various flap and slat settings for the accident airplane:

	Slats	Flap setting (degrees)	Indicated airspeed (knots)
Vss	Retracted	0	139.0
Vs1g	Retracted	0	136.2
Vss	Extended	0	116.5
Vs1g	Extended	0	112.5
Vss	Extended	15	108.0
Vs1g	Extended	15	104.5

1.17 Other Information

1.17.1 Low Level Wind Shear Alert System (LLWAS)

Detroit Metropolitan Airport has a Low Level Wind Shear Alert System (LLWAS), which was functioning at the time of the accident. Pilots are informed that a LLWAS is available by a note on the runway diagram chart of the airport's instrument approach charts. The runway diagram chart does not depict the location of the system's sensors.

The Detroit LLWAS consisted of a centerfield vector-vane type wind sensor 12/ and five additional sensors located at or near the final approach course to each runway. These five peripheral sensors are designated north, northeast, east, south, and west. (See figure 1.) These sensors provide wind direction and speed data to a computer and to display units. There was a display unit located in the tower cab.

The top row of windows of the display unit in the tower shows the centerfield wind direction, speed, and gust speed. The next five rows display wind information from the five peripheral sensors. When a peripheral sensor's average wind reading for 30 seconds shows a vector difference (direction and speed) of 15 knots or more from that of the centerfield sensor's wind reading, an aural alarm will sound and the digital information from the affected sensor or sensors will start flashing in the appropriate row or rows of the tower display. The flashing will continue for five scans of the system's computer, or 37.5 seconds; the aural alarm consists of 2 "beeps" within a 3-second period. The wind gust velocity will be shown in its appropriate window anytime the instantaneous wind speed measured by the centerfield sensor exceeds by more than 9 knots the average wind speed measured over the previous 2 minutes. The peripheral anemometers are direct reading and include only the average wind and not the gusts. The digital readouts for the peripheral sensors do not appear in their appropriate windows in the tower displays unless an alert has occurred. However, a controller can obtain a wind readout for any of the five peripheral locations by pressing the appropriate "blanking" switch on the display unit; the instantaneous readout will be retained until the controller again presses the switch.

The LLWAS has a number of limitations: winds above the sensors are not detected; winds beyond the peripheral sensors are not detected; updrafts and downdrafts are not detected; and if a shear boundary happens to pass a particular peripheral sensor and the centerfield sensor simultaneously, an alarm will not be triggered. In addition, the dimensions of some meteorological phenomena--downbursts or microbursts--may be smaller than the spacing between the sensors and thus might pass between sensors and not be detected. In addition, the wind shear may have dissipated by the time the controller perceived the alarm and broadcast the wind information.

12/ An instrument which measures both wind direction and speed.

Immediately after the accident, the Detroit LLWAS was inspected by FAA technicians. All components of the system were operating within prescribed parameters.

1.17.2 Air Traffic Control Procedures

The air traffic control facility at the Detroit Metropolitan Airport consisted of a tower cab and a level 5 Terminal Radar Control (TRACON). The overall supervision of the facility was under the area manager who also was supervising the TRACON at the time of the accident.

During the time period relevant to the accident, the East Arrival Radar control position was manned by a full performance level controller. The local control position was manned by a controller who was fully qualified on all tower cab positions and two radar positions. There were four personnel in the tower cab at the time of the accident at the following positions: local control, clearance delivery, ground control, and supervisor. The local controller was qualified to take visibility readings and to provide windshear information from the airport's LLWAS.

Area Manager.--The area manager received a weather briefing from the Center Weather Unit meteorologist at the Cleveland ARTCC at 1615. He was aware that there was a broken line of thunderstorms about 35 to 40 miles west of the airport. He knew that traffic was being vectored by approach control to avoid the thunderstorms located to the west and southwest. However, he was not aware that thunderstorms had caused any deviations near the airport.

Tower Cab Supervisor.--The tower cab supervisor was not aware of the 1615 weather briefing which forecast thunderstorms, nor had he seen the 1636 special observation when it appeared on the electrowriter in the tower cab. He stated that the ATIS should have been revised to reflect the weather information in the 1636 special observation. The clearance delivery controller was responsible for revising the ATIS. The tower cab supervisor stated that he would have instructed the clearance delivery controller to update the ATIS if he had been aware of the 1636 special observation.

The tower cab supervisor claimed that he was unaware of the deterioration in the weather or the existence of thunderstorms to the west of the airport until the local controller announced the visibility as 1 mile at 1653. As the supervisor put the visibility information on the electrowriter at 1653, he heard precipitation striking the windows of the tower cab. He turned off the ATIS, which broadcast information Charlie, about 1654. He heard the local controller announce the visibility as 1/4 mile and put that information on the electrowriter. He stated that the local controller should have announced the visibilities of 1 mile and 1/4 mile on the local control frequency. He did not recall any RVR reading of less than 6,000 feet. He stated that the RVR equipment usually was set to activate an alarm at zero visibility and that the facility had no policy to govern the placement of RVR alarms.

East Arrival Radar Controller.--The East Arrival Radar controller had worked the position from 1500 to 1600, took a break, and resumed the position at 1635. He received a weather briefing at 1500 from the controller he relieved and briefed himself. He said he was not expecting thunderstorms at the airport based on the weather information he received within the facility. He noticed no convective activity in the area during his first shift on the position. After 1635, he observed convective activity to the southwest of the airport, but it did not affect his control area or his flow of traffic. He stated that he was not aware of the 1636 special weather observation.

About 1642, he heard thunder which prompted him, at 1642:41, to transmit to Northwest 736, "Thunderstorms are just starting. It is not reported officially, but I do hear the noise out of the window." He characterized the traffic workload before the accident as an "extremely complex and heavy workload." He stated that he observed a weather contour on his radarscope develop rapidly about 5 miles west of the airport when Flight 183 was at the outer marker. He said the contour was 5 miles in diameter but had no defined trailing edge.

Feeder Controller - TRACON.--The feeder controller said the workload was complex due to the weather conditions and that the traffic was moderate. Between 1655:35 and 1656:52, the east edge of a weather contour was west of the airport. Immediately before the accident, he observed cell activity on his radar screen both east and west of the airport.

Local Controller.--The local controller started at the local control position at 1528. She stated that she understood how to interpret the information presented on the LLWAS display in the tower cab, but she did not recall receiving any training on the system at the facility. She said she transmitted the centerfield winds and each boundary quadrant wind that was in an alarm status. The local controller and the tower cab supervisor interpreted the requirements of FAA Handbook 7110.65C, "Air Traffic Control," paragraph 981, "Low Level Wind Shear Advisories," to be that the words "Wind shear alert" would not be stated unless several quadrants were in alert status. "Several" was then defined as three or more quadrants. Since only two quadrants were in an alert status in the time immediately before the accident, she did not consider the wind information she transmitted as wind shear alerts. She stated that no pilot had ever asked her to clarify the meaning of her transmissions when she broadcast data in the manner as she did on June 13, 1984. However, she stated that she considered the information in paragraph 981 "ambiguous."

The local controller characterized her workload before the accident as "very complex," since she had to make visibility observations, control landing and departing airplanes, and provide instructions to the airplanes which were making missed approaches. She stated that she did not require assistance with the traffic load from the tower cab supervisor until after Flight 183 started the go-around. However, she knew he was available to help her. She also stated that she was not aware of the 1636 special weather observation or that thunderstorms were forecast or imminent for the Detroit airport. She was not aware of the presence of thunderstorms until after the visibility fell to below 2 miles. The lowest RVR reading that she recalled seeing before the accident was 6,000 feet.

She recalled that the visibility had been more than 4 miles when it suddenly decreased to 2 miles. At 1652:57, she broadcast the 2-mile visibility observation on the local control frequency. At 1653:40, she observed that the prevailing visibility at the airport was 1 mile. However, she did not transmit the visibility observation on the local control frequency. Instead, she announced the new visibility to the personnel in the tower cab so the information could be placed on the electrowriter. At 1653:54, the East Arrival Radar controller advised a flight that the revised visibility was 1 mile. The visibility continued to decrease, and sometime before 1655:35 she observed that visibility was 1/4 mile. When she made the 1/4-mile visibility observation, she noted lightning and believed that a thunderstorm was in progress. She announced 1/4 mile to the tower cab personnel but did not announce this information or the RVR reading on the local control frequency. FAA Handbook 7110.65C, paragraph 1081 requires controllers to issue current touchdown RVR for the runway in use when the prevailing visibility is 1 mile or less. The local controller provided no RVR information to arriving airplanes. She stated that as the visibility fell the sky became dark. She believed that the restriction to visibility was due to rain. She did not see hail.

ATIS Procedures.--Paragraph 1230b(3) of FAA Handbook 7213.3F, "Facility Operations and Administration," requires ATIS broadcasts to be updated upon receipt of any official weather observations regardless of whether there is a change of values. In addition, the handbook states, "Make a new recording when there is a change in other pertinent data such as runway change, instrument approach in use, new or cancelled NOTAM's, SIGMET's, PIREP's etc."

The 1636 special weather observation was not made available to arriving and departing airplanes through the ATIS. The tower cab supervisor stated that the 1636 observation would have been put in the ATIS if he had known it had been issued. The ATIS in effect from 1555 until 1654 was "Charlie" which stated:

> Weather 4,500 scattered, 30,000 thin broken, visibility 7, temperature 92°, dewpoint 66, wind 280° at 13, altimeter 29.94; ILS runways 21 left, 21 right approaches in use, departing runways 21: Notice to Airmen: birds have been reported on the runway. Gate hold procedures in effect for numerous airports.

Dissemination of LLWAS.--The procedures for the dissemination of information derived from an LLWAS are presented in FAA Handbook 7110.65C, paragraph 981, which reads, in part, as follows:

> 981. LOW LEVEL WIND SHEAR ADVISORIES
> At those locations equipped with a Low Level Wind Shear Alert System, the local controller shall provide wind information as follows:
>
> 981. Reference.--Order 7210.3--1222, Low Level Wind Shear Alert System (LLWAS).
>
> a. If an alert is received, issue the centerfield wind and the displayed field boundary wind.
>
> 981.a. Example.--
>
> "Centerfield wind, two seven zero at one zero. East boundary wind, one eight zero at two five."
>
> b. If unstable conditions produce multiple alerts, issue an advisory that there are wind shear alerts in several/all quadrants. Then, issue the centerfield wind in accordance with 980.b followed by the field boundary wind most appropriate to the aircraft operation.

981.b. Example--

"Wind shear alerts all quadrants. Centerfield wind, two one zero at one four. West boundary wind, one four zero at two two."

Between 1650:54 and 1655:01, the local controller made seven transmissions which included centerfield and boundary winds. Four transmissions gave the centerfield wind and one boundary quadrant wind, two transmissions gave the centerfield wind and two boundary quadrant winds, and one transmission at 1654:27 gave the centerfield wind and three boundary quadrant winds. None of the transmissions included the words "wind shear alert." Flight 183 was on the local control frequency when the last two transmissions were made at 1654:27 and 1655:01.

General Notice (GENOT) 7110.907: Subject: Low Level Wind Shear Alert System/Revision to Handbook 7110.65C, Paragraph 981.a and b.--On August 13, 1984, the FAA issued the following GENOT:

Effectively immediately, the following procedure is in effect:

Paragraph 981.a

If an alert is received, issue the centerfield wind and the displayed field boundary wind.

Phraseology:

Wind shear alert, centerfield wind (direction) at (velocity). (Location of sensor) boundary wind (direction) at (velocity).

981.a Example-

"Wind shear alert, centerfield wind, two seven zero at one zero. East boundary wind, one eight zero at two five."

Paragraph 981.b

If unstable conditions produce multiple alerts, issue an advisory that there are wind shear alerts in two/several/all quadrants. Then issue the centerfield wind in accordance with 980.B followed by the field boundary wind most appropriate to the aircraft operation.

Phraseology:

Wind shear alerts two/several/all quadrants. Centerfield wind (direction) at (velocity). (Location of sensor) boundary wind (direction) at (velocity).

981.b Example-

"Wind shear alert two quadrants. Centerfield wind, two one zero at one four. West boundary wind, one four zero at two two."

1.17.3 USAir Flight Operations Procedures

USAir flight operations procedures and training program requirements are presented in USAir's DC9 Pilot's Handbook and in various official flightcrew publications:

Dispatch Procedures.--The evidence showed that Flight 183 had been dispatched from Hartford in accordance with USAir dispatch procedures. The dispatch package prepared for Flight 183 contained the 1400 surface aviation weather reports for Detroit and adjacent locations and a weather synopsis of the Michigan and Great Lakes area. The information identified frontal systems affecting the route of the flight and forecast the possibility of thunderstorms.

Landing Procedures and Missed Approach Procedures.--The following landing procedures were extracted from the USAir DC9 cockpit checklist:

Preliminary Landing

Fuel Pumps, Crossfeed	Mains On
Brake Pressure/Selector	Checked and Both
Hydraulic Quantity, Pressure, Pumps	Checked and Set
Landing Data - EPR	Checked - Bugs Set
Altimeters	Set
Shoulder Harness	Fastened

Final Landing

Seat Belt/No Smoking	As Required
Ice Protection	As Required
Ignition and APU	As Required
Anti Skid	Armed, Lights Checked
Gear	Down, Lights Checked
Spoilers	Lights Out/Armed
Rudder Unrestricted	Lights On

The following missed approach procedures were extracted from the DC9 Pilot's Handbook:

Missed Approach or Balked Landing

- o Apply maximum power go-around value from EPR bugs set during the approach.
- o Rotate to maximum 15° pitch attitude. Follow speed command in V-bar when selected. (SC commands wings level, 15° maximum pitch-up with two engines, V2 with single engine).
- o Retract flaps to 15°/EXT.
- o Retract gear with a positive rate of climb.

The DC9 Pilot's Handbook contained the following information:

WINDSHEAR

GENERAL

The most important elements for the flight crew in coping with a wind shear environment are crew awareness of an impending wind shear encounter and their decision to immediately respond and properly control the airplane when the actual encounter occurs. It is important that the basic factors involved in the wind shear phenomena, the effects wind shear has on the airplane, and the proper corrective pilot control actions are understood by the flight crew.

DECREASED PERFORMANCE WIND SHEAR AND DOWNDRAFTS

Upon encountering a decreased performance shear and/or downdraft, thrust and pitch attitude should be immediately increased to maintain an acceptable airspeed and flight path. Power should be immediately advanced to the go-around setting if necessary, and a go-around should be initiated when this type of an encounter occurs at low altitude. Stick shaker speeds should be known for the approach and go-around configuration, and airspeed should be traded down to the stick shaker speed if necessary to prevent ground impact.

METEOROLOGICAL CONDITIONS CONDUCIVE TO SHEAR

Thunderstorms - The convective air currents in and around thunderstorm cells are very complex and wind shear can be found on all sides of a cell. The shear boundary or gust front associated with thunderstorms can precede the actual storm by up to 15 nautical miles. Consequently, if a thunderstorm is near an airport of intended landing or takeoff, low level wind shear hazard may exist.

TAKEOFF

If downdrafts or decreased performance wind shear are encountered after liftoff, rotate the airplane to a higher pitch attitude until the descent has stopped. Be prepared to allow the airspeed to decrease to stick shaker speed if necessary to avoid hitting terrain. However, be sure the airplane pitch is not increased too rapidly or that the airspeed does not decrease below stick shaker speed to avoid a stall condition. With all engines operating, the airplane will have substantial rate of climb at stick shaker speed.

* * *

If clearance of surrounding terrain exists, maintain speed margin because decreased performance wind shears can be expected after transversing downdrafts.

OPERATIONAL LIMITATIONS

Maximum 90° crosswind component: 25 knots (USAir Limit)
Maximum 90° crosswind component for landing when visibility less than 3/4 mile or RVR 4000: 10 knots
(The maximum demonstrated crosswind value for landing is 38 knots);

The weather radar section of the Handbook states that radar can be used to,

> provide reasonable clearance around rain areas by selecting a heading which will clear the storm cell by:
>
> -5 miles when OAT [outside air temperature] is above freezing
> -10 miles when OAT is below freezing
> -20 miles when at or above 25,000 feet

There is no specific rule for thunderstorm avoidance in the terminal area. The Director, Flight Training and Standards of USAir stated that 5 miles does apply as a minimum separation distance in the terminal area. However, he stated that the captain's judgment can supersede the handbook guidelines.

The Director, Flight Training and Standards stated that USAir trains its pilots to rotate to an attitude where stickshaker is encountered only as a last resort. However, he said that the company does not recommend the maneuver, "unless they think they are about to crash." The director expressed a personal reservation about the maneuver, since it is based on calculations derived from simulator tests and from airplanes with new engines and clean airframes. He believes that these conditions do not equate to actual airline-flying conditions. Additionally, the operation in the stickshaker regime places an airplane near the stall speed. In gusty, windshear-type wind conditions, the safety margin is very small and may be based on wind conditions which exceed the capability of the airplane. Consequently, the director stressed that the rotation to stickshaker was a last-resort maneuver.

The captain of Flight 183 stated that he had seen information in the DC9 Pilot's Handbook about rotation beyond 15 degrees until the stickshaker was encountered. However, he was never trained in the simulator to perform the maneuver, and he never considered performing the maneuver.

The first officer stated that he was aware of the DC9 Pilot's Handbook instruction about rotating to stickshaker speed. The maneuver had been addressed in his ground training, but he had never experienced it in a simulator.

First Officer Assertiveness Training and Cockpit Resource Management Training.--USAir does not have, and was not required to have, a formal, single block of training for first officers which addresses assertiveness in the cockpit and its role in communicating their views to captains. However, the USAir Director, Flight Training and Standards stated that the subject is important in the total company flight training program, and that first officer assertiveness is evaluated. A single instructor is assigned to newly hired pilots and an element of new-hire instruction addresses first officer assertiveness in the cockpit. He stated that several company publications also address the subject. First officer assertiveness is observed and evaluated by instructors in the simulator and in actual cockpit situations where the first officer interacts with other crewmembers. The Director, Flight Training and Standards stated that it is evaluated and taught within the concept of crew coordination and flightcrew interaction as specified by approved checklists and procedures.

The first officer of Flight 183 stated that he had not received formal assertiveness training. However, he said he did receive company articles on the subject, and he was aware of the importance of assertiveness in the role of the first officer in the crew coordination concept. He stated that in his training he participated in discussions on the importance of the role of the first officer in the cockpit.

Seven first officers who had flown with the captain also were asked about their knowledge of assertiveness training. They reported receiving varying levels of assertiveness training from the company. Four had no training while three had training integrated into their initial company indoctrination. All indicated that they were encouraged to be assertive during simulator training and check rides.

The Director, Flight Training and Standards stated that USAir implemented a program 4 years ago to teach cockpit resource management. Only captains upgraded to that position since that time have been given the training, since he stated that the program is expensive. He also stated that eventually all captains would receive the training. USAir employs a psychologist to give group instruction to newly upgraded captains on the importance of cockpit resource management and crew interaction. The program is supplemented and implemented by check captains as training for the new captains is completed.

FAA operations inspectors from the Pittsburgh Air Carrier District Office (ACDO) monitor USAir flight and simulator training. The FAA principal operations inspector for USAir stated that FAA inspectors do not observe all flight simulator checks but monitor at least one check of each captain annually. They also periodically review training records and are informed by USAir of all flightcrew unsatisfactory training checks or other training problems. Additionally, FAA inspectors have monitored all USAir check airmen and were satisfied that all were objective, competent, and maintained high standards of performance. The inspector said that, as a result, he believed there was no need to pursue the reasons for the amount of training for the captain so long as they were satisfied that the training program insured that the captain met 14 CFR Part 121 requirements at the completion of the training.

1.17.4 Wind Shear Training

FAA Advisory Circular.--On January 23, 1979, the FAA issued Advisory Circular (AC) 00-50A, "Low Level Wind Shear," which contains descriptions of the low level wind activity generated by weather fronts, thunderstorms, and other meteorological events. The AC contains information on thunderstorms, frontal weather, wind shear, and techniques to counter the hazards associated with each phenomenon.

The AC states that, "wind shear can be found on all sides of a thunderstorm cell." The wind shift line or gust front associated with thunderstorms can precede the actual storm by 15 miles or more. The AC concludes that low level wind shear hazards may exist at airports which are near the thunderstorm.

The AC advises pilots to use the LLWAS when it is available. The LLWAS is described as a system with five or six anemometers around the perimeter of the airport, which correlates data from the outlying anemometers to data from the centerfield anemometer. An example of a severe wind shear alert was given as, "Centerfield wind is 230° at 7 knots, wind at the north end of Runway 35 is 180° at 60 knots."

The AC provides extensive information on airplane performance in wind shear, including likely airplane performance in a "downburst cell." The downburst cell example describes an airplane landing during a thunderstorm. As the airplane approaches the cell, the headwind increases as a result of the outward flow of air from the center of the cell. The airplane's indicated airspeed increases. Heavy rain may start shortly as the airplane enters the center of the cell. In the center of the cell the headwind decreases and a strong downdraft is encountered. Shortly, the tail wind begins to increase and continues to increase as the airplane exits the center of the cell. As the airplane exits the cell, the outflow of air from the thunderstorm increases and the indicated air speed decreases.

The final sections of the AC are devoted to procedures for coping with wind shear encounters during takeoff and landing. The AC states that "the worst situation on departure occurs when the aircraft encounters a rapidly increasing tailwind, decreasing headwind, and/or downdraft." Taking off (or going around) under these circumstances would lead to a decreased performance condition.

The pilot techniques recommended in the AC to counter the effects of low level wind shear require the pilot to trade airspeed for altitude. The pilot should apply maximum rated thrust, rotate the airplane to high noseup pitch attitudes--"15° to 22° are to be expected during this maneuver"--and, if necessary to prevent an unacceptable descent rate, maintain the noseup pitch attitudes even though the airplane decelerates below V2. The AC states that jet transport airplanes have substantial climb performance (generally in excess of 1,000 feet per minute) at speeds as low as stall warning or stickshaker speeds. The speed tradeoff should be ended when the stickshaker is encountered. Thereafter, the airplane should be flown at a pitch attitude that will maintain an indicated airspeed just above stickshaker speed.

USAir Ground Training Courses.--USAir addresses wind shear in ground school and in recurrent training. Three different wind shear films have been used--one produced by the Air Line Pilots Association and two by the National Center for Atmospheric Research (NCAR). The Director, Flight Training and Standards for USAir stated that the NCAR developed "Thunderstorm Microburst," a videotape on wind shear which was shown at each DC9 recurrent training class including those of the flightcrew of Flight 183. The two other films were put into the training program in 1984. Additionally, 18 articles on wind shear have been included in the Flight Crew View, a publication of training articles which is circulated to all pilots. Flight Crew View disseminates professional, comprehensive articles on many training and safety issues. Six wind shear articles were published in 1983 and one in 1984. The captain did not recall seeing the wind shear film but recalled receiving several wind shear publications distributed by USAir and its predecessor, Allegheny Airlines.

Two articles have been published on LLWAS. Each article described the LLWAS and referred pilots to their company-supplied Jeppeson manual. Additionally, one article on LLWAS was published in "Flight Crew Views."

Simulator Training.--USAir has incorporated wind shear programs into the simulators for all the airplanes operated by the airline. The older simulators have limited wind shear programs. However, USAir acquired a DC9 Phase II simulator shortly before the June 13, 1984, accident which has six realistic wind shear encounter scenarios for the landing and takeoff phases of flight.

Airlines are not required by Federal Air Regulations to present pilots with wind shear scenarios in simulator training nor is an airline required to record when such training was given. A USAir pilot may ask for wind shear training during simulator training, or an instructor may elect to include a wind shear scenario. The Director, Flight Training and Standards stated that it was likely that a captain would receive wind shear simulator training during a 6-month proficiency training period, even if the pilot had not specifically requested the training. However, there is no record of which pilots received the wind shear scenarios and the type of scenarios they may have received.

The captain testified that it had been at least 2 years since he encountered a wind shear scenario in the simulator. The first officer said that he had never had wind shear training in the simulator.

The Safety Board interviewed several other USAir first officers as part of its investigation. All stated that they had received written information on wind shear. Two first officers had wind shear training in the simulator in the past 6 months, one in the past 1 1/2 years, one 3 years ago, one "several" years ago, and two had never encountered wind shear training in the simulator.

1.17.5 Human Performance Data

The captain was hired by USAir (then Allegheny Airlines) in April 1955. He has been rated on the McDonnell Douglas DC9 since 1968.

In early June 1984, his only scheduled flying was a 2-day trip on June 5 and 6, which he did not make due to illness.

On June 12, 1984, he started a 3-day trip from Washington, D.C. He departed Washington and terminated in Hartford at 2143, after about 6 hours of flight time. He checked into a hotel about 2230 and retired after watching a basketball game. He arose at 0830 on June 13, 1984, and went shopping in the morning. He reported to the airport with the crew for the 1525 departure from Hartford. He said that he was well rested at the time and that he was in good health.

The captain's record indicates successful performance as a captain until May 1983. On May 6, 1983, a DC9 Proficiency Training Session was terminated after 2 hours 20 minutes due to what the instructor noted was, "substandard performance." The captain, he noted, was "not prepared (and) needs further training." The captain later attributed this difficulty to, "an instructor difference, (a) personality clash." On May 9, 1983, a different instructor, after a 45-minute proficiency training session wrote, "Lacks knowledge of equipment and procedures." The captain later also attributed these comments to a personality clash between the instructor and himself. He stated that instructors "yelled" at him as he was trying to perform in the simulator and this adversely affected his performance. He successfully completed the DC9 proficiency check on May 16, 1983.

On June 15, 1983, the captain began ground school to transition to the Boeing-727. He completed 58 hours of ground school through June 27 but did not take the Boeing-727 oral exam. He began ground school again in September 1983 and successfully completed the course on September 30, 1983. He started simulator training in the Boeing-727 in November 1983 but encountered difficulties in the training. The instructor commented after the second session, "does not retain procedures. . . ." After the fourth session the instructor noted, "Still hazy on procedures that have been gone over and over in briefings and in the simulator." In December 1983, after 37 hours of simulator instruction in the Boeing-727, the training was terminated and the captain returned to the DC9 program. When he was asked about his performance in the Boeing-727 simulator, the captain stated, "I think if I had an instructor, if I had a change in instructors to present it to me in a different way, I would have gone through the program alright." Following the Boeing-727 instruction, the captain successfully requalified in the DC9 in January 1984. The check captain who requalified him had no adverse comments about the captain's performance during the requalification in January 1984.

The Director, Flight Training and Standards assumed that position in November 1983. His previous position was as Flight Manager for DC9 flight and simulator training. He stated that he was not aware that the captain felt belittled and intimidated by DC9 and Boeing-727 instructors in 1983. He said that he has never received complaints about instructors "yelling" at any pilot in a training situation. He said situations do arise two or three times a year where pilots and instructors have personality conflicts. In such cases, instructor changes are made at the request of either the pilot or the instructor. In May 1983, as DC9 Flight Manager, he had discussed the captain's unsatisfactory progress with the DC9 simulator instructors who worked for him. The training eventually was completed satisfactorily before the captain started Boeing-727 transition training in June 1983.

After the captain elected to return to the DC9 upon failing to complete Boeing-727 transition training, the Director, Flight Training and Standards met with senior USAir management and the captain to discuss the captain's training problems. The reasons for the captain's problems were not identified specifically, and the director could not recall the specific reasons that were offered by the captain to explain the training problems identified by the instructors.

The USAir contract with the Air Line Pilots Association allowed the captain to return to the DC9, and he exercised that option. The director contacted the captain's chief pilot and discussed his training problems. The chief pilot administered the DC9 flight requalification, which was completed without problems, once the captain completed recurrent training.

On April 20, 1984, the captain again had difficulty during a 4-hour simulator check. The instructor in that session commented, "Very poorly prepared. Had to train in 5° takeoffs, (and) circling approaches before check could be completed satisfactorily." The director said that he had no discussions with the captain or the simulator instructor concerning the April 1984 training period.

The director stated that he never resolved the reasons for the captain's training deficiencies which were noted between May 1983 and April 1984. He also was not aware if the chief pilot at the captain's Washington, D.C., home base had done anything to identify or resolve the problems, or if the captain was receiving special supervision from the chief pilot. A review of USAir training records indicate that in 1983, 17 out of 1,258 simulator flight checks (1.4 percent) were unsatisfactory. Training problems, including unsatisfactory simulator flight checks, were reported to the FAA air carrier district office.

As part of its investigation, the Safety Board interviewed two Washington, D.C.-based USAir chief pilots who were familiar with the captain's performance. The first chief pilot was assigned to the position in 1980, while the captain was on extended sick leave. The captain returned to duty and passed a first-class medical examination. He completed the training and requalification requirements to resume line flying without incident.

The first chief pilot was aware of the captain's difficulties in DC9 training in May 1983 and in Boeing-727 transition training in the latter half of 1983. While the training was conducted in Pittsburgh, by the USAir training department, he was given regular reports of the captain's performance. The first chief pilot said he had no reason, based on the captain's 1983 training difficulties, to disqualify him from resuming his position as a DC9 captain. Consequently, he allowed the captain to complete requalification training in January 1984 on the DC9.

The position of chief pilot was filled (on an acting basis) by a DC9 check captain in February 1984. This pilot was the check airman who had conducted the captain's DC9 requalification in January 1984, and who had flown with him for about 20 hours before the requalification was completed. He stated that the captain was an "average" pilot who performed satisfactorily during the requalification rides. He said that he did not monitor the captain more closely than he did the other approximately 200 company pilots in Washington, D.C. He said that there was nothing reported to him officially or unofficially about the captain's behavior or piloting ability by other pilots or by USAir management.

Seven USAir first officers who had flown previously with the captain were interviewed. In general, the information they gave was quite consistent. He was described as a competent pilot who managed and communicated well in the cockpit. His management style was uniformly characterized as easygoing and congenial. He encouraged first officers to offer information and suggestions to him and would solicit first officer input. He allowed first officers freedom to make decisions when they were flying the airplane.

Responses from the first officers on the captain's piloting ability ranged from "competent" to "average" to "very good." One first officer with several years experience and who had flown with the captain numerous times said he had noted no change in the captain's performance in the past 1 1/2 years.

The first officers uniformly described the captain as "self-confident." This attribute was reflected in his decisionmaking which they classified as "positive." None of the first officers remembered any decision he made with which they had disagreed. Most of the first officers were aware that he had had difficulty with the Boeing-727 transition program. However, they recalled nothing before or after the training which could have led to, or resulted from, this difficulty. None of the first officers recalled anything unusual about his activities or behavior during layovers during trips.

The first officer, who was 32, had been employed with USAir since 1979, and had been a first officer since 1980. His training record indicated no problems with training or performance. He was scheduled for two trips for a total of 5 days between June 1 and 12. He flew both trips.

1.18 New Investigative Techniques

None.

2. ANALYSIS

2.1 General

The airplane was certificated, equipped, and maintained in accordance with Federal regulations and approved procedures. There was no evidence of a malfunction or failure of the airplane, its components, or powerplants that would have affected its performance.

Damage to the landing gear indicated that the landing gear was being extended when the airplane made contact with the runway. The weight of the airplane forced the landing gear to retract into the wheel wells. The overload damage to landing gear actuators, the gear doors, both shimmy dampers, and grind marks on the outboard rim of the left outboard wheel indicated that the landing gear was in transit at impact.

The wing flaps were determined to be at 15 degrees at impact, based on damage observed on the airplane. The damage to the fibreglass fuselage fairings was consistent with a 15-degree flap setting. The fuselage fairings extend about 3 feet below the main flap panels. When the flaps were positioned to 15 degrees, the fairing damage was level with the underside of the fuselage and consistent with the damage observed on the fuselage.

The inboard flap hinges were ground down, thereby disconnecting the pushrod attachments which ultimately connect the flap to the flap handle in the cockpit. The disconnection of the pushrods during the ground slide allowed the flaps to retract to the "up" position. Consequently, the determination that the flaps were positioned at 15 degrees for the missed approach and were at 15 degrees at impact was based on damage to the flap and flap system, and not the final position of the flaps when the airplane was examined.

The flightcrew was certificated properly, and each crewmember had received the training and off-duty rest time prescribed by FAA regulations. There was no evidence of any preexisting medical condition or fatigue that adversely affected the flightcrew's performance.

The air traffic controllers on duty in the Detroit tower and the TRACON were certificated properly. Each controller had received the FAA's prescribed training. The East Arrival Radar controller and the local controller were qualified to perform the duties of their respective positions.

The investigation revealed that the instrument landing approach was conducted in weather which changed abruptly from broken and scattered cloud layers with more than 5 miles visibility and no precipitation to thunderstorm-associated weather near the threshold of the landing runway. Weather at the airport included a low ceiling, ground visibility of 1/4 mile with heavy rain, hail, and rapidly shifting surface winds.

The flightcrew accounts and the CVR conversations indicated that the cockpit before-landing checklists were completed properly, and that the captain flew a stabilized ILS approach until a missed approach was started about 1656:05. Accordingly, the Safety Board directed its attention to the influence of meteorological, airplane aerodynamic performance, and operational factors on the accident, and the human performance and company management factors which affected the decisionmaking processes and flying abilities of the flightcrew. The analysis of the processing and dissemination of weather information by air traffic control is treated as an operational factor rather than as a meteorological factor.

2.2 Meteorological Factors

2.2.1 Dispatch Weather Information

The examination of the dispatch weather information that the flightcrew received at Hartford showed that the required weather documents were given to the flightcrew. The forecasts, which were current for the arrival of Flight 183, stated that there was a possibility of thunderstorms. However, the possibility of thunderstorms was stated broadly as applicable to the "entire Gulf Coast/Central Plains/Great Lakes area/northern Ohio Valley/and Northern New York and New England." Consequently, although the dispatch weather information alerted the flightcrew to thunderstorms, it did so only in a most general sense. The weather encountered at Detroit by Flight 183 was worse than forecast. The terminal forecast called for ". . . chance of ceiling 2,500 feet broken, visibility 3 miles in thunderstorms with light rain showers," while the actual weather was thunderstorms, very heavy rain showers, and hail.

When the dispatch package was prepared, no weather warnings had been issued by the NWS for the route of Flight 183 because the information available to the NWS at the time did not warrant such warnings. As a result there were no weather warnings in the dispatch weather package.

2.2.2 Weather Conditions in Detroit Area

Convective Weather Activity.--For about 45 minutes before the accident, convective weather radar cells were observed in the area west of Detroit. The meteorologist at the Cleveland ARTCC observed scattered convective activity developing west of Detroit between 1600 and 1615. After 1630, he paid specific attention to the area west of Detroit to monitor the thunderstorm activity more closely. Nevertheless, he was unable to see a severe thunderstorm move into the immediate airport area just before the accident. He attributed this fact to the rapid development of the storm cell and to the ground clutter on the Detroit radar, which extended about 20 miles from the antenna and thus prevented him from receiving a true radar picture of the airport area. The 1630 radar overlay from the NWS weather radar at Detroit confirmed VIP level 3 cells about 40 miles west moving from 260 degrees at 30 knots.

Pilots, including the flightcrew of Flight 183, who arrived in the Detroit area about the time of the accident observed weather cells on their cockpit weather radarscopes. The weather echos were to the west and southwest, 0 to 10 miles from the airport. The flightcrew of Flight 183 observed a contouring cell about 5 to 8 miles west-southwest of Detroit Metropolitan Airport when Flight 183 was 10 to 15 miles from the airport. The captain of Learjet N103CF observed a weather radar cell moving across the northern portion of the airport at the time of the accident. The weather radar indicated to the Learjet captain that the storm was of significant intensity because it appeared red on the radarscope and because he observed a sharp rain gradient.

In addition to ground and airborne radar indications of thunderstorm activity, pilots, including the flightcrew of Flight 183, visually observed thunderstorms west of Detroit as they came within 100 miles of the airport. The weather observer at the Detroit NWS station visually observed a thunderstorm about 3 miles west of the airport at 1635, which was the basis of the 1636 special observation.

Based on this evidence, the Safety Board concludes that the thunderstorm which affected Flight 183 at 1656 was part of an area of scattered cells which were observed as early as 1615, and which were noted by pilots and ground observers visually, and on radar, within 10 miles of the airport from 1635 until the time of the accident. The thunderstorm, which was over the airport at 1656, intensified rapidly as it approached and passed over the airport, from the west to east. The path of the center of the cell placed the shaft of rain and hail along the northern part of the airport where it intersected the approach path to runway 21R at the threshold-middle marker area. This movement is consistent with the fact that the transmissometers, which were located generally south of the storm path, did not indicate decreasing visibility until after 1656. The observations of the captain of Frontier 214 that the conditions were worse on runway 21R than on runway 21L confirmed the movement of the storm along the northeast part of the airport.

The lack of reports by ground observers of heavy rain and hail west of the airport as well as the NWS radar observations of the cell at 1630, indicated that the thunderstorm did not develop into a very heavy thunderstorm until it was close to the airport. Once close to the airport, ground clutter prevented radar observers from assessing accurately the VIP level of the cell.

The Safety Board concludes that the thunderstorm, which was at the airport at 1656, was a VIP level 4 storm which was traveling along the northeast portion of the airport at 30 knots. The VIP level was confirmed by weather radar observations at 1730. The heavy rain, 3/4-inch hail, and wind gusts to 42 knots further confirm the intensity of the thunderstorm. 13/ The center of the cell passed over the approach end of runway 21L, which placed the rain and hail shaft in the path of Flight 183. Based on the length of time Flight 183 was in the heavy rain and hail (11 seconds on the CVR at an average groundspeed of 127 knots), the diameter of the shaft was about 0.3 nautical mile at 100 to 200 feet above the ground.

Wind Direction and Speeds.--The wind information at Detroit was based upon recorded surface observations, the NWS gust recorder, and the ATC tapes of the local controller reporting wind readings from the LLWAS. (The LLWAS wind data were not recorded.) The wind data were insufficient for investigators to develop the complete wind field associated with the thunderstorm which passed over the airport about 1656 or to determine the horizontal wind components which affected Flight 183.

The direction of the centerfield winds between 1650:54 and 1655:23 was virtually steady at 320 degrees. The speed increased from 11 knots to 28 knots with gusts to 42 knots. The north boundary LLWAS anemometer was in alarm throughout the period, which further indicates that the path of the cell was along the northern portion of the airport. The north boundary winds consistently were from the west-southwest. The east boundary anemometer, while only going into alarm twice, consistently indicated winds from the northwest before the accident. Because there were no reports from the west anemometer, the wind pattern cannot be documented definitely from ground-based sensors. It would appear, however, that the wind pattern generally represented an increasing headwind as Flight 183 approached the airport. Since the storm was a classical thunderstorm, the wind flow undoubtedly spread radially from the center. An increasing headwind followed by an increasing tailwind as developed in the airplane performance study confirmed that the airplane encountered the outflow from a storm when it entered and exited the rain and hail shaft.

13/ The NWS defines a severe thunderstorm as one with wind 50 knots or greater with 3/4-inch hail.

2.3 Airplane Aerodynamic Performance

The airspeed and altitude data recorded on the airplane's UFDR show conclusively that the airplane encountered divergent winds characteristic of microbursts as it passed through the heavy rain and hail during the approach. As the airplane descended through 1,200 feet m.s.l., about 560 feet above the ground, the descent rate and airspeed were stabilized. As the airplane descended through about 800 feet m.s.l., the airspeed began to rise and the descent rate reduced. The airspeed rose from a stabilized level of 135 knots to about 143 knots in 4 seconds, after which it decreased to a low value of 119 knots within the next 12 seconds. The airplane remained level about 120 feet above the ground as the speed decayed. The Safety Board concludes that the increase in airspeed and the reduction in the descent rate as the airplane reached 800 feet m.s.l. was caused by the encounter with the outflowing winds from the center of the microburst. As the airplane continued to penetrate the divergent wind field, it encountered a sudden wind shift from the airplane's nose to its tail. The sudden reduction in the headwind component produced the airspeed loss.

The longitudinal stability characteristics of an airplane encountering these conditions would cause the airplane to pitch nose down and accelerate to regain the neutral trim airspeed. The pitch-down tendency must be countered by pilot force exerted to the control column and possibly pitch trim changes if the wind shear is to be penetrated without a significant loss of altitude. In fact, the procedures recommended for pilots upon a sudden inadvertent entry into a microburst-type wind shear during approach (below 500 feet) includes the immediate advancement of power to a maximum thrust level and the initiation of go-around procedures. The fact that Flight 183 remained at a nearly level altitude as the airspeed decayed showed that the captain did respond appropriately with the increasing pitch-up control forces necessary to prevent a continuing descent. Further, the power increase noted by the flight attendants and passengers and the airplane configuration when it struck the ground are compatible with the captain's action to initiate a missed approach. The Safety Board could not determine precisely when the go-around was initiated in the sequence of events as indicated by the UFDR data. However, it is evident that the airplane did not achieve a positive rate of climb even with maximum power. A DC9 under the existing conditions of weight, configuration, and density altitude should have been capable of a level flight inertial acceleration of about 3.9 knots per second with maximum power. Under a stable wind condition, this inertial acceleration would be reflected directly in an equivalent increase in airspeed. However, the airspeed actually decreased at about 2 knots per second, indicating that the longitudinal component of the wind along the airplane's flightpath was changing at a rate about 2 knots per second greater than the airplane's longitudinal acceleration capability. Thus, the actual wind change acting on the airplane could have been as much as 6 knots per second over a 10- to 12-second period. The wind velocities necessary to produce such a change are not unusual in microburst conditions. However, without more definitive data regarding the timing of the captain's actions to advance power, to retract the landing gear, and to raise the flaps, the precise wind environment of the thunderstorm cannot be reconstructed. Nevertheless, the Safety Board concludes that the wind shear was severe and that the captain's actions to initiate the missed approach probably prevented a more catastrophic accident. It is likely that the captain's action to start a missed approach when the airplane entered the rain and hail shaft prevented the airplane from hitting the ground well short of the runway.

As the airplane exited the significant rain and hail associated with the thunderstorm, the captain apparently became concerned that the missed approach would not be successful, and he decided that the best course of action would be to put the airplane on the ground. According to the captain, his decision was based upon his perception that the airspeed had decreased to 119 knots and that the airplane was still descending. Although the UFDR showed that the airplane was maintaining an altitude about 120 feet above the ground, the increase in visual cues as the airplane exited the rain may have heightened a perception that the airplane was too low and caused him to believe that descent to the ground could not be avoided even with maximum power. Given the captain's perception of possibly inevitable contact with the ground, the lowering of the landing gear was appropriate. However, the Safety Board believes that the captain's action to abandon the missed approach and reduce power was improper.

There were not sufficient data available regarding the timing of the captain's actions to extend the landing gear and reduce power to permit an accurate analysis of the relative effect of the wind and pilot actions. Additionally, the insufficient data precluded an analysis of the airplane's performance and the possibility that descent below 120 feet and even contact with the ground could have been avoided had the missed approach been continued. However, the UFDR data showed that the airspeed began to increase as the descent to the runway was initiated. Given the captain's statement that he had reduced power, the airspeed rise supports the hypothesis that the airplane had penetrated the severe wind shear and had achieved climb capability when it struck the runway.

A well-trained and alert captain should have been aware that the airplane at maximum power would regain a positive performance capability after penetrating a microburst. Moreover, he should have anticipated that the airplane would begin to respond to maximum power after it exited the rain and hail shaft. Even though his restricted forward visibility may have precluded his awareness that over 8,000 feet of runway remained, his knowledge that he was over the runway should have mitigated his concern about possible ground contact after the landing gear were down during the continued missed approach. Therefore, rather than reduce power and commit to a landing before the landing gear were fully down, the Safety Board believes that the proper decision would have been to continue the missed approach even after the landing gear were lowered and even if a "touch and go" on the runway proved necessary to prevent further loss of airspeed.

2.4 Operational Factors

The Safety Board believes that the major safety lesson from this accident involves the flightcrew's decisions made at the beginning of the approach which led to entering the microburst with its wind shear rather than in an evaluation of the crew's performance after the wind shear encounter or the ability of the airplane to penetrate the microburst successfully. The key issues in the accident sequence thus were the operational factors, which, combined with meteorological and airplane performance factors, influenced the captain's decision to initiate and continue the instrument approach to runway 21R. To address these issues, the Safety Board analyzed the policies and guidelines of USAir which addressed adverse weather, the role of air traffic control, and the actions of the flightcrew during the instrument approach.

USAir Policy and Procedures.--The USAir DC9 Pilot's Handbook guidelines for thunderstorm and wind shear encounters are supported by topical material in the company flightcrew publications (Flight Crew View and Flight Crew Quarterly). The company publications expand on handbook policy and procedures and provide substantial information on weather phenomena. Additionally, the thunderstorm and wind shear information parallel data are contained in FAA Advisory Circular AC 00-50A, "Low Level Wind Shear." The information and guidance provided USAir pilots in company manuals and handbooks were accurate and emphasized that wind shear and gust fronts associated with thunderstorms can precede the actual storm by as much as 15 miles. Additionally, the Pilot's Handbook provides specific guidance for configuration of the airplane if a wind shear may be encountered and for flying the airplane at stickshaker speeds.

USAir does not have a specific policy which governs the avoidance of thunderstorms in the terminal area. The Pilot's Handbook, under the weather radar section, states that storm cells should be avoided by 5 miles when the outside air temperature is above freezing. However, the 5-mile guideline is not absolute. The Director, Flight Training and Standards stated that the captain's judgment in a landing situation takes precedence over the 5-mile guideline in the handbook. Additionally, while the handbook warned of thunderstorm-related hazards within 15 miles of the actual storm, the information was regarded as advisory in nature and not a definite or suggested limit. Perhaps the most specific guidance provided flightcrews was contained in a 1983 article on thunderstorms in the Flight Crew View, which stated:

> Do's and Don'ts of Thunderstorm Flying: Don't land or take off in the face of an approaching thunderstorm. A sudden gust front of low level turbulence could cause loss of control.

Similar articles are consistent in stating that USAir does not want its flightcrews to take off, land, or fly near thunderstorms. However, the same strong guidance and admonitions are not contained in the DC9 Pilot's Handbook--the policy manual. Consequently, although there was no specific prohibition by USAir policy governing a landing in the proximity of the thunderstorm, the intent of the company handbook and publications is evident. Flightcrews are expected to anticipate the hazards of thunderstorms, to evaluate the available information, and to make a decision based on the safety of the flight.

The policies and procedures in the DC9 Pilot's Handbook were straightforward, including the procedures related to the rotation to stickshaker in an emergency. The USAir training program exposed pilots to the maneuver and explained the additional performance capability that may be available in an emergency if an airplane is rotated to stickshaker. The Safety Board believes that pilots should be made aware of the performance available by rotating to stickshaker as a last resort during a severe wind shear encounter. However, the maneuver must be performed in a flight simulator to give pilots the proper foundation to anticipate and perform the maneuver in an actual wind shear encounter.

Air Traffic Control.—The quality and management of the air traffic services was related directly to the workloads of the controllers at the time of the accident. Controllers and supervisory personnel described the traffic and workload as moderate to heavy and "very" complex because of the number of aircraft and the developing weather conditions. Heavy workloads are likely to cause controllers to accelerate the pace of their transmissions and to increase the chance of transmission errors or omissions. Each of these circumstances arose at the radar and local control positions in the sequence of events which preceded the accident. At 1651:51, the East Arrival Radar controller cleared Flight 183 for the ILS approach to runway 21L and said "USAir 183 six miles from Scofi, maintain three 'til Nesbi, reduce and maintain 170 to the marker." However, at the conclusion of the transmission he said ". . . correction, that's the ILS twenty one right USAir 183." Aside from the fact that the flightcrew did not hear the correction to the initial approach clearance, some information in the clearance changed when the controller revised the landing runway to 21R. Scofi and Nesbi are fixes associated with the ILS 21L procedure. When the controller changed the landing runway he should have said "you are 6 miles from Ilupt, maintain three thousand 'til Rouge. . .". Additionally, Flight 183 was not told to contact the tower by the East Arrival Radar controller.

The local controller had the heaviest workload; she may have been approaching the limit of her performance capabilities. This supposition is based, in part, on the number of transmissions at the local control position between 1654:21 and 1656:25. In the 2-minute 4-second timeframe, the local controller made 16 transmissions and received 14 responses from 5 flights including 3 flights that were making missed approaches. Additionally, she made one visibility reading and was monitoring and transmitting the data derived from the LLWAS display. Another indicator of the local controller's perception of her workload was the rapidity with which she spoke. There was a nonstop progression of transmissions and responses and virtually no time available to add more transmissions or instructions to additional airplanes.

Probably as a result of her workload, the local controller made some errors as she handled the traffic. At 1655:18, she cleared Northwest 736 to land on runway 21R although the flight was aligned with runway 21L and had reported the marker to land on runway 21L. (See appendix D.) This error resulted in three additional transmissions from Northwest 736 and one transmission from the local controller who stated, at 1655:49, "Northwest 736 twenty one left, cleared to land. Is that the approach you're on?" At 1652:57, she noted that the visibility had dropped from 4 miles to 2 miles, and this information was transmitted on the local control frequency. However, at 1653:40, she announced, to tower personnel only, that the visibility was 1 mile, and about 1655:35, she announced, again to tower personnel only, that the visibility was 1/4 mile, despite the requirement to provide RVR information to aircraft on the local control frequency. (Paragraph 1081 of FAA Handbook 7110.65C instructs controllers to issue current touchdown RVR/RVV for the runway(s) in use when the prevailing visibility is 1 mile or less). None of the controllers recalled the RVR dropping below 6,000 feet. The facility RVR alarms were set to "zero". 14/ The only transmissometer which recorded RVR was located on the approach end of runway 3R. As a result, the Safety Board was not able to determine if the RVR on runway 21R indicated declining visibility conditions before the accident which were not observed by the local controller.

The Safety Board's primary concern with the quality and management of the air traffic services involved in the accident centers on the management inputs of the tower cab supervisor rather than the activities of the local controller. It should have been apparent to the supervisor that the working conditions were becoming more demanding and that the local control position was very busy. The tower cab supervisor, however, took no positive action to assist the local controller. His action in the time period before the accident appeared only to be to ask her if she was managing the workload. However, several facts should have been evident to the tower cab supervisor to indicate that the local controller faced a rapidly increasing workload: first, not only was a thunderstorm(s) influencing the air traffic situation, but, in fact, a thunderstorm was at the airport; second, the visibility was falling rapidly, perhaps below approach limits for the active runways, and this information was not transmitted to airplanes on the local control frequency; and third, the LLWAS was in constant alarm indicating wind shear conditions in two or three airport quadrants. There was clear evidence that the local controller was working near her maximum capability because of the traffic and meteorological conditions.

The Safety Board recognizes that the workload environment in the tower cab was dynamic and that it is difficult, at any given moment, to determine that an individual controller has reached a workload saturation. However, in this case the supervisor should have been alerted by the rising tempo of the controller's transmissions and should have

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14/ Most facilities set RVR alarms at 6,000 feet to alert controllers when the visibility drops. There is no specific procedure which governs the placement of the RVR alarm.

anticipated missed approaches or other delays because of the deteriorating weather conditions. These conditions should have resulted in close monitoring of the conditions to insure that the RVR was announced and to provide assistance to the local controller as necessary. A logical decision by the tower cab supervisor to alleviate the workload environment would have been to instruct the approach controllers to space out arriving airplanes to a wider interval. He also could have been more aware of the deteriorating weather conditions, and attempted to determine what was causing the rapidly decreasing surface visibility. The Safety Board believes it should have been evident to the tower cab supervisor that a thunderstorm was approaching the airport. However, the tower cab supervisor did not anticipate the developing workload, and consequently he let it proceed to the point where it may have exceeded the local controller's limitations. This was evident by the fact that the local controller finally asked him to assist her when Frontier 214 and USAir Flight 183 started missed approaches.

Other facts also underscore the shortcomings in the tower cab supervisor's performance. First, no one in the tower cab or the TRACON was aware of the 1636 special surface observation which warned of a thunderstorm 3 miles west of the airport. The observation was on the electrowriter and available to but not monitored by the tower cab supervisor. Second, the ATIS broadcast at the airport was based on information from the 1555 surface observation, and it was broadcast continuously until 1654, when the tower cab supervisor turned it off. The weather information reported on the ATIS was significantly better than the actual weather conditions at the airport because the ATIS was not updated from the 1636 observation or the observed weather conditions. Although the clearance delivery controller was responsible for the ATIS, the tower cab supervisor had a distinct management responsibility to insure that the ATIS was updated and current. As a result, the Safety Board concludes that the management of the tower cab by the supervisor was deficient.

The LLWAS system and the dissemination of wind data were the source of some confusion before the accident. The captain of Flight 183 and other pilots stated that the LLWAS wind data provided by the local controller was difficult to understand and could not be used to determine the wind situation. The review of the ATC voice transcript of the local control position by the Safety Board supported the statements of the flightcrews. The transmissions containing LLWAS data were very rapid, did not afford a pilot sufficient time to write down the wind directions and speeds, and would have made it difficult for a pilot to assimilate the nature of the airport wind pattern.

In its report of an accident involving wind shear at Kenner, Louisiana, in 1982, 15/ the Safety Board stated:

> The Safety Board also believes that the manner in which LLWAS wind shear alert information is presented could be improved. The wind shear alert information would be more meaningful if it were presented to the pilots as either a head wind, a tailwind, or a crosswind shear relative to the runway being used. The direction of the shear should be accompanied by its magnitude. In cases where crosswind shears in excess of a specified minimum value are combined with either a headwind or tailwind, shear direction and magnitude of both components should be provided. The Safety Board believes that the LLWAS computers could be modified to present LLWAS wind data in this format, and that the issuing of advisories based on the revised format would not pose a serious burden to controllers.

15/ Aircraft Accident Report—"Pan American World Airways, Inc., Clipper 759, Boeing 727-235, N4737, New Orleans International Airport, Kenner, Louisiana, July 9, 1982" (NTSB/AAR-83/02).

As a result of the investigation, the Safety Board recommended that the FAA:

> Make the necessary changes to display Low Level Wind Shear Alert System wind output data as longitudinal and lateral components to the runway centerline. (A-83-20)
>
> Recommend to air carriers that they modify pilot training on simulators capable of reproducing wind shear models so as to include microburst penetration demonstrations during takeoff, approach, and other critical phases of flight. (A-83-25)

The FAA has informed the Board that it is conducting evaluations of various displays of wind shear information to improve the capabilities of the LLWAS system and is awaiting the results of studies by the National Center for Atmospheric Research to provide data on microburst. Safety Recommendations A-83-20 and -25 are classified "Open--Acceptable Action."

This accident has underscored further the need to present wind shear data in simple, understandable terms. Although the FAA has taken measures to improve the LLWAS program, the Safety Board believes that LLWAS data must be presented to conform to human limitations of short-term memory and information processing during periods when large quantities of information must be assimilated. Therefore, the Safety Board reiterates Safety Recommendations A-83-20 and -25 and urges the FAA to expedite its work to improve the effectiveness of LLWAS. An improved information format would give pilots an immediate assessment of the wind shear hazard in a manner more usable by pilots for dynamic decisionmaking, especially during the final approach phase of the flight when the wind shear information is most needed and when the cockpit workload is highest.

Another problem relating to LLWAS data evident in this investigation was the phraseology used by the local controller when she transmitted LLWAS data. FAA Handbook 7110.65C, paragraph 981, gives two examples for controllers to use when providing LLWAS advisories. One example does not include the term "wind shear alert" while the other uses the phrase. The local controller and the tower cab supervisor stated that the term "wind shear alert" would not be used when transmitting LLWAS advisories unless "several" quadrants of the LLWAS were in alert status. "Several" was then defined by Detroit ATC personnel as three or more quadrants. The local controller, however, admitted that paragraph 981 was "ambiguous," and stated that she never had received facility training concerning the interpretation of the handbook. Despite this interpretation of the meaning of paragraph 981 by the local controller and the tower cab supervisor, the local controller did not apply the "three or more" quadrant criterion while making LLWAS transmissions. At 1654:27, she broadcast an LLWAS advisory with three boundary quadrant winds. However, the term "wind shear alert" did not preface the transmission, and consequently, aircraft in the terminal area were not told specifically that the wind data constituted a wind shear alert.

The Safety Board disagrees with the interpretation of paragraph 981 that shears in three or more quadrants constitutes a wind shear alert. The wind data, transmitted seven times by the local controller, were derived from the LLWAS after one or more quadrant sensors went into alarm. A single alarm in a single quadrant constituted a wind shear, and this fact should have been transmitted to pilots as a wind shear alert. The failure of the local controller to preface any LLWAS-derived wind information with "wind shear alert" caused some confusion for the crew of Flight 183, which stated that they did not consider the wind information as being a wind shear alert.

Since the accident, the FAA has issued a GENOT which clarifies paragraph 981. The GENOT requires controllers to preface all transmissions of LLWAS-derived wind data with "wind shear alert" regardless of whether one or five boundary quadrant sensors is in alarm. The Safety Board believes that the GENOT clarifies the intent of paragraph 981, although the more reasonable interpretation of the paragraph before the GENOT also should have included the proper phraseology.

In summary, the investigation revealed several examples where controller and supervisory personnel made procedural errors or errors of omission. The East Arrival Radar controller provided wrong information to Flight 183 on one occasion while the local controller made mistakes with regard to some clearances, the transmission of LLWAS information, and the transmission of RVR data. The tower cab supervisor did not insure that current weather information was processed and disseminated to controller personnel or put on the ATIS. In addition, he did not monitor or anticipate the increasing workload of the local controller and, consequently, allowed the workload to grow to the point where it may have approached the capability of the local controller. The ATC deficiencies, which were generally of a procedural and management nature, did result in a lesser quality of ATC services and reduced to some degree the total amount of information available to the crew of Flight 183 for decisionmaking. However, flightcrews did have sufficient information from other sources to make prudent decisions as evidenced by the actions taken by a number of crews.

Operational Decisions.--In analyzing the decisions made by the captain of flight 183 to continue the ILS to runway 21R and the events which occurred during the missed approach and crash, the Safety Board considered the guidelines and procedures in the USAir DC9 Pilot's Handbook and official publications, the USAir DC9 flight training program, the weather information available to the flightcrew, and the ATC services provided to the flightcrew. The training and experience of the captain and the first officer also were analyzed in relation to the events of the accident.

The procedures and guidance in the USAir DC9 Pilot's Handbook and official publications warn of the hazards of thunderstorms and wind shear and admonish pilots to avoid operations near convective activity. Since there was no specific guidance which established a minimum distance from a thunderstorm inside of which a USAir captain could not operate an airplane, the captain's decision to start the instrument approach to runway 21R was not contrary to company policy and was within his prerogative as the captain. The determination of the potential hazards associated with ongoing weather phenomena and the measures to be used to cope with weather always must be vested in the captain. These decisions are based on his training, experience, and judgment, and the availability of accurate and timely reports concerning the location and severity of the weather conditions.

The principal factor which should have influenced the captain's decision to continue the instrument approach was his knowledge of the location of thunderstorms near the airport. Testimony of pilots who arrived in the Detroit terminal area about the time of the accident was consistent in that convective activity was discernible on radar up to 100 miles from the airport. All pilots reported that scattered thunderstorm cells appeared clearly on airborne weather radar and that the primary cells were west and southwest of the airport. Pilots with color radar indicated that the cell to the west of the airport displayed a heavy rainfall rate. The flightcrew of Flight 183 stated that they were aware of thunderstorms west and southwest of the airport, and their comments on the CVR indicated that they observed the thunderstorm on radar and visually. They also were aware that the visibility had dropped from 4 miles to 1 mile and that the winds at the airports were "shifting rapidly" or were "cyclonic." Additionally, they heard discussions on the East Arrival Radar controller frequency about a thunderstorm in progress. In light of this evidence, the Safety Board concludes that the flightcrew of Flight 183 was aware that a thunderstorm was no more than 5 miles west of the airport, probably closer, as they reached the outer marker. They also were aware that the thunderstorm was affecting the wind conditions at the airport and that the surface winds were, at the least, approaching the crosswind landing limits of the DC9. They also expected to encounter a rain shower as they neared the airport. Given this information, the flightcrew should have anticipated that they would encounter thunderstorm-associated conditions if the instrument approach to runway 21R was continued. The Safety Board concludes that the captain's decision to continue the approach under such conditions was inappropriate.

Although by regulation the captain could continue the instrument approach beyond the outer marker to the point where he started the missed approach, it probably was contrary to the guidelines in USAir publications and, at the least, unwise. The flightcrew should have known and anticipated that if they did land, the landing would be made at the same time as, or just before, the time that the thunderstorm arrived at the airport. Additionally, they were aware that the surface winds might exceed the USAir DC9 crosswind limits of 25 knots direct crosswind. If the pilots were unsure of the winds, which they both testified that they were, they should have requested current airport wind conditions. Finally, they should have been aware that the probability of a gust front and/or wind shear from the thunderstorm existed and that this would present a hazard to the airplane during landing. While the captain of Frontier 214 also continued his approach beyond the outer marker, the similarities and differences in the circumstances are noteworthy. Frontier 214 was landing on runway 21L which was farther away from the thunderstorm cell. Frontier 214 started the missed approach more than 1 minute before Flight 183 and did not fly into the center of the thunderstorm.

Based on the factors cited above, the Safety Board concludes that the captain's decision to continue the instrument approach to the point where the missed approach was started was imprudent, showed poor judgment, and subsequently resulted in a severe wind shear encounter which led to the accident.

The final operational decision of concern was the decision to land immediately, which the captain made when he saw the runway. Shortly after Flight 183 passed the middle marker at 1656:16, the airplane may have had the capability to continue to maintain a constant, level altitude. However, the captain apparently did not consider further efforts to continue the missed approach once he saw the runway and, in fact, said that, "the only thing that I could think of was the landing, contact to the ground was imminent." Consequently, the captain's decision, made sometime between 1656:16 and 1656:21, was to exercise what he believed to be his only option, which was to land on the runway. The captain lowered the pitch attitude of the airplane, reduced thrust, and lowered the landing gear. The sound similar to stickshaker 3 seconds before impact was likely caused by the flare of the airplane to halt the rate of descent and to cushion the landing on the runway. It was not caused by an attempt to fly the airplane at stickshaker airspeed.

The airplane performance analysis established that although the indicated airspeed was decreasing steadily, the airplane was not descending or "being pushed down" as the captain recalled. Rather, the captain's perception of what was happening to the airplane was likely influenced by his perception of the need to apply an abnormal force to the control wheel to raise the nose of the airplane, by the intimidating sounds of hail and heavy rain on the cockpit, and, most significantly, by the observed loss of 24 knots of airspeed in 10 to 12 seconds. As a result, when the captain saw the runway ahead of him, he immediately committed the airplane to the runway.

The flightcrew's recollection of the accident parallels closely findings included in an analysis of a number of wind shear-related accidents and incidents that was made by the Boeing Commercial Airplane Company. 16/ In particular, Boeing's analysis found that pilots experienced difficulty in maintaining proper pitch attitudes because of "perceived" heavy elevator control forces. The analysis stated, "The pull stick forces required, after a normal rotation, may be perceived as an abnormal response and a concern to a pilot expecting to be flying in trim during climb." The analysis also noted that, "Even the decreasing pitch attitude in response to the loss of airspeed may be perceived as normal in light of the pilot's airspeed control training emphasis." The analysis concluded that since pilot reaction to wind shear encounters must be made in seconds when at a low altitude, it was difficult for the flying pilot alone to scan, interpret, and react to all the cockpit information in a timely fashion. Therefore, specific wind shear training, emphasizing coordinated flightcrew actions and reactions, and proper flight path management were critical to minimize the hazards of the wind shear encounter.

The captain's inability to perform successfully in the stressful situation which developed was similar to the documented problems he encountered in previous simulator training periods. Specifically, an inability to recall procedures and to fly basic instruments were evident in the June 13, 1984, accident. However, the flightcrew should have been better prepared for the possibility of a wind shear encounter in the light of the weather conditions so as to respond with proper wind shear encounter techniques. Although the captain had received simulator wind shear training, it appears to have been at least 2 years before the accident. The first officer did not recall receiving any wind shear training in the simulator. Additionally, neither pilot was confident in the Pilot's Handbook technique of rotating the airplane to stickshaker speeds. These incidents and the statements of other USAir first officers indicate inconsistencies in the manner and philosophy of wind shear training at USAir.

The Safety Board believes that exposure to the effects of wind shear is a valuable simulator training experience which every flightcrew member should receive. The Board believes it counterproductive to incorporate expensive wind shear training scenarios into flight simulators and then not require flightcrews to use them in training. The fact that USAir will include wind shear training in future simulator sessions will insure that its pilots receive the valuable training. The simulator technology now available to air carriers operating turbojet airplanes is adequate to present realistic, useful wind shear training. The Safety Board believes that simulator wind shear training, including simulator flight training, should be given to all pilots of turbojet transport airplanes during routine flight training and that the training should emphasize the optimal procedures for inadvertent encounters during the takeoff and landing phases of flight. Nevertheless, the Safety Board believes it must be emphasized that these procedures are emergency procedures which never should replace the prudent practice of avoidance.

Although this accident did not have as severe and critical wind shear influences of the accident at Kenner, Louisiana, in 1982, it does point out the continued need to provide improved guidance and information to flightcrews. In its Kenner, Louisiana, accident report the Safety Board stated:

16/ "Lessons Learned From Wind Shear Encounters," Charles R. Higgins, The Boeing Commercial Airplane Company, 1984 SAE Aerospace Congress and Exposition, October 15, 1984.

While the Safety Board believes strongly that the most positive prevention of this type of accident is avoidance of critical microburst encounters, other actions must be taken to enhance the capability of flightcrews who may experience the hazard without warning to recover from the encounter. The airplane's flight instrumentation must be improved. In addition, the contents and scope of present simulator training must be broadened to increase the flightcrew's knowledge of the airplane's flight characteristics during varied wind shear encounters so that they can recognize the onset of the wind shear more quickly and also recognize the need to take rapid corrective action in order to prevent a critical loss of altitude. Both of these actions could effectively improve pilot response time and may mean the difference between a catastrophic accident and successful microburst penetration.

Present generation flight directors provide the pilot pitch command guidance to either a fixed takeoff attitude, as is the case with most older jet transport airplanes such as the B727 involved in this accident, or an optimum climb airspeed, as is the case with the newer wide-body airplanes. In either system, the pitch command guidance is not programmed to account for the environmental wind condition experienced in a downburst or microburst. These flight directors will in fact provide takeoff and initial climb pitch commands which are likely to produce a descending flightpath as the airplane experiences a downdraft and loss of headwind. The Board believes that the FAA and industry should expedite the development and installation of a flight direction system such as MFD-delta-A which includes enhanced pitch guidance logic which responds to inertial speed/airspeed changes and ground proximity.

Although the Safety Board notes that most air carriers including Pan Am provide pilots with wind shear penetration demonstrations during their recurrent simulator training, there does not appear to be a consistent syllabus which encompasses microburst encounters during all critical phases of flight. Because of the differences in airplane configuration, performance margins, flight director logic, among others, the Board believes that flightcrews should be exposed to simulated microburst encounters during takeoff as well as approach phases of flight.

Cockpit Management.--The management of the final stages of the flight by the flightcrew was characterized by a lack of preparation and anticipation. The standard cockpit duties were accomplished; however, there were no discussions by either flightcrew member of the need for special consideration for the conditions present at the airport and their potential effects on the instrument approach. The specific events which indicate a lack of preparation and anticipation were: no request for an update of actual weather when it was obvious that it was worse than the ATIS weather; no request for clarification of reported surface winds despite the admission by both the captain and the first officer that neither completely understood the nature of the surface winds; awareness of a thunderstorm reported by a controller, but no effort to establish the location of the thunderstorm cell, although the first officer complained that the ATC transmissions of thunderstorm activity were not helpful because he was not provided a location; flying the airplane into the center of the thunderstorm before a missed approach was started; lack of anticipation of thunderstorm-associated heavy rain, hail, and turbulence--there was no discussion or anticipation of the classic headwind-tailwind effects of a thunderstorm on the airplane--and lack of recognition of the onset of the effects of wind shear on airplane performance or cockpit instruments.

The cumulative effect of the lack of anticipation and preparation was a state of confusion in the cockpit and a subsequent breakdown in the decisionmaking process. The captain's belief that the airplane was being "pushed down" was actually the decreasing indicated airspeed as the airplane slowed from the wind shear encounter and was not an actual loss of altitude. One other characteristic of an encounter with a decreasing headwind is that the airplane's nose will pitch down, which, in this case, required further control inputs from the captain and reenforced his belief that he was descending. The actual status of the airplane could have been determined from the cockpit instruments available to him and the first officer and from better anticipation and preparation based on existing information. As a result, the captain's decision to land was not dictated by the physical circumstances of the accident but by his incorrect interpretation of information, his incorrect perception of what was happening to the airplane, and the inadequate anticipation and preparation for the developing state of flight.

Contributing to the ineffective cockpit management was the absence of cockpit coordination. Good cockpit coordination, which is the responsibility of both flightcrew members, requires constant analysis and assessment of flight conditions. Aside from routine checklist procedures, there was no indication that the flightcrew actually discussed or participated in analytical discussions of conditions affecting the flight, the feasibility of discontinuing the instrument approach, or the need for additional information.

The first officer, aside from his standard checklist duties, did little to support the captain or to provide assistance or information. In fact, although he admitted doubt about the location of the thunderstorm, the actual airport surface wind conditions, and the actual weather conditions at the airport, he did not ask for more information from controllers or raise his concern about these doubts to the captain. The Safety Board believes that the first officer should have been more aggressive in resolving his concerns about the existing conditions, and he should have articulated to the captain his uncertainties. Finally, his uncertainties should have caused him to discuss the feasibility of abandoning the approach. In this accident, the Safety Board saw little indication that the captain provided leadership and planning guidance, while the first officer, by not articulating his uncertainties about the weather or discussing with the captain the feasibility of terminating the approach, failed to assist effectively the captain in the conduct of the flight.

The Safety Board believes that the first officer's performance in this regard is partially a result of his lack of training in first officer assertiveness and crew coordination. Neither crewmember received training in this area, and the Board believes that this accident points to the need for such training for airline crews. First officers should be given assertiveness training in which they practice being participants in decisionmaking and they vocalize their disagreements, if any, with a captain's decision. At the same time, captains should be trained to solicit the opinions of first officers and to use their full potential as participants in the decisionmaking process. Although air carriers are not required to train their crewmembers in this area, the Board believes that it would be a benefit to their crewmembers. In fact, the FAA has issued an Operations Bulletin which urges airlines to provide such training. The fact that USAir currently is offering a related program to its less senior captains indicates that USAir recognizes the importance of this type of training. Just as all crewmembers are trained thoroughly in flight operations and aircraft handling, the Board believes that all crewmembers should be required to be trained in crew coordination and decisionmaking skills that are essential to the safe operation of aircraft.

2.5 USAir Management

The captain continuously maintained his status as a pilot-in-command, despite the fact that between May 1983 and April 1984 he performed poorly in three separate training sessions. The captain's recent poor training performances, after almost 29 years of satisfactory air carrier flying, should have caused USAir training managers and the Washington, D.C., Chief Pilot to attempt to identify the reasons for the emerging pattern of training difficulties and to resolve them definitively.

USAir management's attempt to address the captain's emerging pattern of training deficiencies after the May 1983 DC9 training problems and the unsuccessful Boeing-727 transition program was inconclusive. While a meeting was held with the captain and USAir operational and training managers, the meeting failed to determine the reasons for the captain's training and proficiency problems. Nevertheless, the captain was allowed to undergo DC9 requalification in December 1983.

The USAir management's evaluation of the captain's training and proficiency problem in late 1983 may be attributed, in part, to USAir's belief that pilots sometimes have difficulty transitioning to new airplanes. Furthermore, it was suggested by the Director, Flight Training and Standards that the captain's long tenure and successful performance in the previous 28 years may have caused company management to downplay the unsuccessful training sessions in 1983. As a result, when the captain was able to requalify on the DC9 in January 1984, he was returned to the line as a captain. However, despite the failure to identify the training and proficiency problems, there was no control established for company management to exercise closer surveillance of the captain's future training and line-flying performance.

In April 1984, the captain again demonstrated a low level of proficiency in DC9 training, and the written comments by the training instructors again indicated a lack of preparation and unfamiliarity with airplane procedures. However, this training session did not result in further evaluation of the captain's abilities or other attempts to resolve his training and proficiency problems. The Safety Board believes that the third episode of poor simulator performance by a captain in 12 months should have caused USAir management to conduct a systematic and thorough examination of the reasons for the training difficulties, as it is unusual to find consistently documented training problems with air carrier captains. In fact, since fewer than 1.4 percent of all USAir simulator flight checks were unsatisfactory in 1983, the fact that one pilot had three poor training evaluations in 12 months should have caused USAir management to have been very concerned about the captain's training and proficiency problems. Consequently, the Safety Board concludes that by April 1984, USAir training and management personnel should have identified the pattern of unsatisfactory training sessions and the reasons for the captain's proficiency problems. Additionally, the captain's apparent lack of proficiency should have caused USAir management to examine his ability not merely under routine flight regimes but in more complex and dynamic flight conditions. However, he was again given additional training and returned to the line as a DC9 captain in April 1984 with no company action to identify his problems and without specific management surveillance of his performance. It is apparent, in retrospect, that the evaluations by USAir training instructors were accurate in assessing the degraded ability of the captain to perform in certain complex and dynamic flight situations. While company management personnel acted on the information provided by the training instructors, it was deficient in its management responsibilities by not identifying his specific problems and by not following through in monitoring his performance. Instead, the captain underwent a standard evaluation of his training progress and was returned to pilot-in-command duties before the training and proficiency problems were identified and corrected.

2.6 Federal Aviation Administration Surveillance

The FAA is responsible to insure that airlines conduct a thorough training program and that airline management actions promote safe flight operations. The findings of this accident investigation indicate that the USAir training program met the requirements of FAA regulations. The FAA was aware of the captain's training difficulties and knew that he had undergone retraining in the simulator to meet the regulatory requirements. The principal operations inspector stated that his concern was not with the amount of training time required for a pilot to meet 14 CFR Part 121 standards but that the company insure that pilots did meet the standards before performing assigned duties. The FAA performed its training oversight responsibilities by insuring that a program was in place to train USAir pilots to meet proper regulations and that it was administered in an adequate manner.

3. CONCLUSIONS

3.1 Findings

1. The airplane was certificated, equipped, and maintained in accordance with Federal regulations and approved procedures.

2. The flightcrew was certificated properly and had received the training prescribed by Federal regulations.

3. The air traffic controllers were certificated properly and were qualified to perform the assigned duties.

4. The dispatch weather information was adequate for the flight and alerted the flightcrew to the possibility of thunderstorms during the arrival at Detroit.

5. The actual weather conditions at Detroit were worse than forecast.

6. The existence and location of thunderstorms west and southwest of the airport were evident to flightcrews arriving at Detroit about the time of the accident both visually and on airborne weather radar.

7. The flightcrew of Flight 183 observed the thunderstorm which they believed was located 5 to 8 miles west of the airport as the airplane passed the outer marker.

8. A VIP level 4 thunderstorm moved west to east and was over the northern portion of the airport and the threshold of runway 21R as Flight 183 approached decision height.

9. The flightcrew had sufficient information upon which to make a decision to start a missed approach before entering the thunderstorm.

10. The airplane was flown into the thunderstorm before a missed approach was started, and the missed approach was initiated as the airplane passed through the center of the rain and hail shaft.

11. The airplane's rate of descent was stopped by the initiation of the missed approach, and the airplane was flown at a constant altitude for about 16 seconds.

12. The indicated airspeed increased to about 143 knots as the airplane flew through the thunderstorm cell. The airspeed then decreased to about 119 knots.

13. The airplane was capable of maintaining level flight during the missed approach.

14. The captain's belief that the airplane would not climb was influenced by the incorrect perception of information, and the physical consequences of entering the thunderstorm cell, i.e., the rain, hail, and effect on the airplane's pitch attitude.

15. The captain elected to land the airplane when he saw the runway, although the airplane may have been capable of continued safe flight.

16. There was inadequate cockpit crew coordination and management during the instrument approach and missed approach.

17. The first officer failed to assist the captain to the fullest extent possible under the circumstances by not articulating his uncertainty about airport weather conditions.

18. The Automatic Terminal Information Service weather information broadcast from 1555 until 1654 was not representative of the actual weather for that period and should have been updated when the 1636 special weather observation was received.

19. The air traffic controllers did not note the 1636 special weather observation which contained important weather information about thunderstorm activity.

20. The local controller failed to provide runway visual range information after the prevailing visibility dropped to 1 mile.

21. Improper phraseology was used by the local controller in at least one LLWAS data transmission.

22. The management and controllers at the Detroit ATC facility improperly interpreted FAA Handbook 7110.65C, paragraph 981. However, the language of paragraph 981 was confusing and ambiguous.

23. The transmissions of the LLWAS data by the local controller were difficult for flightcrews to understand and to use to plan approaches and landings because of the amount of data that was required to be transmitted and the speed at which the controller talked.

24. There continues to be a need for improvement of the format used to transmit wind shear information to pilots.

25. USAir policy and procedure documents warn pilots of the hazards and dangers of thunderstorms.

26. Not all USAir pilots received simulator wind shear training, although the scenarios were available in flight simulators.

27. USAir training instructors documented the captain's training deficiencies, and the extent of the training and proficiency problems were known to company management. Inadequate action was taken by management to resolve the reasons for the captain's poor performance in training.

3.2 Probable Cause

The National Transportation Safety Board determines that the probable cause of the accident was inadequate cockpit coordination and management which resulted in the captain's inappropriate decision to continue the instrument approach into known thunderstorm activity where the airplane encountered severe wind shear. The failure of air traffic control personnel at the airport to provide additional available weather information deprived the flightcrew of information which may have enhanced their decisionmaking process.

4. RECOMMENDATIONS

As a result of its investigation of this accident, the National Transportation Safety Board recommended that the Federal Aviation Administration:

> In cooperation with air carriers and manufacturers, develop a common wind shear training program, and require air carriers to modify airline training syllabi to effect such training. (Class II, Priority Action) (A-85-26)
>
> Conduct research to determine the most effective means to train all flightcrew members in cockpit resource management, and require air carriers to apply the findings of the research to pilot training programs. (Class II, Priority Action) (A-85-27)

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

/s/ JIM BURNETT
Chairman

/s/ PATRICIA A. GOLDMAN
Vice Chairman

/s/ G. H. PATRICK BURSLEY
Member

JIM BURNETT, Chairman, filed the following additional views:

Contributing to the accident was the failure of USAir management to determine the reason for the captain's recent, repeated and unusual difficulty in meeting training and proficiency standards and resolve the problem before permitting him to continue to serve as pilot-in-command.

March 5, 1985

5. APPENDIXES

APPENDIX A

INVESTIGATION

1. Investigation

The National Transportation Safety Board was notified of the accident about 1720 e.d.t., on June 13, 1984, and immediately dispatched an investigative team to the scene from its Washington, D.C., headquarters. Investigative groups were formed for operations, weather, air traffic control, systems/structures, powerplants, survival factors, airplane performance, cockpit voice recorder and flight data recorder. A human performance specialist participated in all phases of the investigation.

Parties to the investigation were the Federal Aviation Administration, USAir, Inc, Air Line Pilots Association, Association of Flight Attendants, Douglas Aircraft Company, Pratt and Whitney, National Weather Service, and Detroit Metropolitan Airport.

2. Deposition Proceeding

A 2-day deposition proceeding was held in Romulus, Michigan, beginning July 17, 1984. Parties represented at the deposition proceeding were the same as those in the onscene investigation.

APPENDIX B

PERSONNEL INFORMATION

Captain Arthur L. Sanderhoff

Captain Sanderhoff, 57, was employed by USAir and its predecessor, Allegheny Airlines, in April, 1955. He holds Airline Transport Pilot Certificate No. 554407 with type ratings in the DC-3, F-27, Martin 202, Convair 340 and 580, and DC9. His most recent first-class medical certificate was issued on June 11, 1984, with the limitation that he must possess correcting lenses for near vision when exercising the privileges of his airman certificate.

Captain Sanderhoff qualified in the DC9 in 1968, and had flown the DC9 continuously except for a 6-month period in 1983 when he was in a Boeing-727 transition course. He passed his last proficiency check on April 20, 1984. His most recent line check was on May 6, 1984. The captain had flown 30,650 flight hours, of which 14,300 hours were in the DC9. He had flown 4 hours 33 minutes in the past 24 hours, and 7 hours 41 minutes in the past 13 days.

First Officer Richard T. Gould

First Officer Gould, 32, had been employed by USAir for 4 1/2 years. He holds commercial pilot certificate No. 1959117 with airplane single and multiengine land and instrument ratings. His first-class medical certificate was issued on June 9, 1983, and contained no limitations.

First Officer Gould had flown about 4,000 total flight hours, of which 1,830 hours were in the DC9. He qualified as DC-9 first officer in February 1981. He completed recurrent training on December 22, 1983, and simulator training on January 13, 1984. His most recent line check was on November 16, 1983. He had flown 4 hours 3 minutes in the past 24 hours.

Flight Attendants

Flight Attendant Sandy Quinn (Flight Attendant "A"), Flight Attendant Diane Reber (Flight Attendant "B"), and Flight Attendant Nancy Miles (Flight Attendant "C") completed recurrent training on February 10, 1984, February 17, 1984, and February 18, 1984, respectively.

Air Traffic Controllers

Paul Satterwhite, East Arrival Radar controller, was hired by the FAA on June 11, 1973. He was assigned to the Detroit ATC facility on August 29, 1976, and reached full performance level on September 30, 1977. His second-class medical certificate was issued on December 12, 1983. His most recent over-the-shoulder evaluation was on August 18, 1983.

Amanda Wilcox, local controller, was hired by the FAA on November 8, 1981. She was assigned to the Detroit ATC facility on March 1, 1982. She was qualified on all control positions in the tower cab and two radar positions. Her last over-the-shoulder evaluation was on October 28, 1983. She holds a private pilot certificate.

APPENDIX C

AIRPLANE INFORMATION

McDonnell Douglas DC9-32, N964VJ

The airplane, manufacturer's serial No. 47590, was powered by JT8D-7B engines manufactured by Pratt and Whitney Aircraft Group.

Powerplants

Engine	No. 1	No. 2
Serial	657064	657740
Date installed	April 24, 1984	September 30, 1982
Hours since installed	379 hours	4,194 hours
Cycles since installed	443 cycles	4,810 cycles
Last shop visit	Heavy check	Heavy check

APPENDIX D

TRANSCRIPT OF COCKPIT VOICE RECORDER

TRANSCRIPT OF A V-557 SUNDSTRAND COCKPIT VOICE RECORDER S/N 2535, REMOVED FROM THE US AIR DC-9 WHICH WAS INVOLVED IN AN ACCIDENT AT DETROIT, MICHIGAN, ON JUNE 13, 1984

LEGEND

CAM	Cockpit area microphone voice or sound source
RDO	Radio transmission from accident aircraft
-1	Voice identified as Captain
-2	Voice identified as First Officer
-?	Voice unidentified
DAP	Detroit Approach
TWR	Metro Tower
214	Other aircraft
593	Other aircraft
736	Other aircraft
592	Other aircraft
3CF	Other aircraft
09G	Other aircraft
92	Other aircraft
93AP	Other aircraft
542	Other aircraft
X24	Other aircraft
424	Other aircraft
895	Other aircraft
590	Other aircraft
*	Unintelligible word
#	Nonpertinent word
%	Break in continuity
( )	Questionable text
(( ))	Editorial insertion
---	Pause

Note: All times are expressed in Greenwich Mean Time.

INTRA-COCKPIT

TIME & SOURCE	CONTENT

AIR-GROUND COMMUNICATIONS

TIME & SOURCE	CONTENT
2049:22 DAP	(Two) two fourteen, turn right to heading zero five zero
2049:24 214	Two fourteen, right zero five zero
2049:27 DAP	Okay Sugar Pop, turn left to two thirty a mile and a half to the outer marker, maintain twenty six hundred until established on the localizer cleared the ILS approach to runway twenty one left present speed to the marker, tower at the marker eighteen four
2049:35 SP	Sugar Pop will do all that
2049:37 DAP	(US Air) one eighty three left to two forty, join twenty one right
2049:41 RDO-2	Left to two forty twenty one right now US Air one eighty three
2049:43 DAP	Runway two one right for US Air one eighty three
2049:45 RDO-2	Thank you

INTRA-COCKPIT

TIME & SOURCE	CONTENT
2049:47 CAM-1	Oh the right one
CAM-2	They just changed it
CAM-2	That's the one we want
2049:50 CAM-1	Yeah that the one we want all right
CAM-1	I'm all set up for the left one
CAM-2	Yeah, well he told us that originally so ah
CAM-1	Yeah okay well that what * *
2050:05 CAM-2	Yeah that's what they do to us here in Detroit ● I flew in here for three months and ah they try to the give you the left side and try to give you the right side if they can
2050:14 CAM-1	* *

AIR-GROUND COMMUNICATIONS

TIME & SOURCE	CONTENT
592	Republic five ninety two going down to six with Charlie
DAP	Republic five ninety two plan twenty one right
592	Twenty one right roger
2049:54 DAP	(Flight two) two fourteen come up heading two seven zero
214	Two fourteen left two seven zero, roger

INTRA-COCKPIT

TIME & SOURCE	CONTENT
CAM-2	Okay here we go

AIR-GROUND COMMUNICATIONS

TIME & SOURCE	CONTENT
2050:15 DAP	(Two) two fourteen descend and maintain two thousand six hundred, turn left to heading two six zero
2050:20 214	Two fourteen two thousand six hundred, two six zero
2050:23 DAP	(US Air) one eighty three, descend and maintain three thousand
2050:26 RDO-2	Down to three US Air one eighty three, one eighty, one ninety on speed
2050:29 RDO	((Click of microphone))
2050:30 DAP	(Two) two fourteen five miles from Scofi come up heading two three zero maintain two thousand six hundred until established on localizer one seventy knots to the localizer cleared to ILS twenty one left
2050:38 214	Roger two fourteen be a left turn two thirty cleared to for the ILS runway two one left, roger

INTRA-COCKPIT

TIME & SOURCE	CONTENT
2047:35 CAM-1	Slats and fifteen
2051:04 CAM	((Sound similar to stablizer in motion horn))
2051:20 CAM	((Sound similar to stabilizer in motion warning))

AIR-GROUND COMMUNICATIONS

TIME & SOURCE	CONTENT
2050:43 DAP	US Air ah one eight three, descend and maintain two thousand six hundred but maintain one ninety knots
2050:48 RDO-2	Two point six one ninety on the speed ah US Air one eight three
2050:51 DAP	Republic five ninety two left heading zero three zero
593	Thirty Republic five ninety three you got a lower
2050:56 DAP	Ah not just yet in five miles there's a departure two o'clock and two miles he's eastbound climbing out of three for five
2051:11 DAP	(US) seven thirty six maintain four thousand I'll have you on base leg turn for you in three miles
2051:15 736	Down to four northwest seven thirty six

INTRA-COCKPIT

TIME & SOURCE	CONTENT
2051:21 CAM-2	Look at the contour on that first
CAM-1	(Sure is)
2051:27 CAM-1	Ten miles
2051:28 CAM-1	Yeah ten miles from the airport * *
CAM-?	Right under the * *
CAM-2	* you gonna be low enough that ah
2051:43 CAM-1	Summer time * storm
CAM-2	(Yup *)

AIR-GROUND COMMUNICATIONS

TIME & SOURCE	CONTENT
2051:28 DAP	Attention all aircraft inbound to metro, metro visibility is two miles
2051:32 DAP	Northwest seven thirty six turn left heading three zero zero
2051:37 736	Three zero zero Northwest seven thirty six
2051:43 RDO-2	US Air two fourteen one seventy to the marker tower at the marker eighteen four, good day
2051:48 RDO-2	Two fourteen roger
2051:51 DAP	US Air one eighty three six miles from Scofi maintain three to Nesbi, reduce and maintain one seventy to the marker cleared to the ILS twenty one left

INTRA-COCKPIT TIME & SOURCE	CONTENT	AIR-GROUND COMMUNICATIONS TIME & SOURCE	CONTENT
		2051:55 RDO-2	Roger one seventy and back down to three US Air one eight three
CAM-1	Fifteen on the flaps		
		2051:59 DAP	Northwest seven twenty six turn left heading two seven zero reduce airspeed to one seven zero
CAM	((Sound similar to landing gear warning horn))		
		2052:05 DAP	Two seven zero on the heading one seven zero the speed Northwest seven thirty six
2052:06 CAM-2	(There's detent)		
		2052:10 DAP	Republic five ninety two, your airspeed is one hundred and seventy knots is that correct
		2052:13 592	Correct
		2052:14 DAP	(*)
CAM-1	Now then		
CAM-1	Down the gear		
		2052:18 3CF	Detroit approach good afternoon, it's Learjet one oh three charlie fox at eight thousand and we've got information Charlie ah any changes?
2052:21 CAM	((Sound of gear extension))		

INTRA-COCKPIT

TIME & SOURCE	CONTENT
2052:31 CAM-2	Seatbelt, no smoking
CAM-1	On
CAM-1	Ice protection
CAM-1	As required
2052:36 CAM-2	Ignition APU
CAM-1	Not required
CAM	((Sound similar to altitude alert))
CAM-2	Anti skid
CAM-1	Armed
2052:40 CAM-2	Landing gear
CAM-1	Down and in the green

AIR-GROUND COMMUNICATIONS

TIME & SOURCE	CONTENT
2052:25 DAP	Northwest seven thirty six left to two thirty your position is six miles from Scofi maintain three to Nesbi one hundred and seventy knots on the airspeed to the marker, cleared the ILS twenty one left
2052:33 736	Two thirty on speed and ah twenty one left, Northwest seven thirty six
2052:38 DAP	That's correct one seventy to the marker, tower at the marker one eighteen four, Northwest seven thirty six

INTRA-COCKPIT

TIME & SOURCE	CONTENT
CAM-2	Spoilers
CAM-1	Three armed

AIR-GROUND COMMUNICATIONS

TIME & SOURCE	CONTENT
2052:43 DAP	Three charlie fox thunderstorm in progress descend and maintain six thousand two seventy heading for runway two one left altimeter two nine nine two did you say you had (that) charlie
2052:51 3CF	We have charlie yes and we're looking at the thunderstorm here
2052:53 RDO	((Sound of click))
2052:54 09G	And twin Cessna three nine zero nine golf is back with you
2052:58 DAP	Niner golf Detroit fly heading zero three zero up to twenty one left
2053:00 09G	Zero three zero

INTRA-COCKPIT

TIME & SOURCE	CONTENT

AIR-GROUND COMMUNICATIONS

TIME & SOURCE	CONTENT
2053:07 DAP	Republic five ninety two descend and maintain four thousand
2053:10 592	To four, five ninety two
2053:20 3CF	Zero three charlie fox reduce your speed to one hundred and ninety knots
2053:23 3CF	Okay reducing to one nine zero, charlie fox, we're going to six thousand and we have a request for the right side we're going customs
2053:29 DAP	I have the request I'll keep you advised
2053:30 3CF	Roger
2053:36 DAP	Three charlie fox fly heading two six zero maintain two hundred and ten knowe for twenty one right
2053:40 3CF	Okay a hundred and --- two ten and two sixty right

INTRA-COCKPIT

TIME & SOURCE	CONTENT
2053:48 CAM-2	* the missed approach is --- it's * pretty # procedure that takes you right out to Willow Run, it's a terrible procedure * down
2053:53 CAM-1	Yeah we don't want to go that way
2053:55 CAM-2	We don't want to go that way cause that one's right over Willow Run
2054:00 CAM	((Sound of outer marker))
CAM-1	The outer marker
2054:08 CAM-2	Altitude checks

AIR-GROUND COMMUNICATIONS

TIME & SOURCE	CONTENT
2053:54 DAP	Republic five ninety two plan the left I can't get you in any sooner for the right and there's one mile on the visibility now Republic five ninety two
592	Ninety two roger left
DAP	Three charlie fox descend and maintain five thousand
2054:05 3CF	Five thousand, charlie fox
2054:08 3AP	Two alpha poppa turning to zero five zero seven thousand
2054:13 DAP	Alpha poppa Detroit that heading is a vector for twenty one left altimeter two niner nine three
2054:18 3AP	Ninety three alpha poppa

INTRA-COCKPIT TIME & SOURCE	CONTENT	AIR-GROUND COMMUNICATIONS TIME & SOURCE	CONTENT
2054:23 CAM-1	Smell the rain		
2054:25 CAM-1	Smell it?		
2054:26 CAM-2	Yup, got lightning in it too		
		TWR	* winds are three two zero at two six peak gusts three six, north boundary winds two seven zero at one six, east boundary winds three one zero at eight south boundry winds two niner zero at two two
2054:34 CAM-1	It's going to get choppier than # here in a minute		
2054:35 CAM-2	Sure is		
		2054:40 542	* * five forty two going to departure
		2054:43 TWR	--- five forty two good day
2054:44 CAM-1	(Flaps down)	2054:44 542	And it's quite gusty, there about the rotate
2054:48 CAM-1	I'll betcha it is, it's right on on the end of the # runway	TWR	Roger

INTRA-COCKPIT

TIME & SOURCE	CONTENT
2055:02 CAM-1	Full flaps
2055:03 CAM-2	Out of a thousand
2055:04 CAM-1	Wipers on
2055:05 CAM-2	Here they go
2055:13 CAM-2	Approach lights in sight

AIR-GROUND COMMUNICATIONS

TIME & SOURCE	CONTENT
2054:50 RDO-2	Tower US Air one eighty three is with you for the right side
2054:53 TWR	US Air one eighty three Metro tower twenty one right cleared to land
2054:56 RDO-2	Cleared to land US Air one eighty three
2055:01 424	* * two four seven out for two one right
TWR	Four two four number two for twenty one right
2055:04 TWR	Wind check, centerfield wind three two zero at two seven east boundary wind three two zero at niner the north boundary wind two six zero at one three
2055:10 424	Four two four (copy)
2055:14 736	Northwest seven thirty six is inside the marker for the left one

INTRA-COCKPIT

TIME & SOURCE	CONTENT
2055:20 CAM-1	Rick you might have to stand by these spoilers when we get on the ground
2055:22 CAM-2	I'll stay right on top of 'em
2055:23 CAM-2	Okay
2055:34 CAM-2	Outta five hundred feet speed is plus fifteen fifteen
2055:36 CAM-2	Sinkin' eight no flags

AIR-GROUND COMMUNICATIONS

TIME & SOURCE	CONTENT
2055:18 TWR	Seven thirty six Metropolitan tower number two for twenty one right Frontier two fourteen advise on the ground
2055:26 736	Northwest seven thirty six understand two one left
2055:29 214	Frontier two fourteen going around ((Hetrodyne))
2055:31 TWR	Two Frontier two fourteen advise on the ground
2055:35 214	Two fourteen's going around

INTRA-COCKPIT

TIME & SOURCE	CONTENT
2055:40 CAM-2	Runway * * approach lights in sight
2055:59 CAM-1	Ask 'em if they got the runway lights on, I can't get a word in edgewise
CAM-2	All right
2056:05 CAM	((Sound of hail begins overriding all other audio))

AIR-GROUND COMMUNICATIONS

TIME & SOURCE	CONTENT
2055:37 TWR	Frontier two fourteen fly runway heading climb and maintain three thousand
2055:41 214	Frontier two fourteen runway heading up to three roger
2055:45 736	Northwest seven thirty six understand it's two one left
2055:48 TWR	Seven thirty six twenty one left cleared to land is that the approach that you're on
2055:53 736	Northwest Air seven thirty six we're on twenty one left
2055:56 TWR	Twenty one left Northwest seven thirty six cleared to land center field, wind three two zero at two eight peak gusts four zero correction forty two

INTRA-COCKPIT

TIME & SOURCE	CONTENT
2056:16 CAM	((Sound similar to middle marker))
CAM	((Sound of hail subsides))
2056:17 CAM	((Sound of ground proximity warning horn begins))
CAM-?	# #
2056:24 CAM-1	Down the gear, down the gear
2056:26 CAM	((Sound similar to stickshaker for one second))
CAM-1	Down the gear

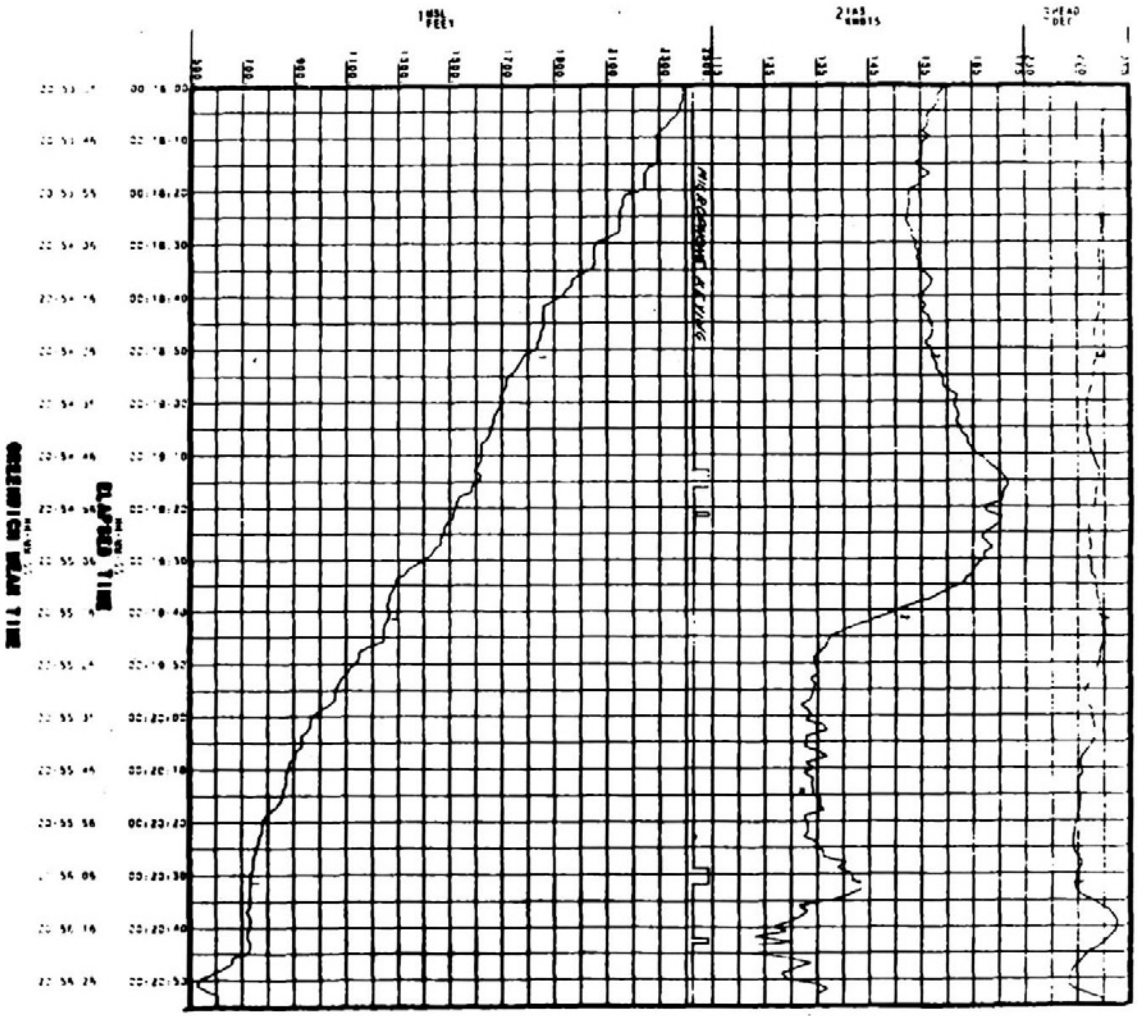
AIR-GROUND COMMUNICATIONS

TIME & SOURCE	CONTENT
2056:05 RDO-2	Tower US Air one eighty three turn the runway lights onto the left side please
2056:09 TWR	Frontier two fourteen contact departure one one eight point niner five
895	Eighteen ninety five so long
2056:19 592	Five ninety two with you on final for the left
2056:20 TWR	US Air one eighty three advise on the ground
2056:22 RDO-2	US Air one eighty three missed approach
2056:25 TWR	US Air one eighty three roger, fly heading two seven zero, climb and maintain three thousand

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
2056:28 CAM-1	Down		
2056:29 CAM	((Sound similar to impact))		
		2056:32 590	Republic five ninety two with you
		2056:35 TWR	Five ninety two number two for twenty one left
CAM-?	Oh #		
		2056:43 TWR	US Air one eighty three ——
CAM-?	(Let's get outta here)		
2056:47	((End of tape))		

APPENDIX E

READOUT OF FLIGHT DATA RECORDER



NATIONAL TRANSPORTATION SAFETY BOARD
BUREAU OF TECHNOLOGY
WASHINGTON, D. C.

LOCATION. DETROIT, MI
DATE . JUNE 13, 1984
AIRCRAFT. DC-9-30, N984
OPERATOR. USAIR
FLT. NO. 183

RECORDER M/N. SDC #FDR-FDUS
RECORDER S/N. 1309
IDENT. NO. DCA 84-A-A028
REPORT NO. 84-35

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