NATIONAL TRANSPORTATION SAFETY BOARD
Office of Aviation Safety
Washington, D.C. 20594

October 14,1999

Meteorology

Group Chairman Factual Report
by Donald E. Eick

DCA99MA060

A. ACCIDENT

Location:	Little Rock, Arkansas
Date:	June 1, 1999
Time:	2351 Central Daylight Time (0451Z June 2, 1999)
Aircraft:	American Airlines Flight 1420, McDonald-Douglas MD-82, N215AA

B. WEATHER GROUP

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C. SUMMARY

On June 1, 1999, at 2351 Central Daylight Time (CDT), a McDonnell Douglas MD-82, N215AA, operated by American Airlines as flight 1420, regularly scheduled passenger service from Dallas, Texas, overran the end of runway 4R and collided with the approach light stanchion at the Little Rock National Airport, in Little Rock, Arkansas. The captain and 10 passengers sustained fatal injuries; the remaining 134 passengers and crewmembers sustained various injuries. Shortly before the accident, the weather conditions at the airport were reported as: wind from 180 degrees at 9 knots, visibility 7 miles with thunderstorms, few clouds at 7,000 feet in cumulonimbus clouds, ceiling broken at 10,000 feet; temperature 77 degrees F, dew point 73 degrees F, altimeter 29.86 inches of mercury. Remarks; Automated Surface Observation System (ASOS) observation, thunderstorm began at 23 minutes after the hour, frequent lightning in-clouds and cloud-to-cloud, located from the west through the northwest, thunderstorms west through northwest moving northeast. The airplane was being operated in accordance with 14 CFR 121, and an instrument flight rules (IFR) flight plan had been filed.

D. DETAILS OF INVESTIGATION

The Meteorological Group was convened on June 3, 1999, and tasked with defining the environment that American Airlines Flight 1420 was operating in prior to and up to the time of the accident. The group was also tasked with documenting pertinent products, services, and actions of agencies and individuals involved in the accident. These included the Federal Aviation Administration (FAA), the National Weather Service (NWS), and American Airlines. During the investigation numerous individuals were interviewed. Data were collected from several data sources including the FAA, NWS, Global Atmospherics, Inc. and American Airlines. A Level II tape of the North Little Rock Weather Surveillance Radar 1988 Doppler (WSR-88D) was also obtained and numerous color products generated. Lightning data was obtained from Global Atmospherics, Inc, with strike polarity, azimuth and range mapped out at various ranges and time periods. Satellite imagery was generated on the Safety Board's Man Computer Interactive Data Access System (McIDAS) workstation.

All times used in the following report are based upon the 24-hour clock and are in Universal Coordinated Time (UTC), local Central Daylight Time (CDT) is +5 hours to UTC, and UTC=Z. Directions are relative to true north unless otherwise noted and distances in nautical miles. Visibility is reported in statute miles and fractions of statute miles. All heights are reported above mean sea level (msl) unless otherwise noted. Cloud heights in terminal weather forecasts and surface weather observations are reported in height above ground level (agl).

Part D - Details of the Investigation Index:

1.0 Synoptic Situation

The National Weather Service (NWS) Surface Analysis Chart at 0300Z on June 2, 1999 (attachment 1), issued from the NWS National Center for Environmental Prediction (NCEP) depicted a low pressure system in eastern Iowa with a central pressure of 1004 millibars (mb). A cold front stretched from the low from Iowa southwestward into eastern and southwestern Missouri, eastern and southern Oklahoma into northern Texas. The front then became stationary over northern Texas through the Texas panhandle and into New Mexico where another low pressure center was located. A squall line was also depicted ahead of the cold front, depicted from Lake Michigan southward across Illinois to just east of the boot heal of Missouri. The station model over Little Rock, Arkansas indicated a thunderstorm within sight of the station, but not at the station, southerly wind at approximately 10 knots, overcast skies, a temperature of 78 degrees Fahrenheit (F), a dew point temperature of 74 degrees F, and sea level pressure of 1010.3 millibars (mb).

The NWS Surface Analysis Chart at 0600Z (attachment 2), depicted the main low pressure system on the Illinois and Wisconsin border with the cold front across western Illinois southward into southeast Missouri and northern Arkansas and then southwestward across west central Arkansas, southeastern Oklahoma into north central Texas. The front then became stationary across Texas into New Mexico where it merged with a second low pressure system. The squall line earlier depicted was now presented as an outflow boundary extending from Michigan, eastern and southern Indiana, into southern Illinois. A second outflow boundary was depicted over Arkansas. The station model for Little Rock indicated winds were southeasterly at 10 knots, a thunderstorm with rain was occurring, broken sky conditions, a temperature of 68 degrees F, dew point of 64 degrees F with sea level pressure of 1012.6 mb.

The NWS Radar Summary Chart at 0435Z on June 2, 1999 (attachment 3) depicted severe thunderstorm watch number 357 across most of Arkansas, and extended into portions of northern Louisiana, northeast Texas, and eastern Oklahoma. Within the watch box was an area of thunderstorms with the maximum intensities reaching intense to extreme (NWS VIP Level 5 to 6) across central, eastern, and southern Arkansas. The maximum radar tops depicted within the area were reported from 53,000 to 57,000 feet.

The next issued Radar Summary Chart at 0535Z (attachment 4), included an embedded solid line[1] of thunderstorms with intensities intense to extreme within the severe thunderstorm watch box, with no change in intensity noted. Cell movement was provided as towards the east southeast at 20 knots. The

[1] A solid line is defined as a radar echo configuration having more than eight tenths coverage or more.

maximum tops were depicted at 51,000 feet.

The National Lightning Detection Network picture supplied by American Airlines Weather Services indicated 1,177 cloud-to-ground lightning strikes were recorded between 0445Z to 0500Z (attachment 5) on June 2, 1999, over the state of Arkansas.

The NWS 850 mb Constant Pressure Chart at 0000Z on June 2, 1999 (attachment 6), provided winds and temperatures at approximately 5,000 feet. The 850 mb chart depicted a low pressure center over Iowa. From the low a trough of low pressure extended to the south-southwest into south central Oklahoma. The contour lines over Arkansas were orientated in a northeast to southwest direction, with the +20 degree Celsius (C) isotherm perpendicular to the contours across Oklahoma and eastern Texas. The station model over central Arkansas depicted a southwest wind of 30 knots with warm air advection indicated. A temperature of 17 degrees C, with a temperature-dew point depression of 3 degrees C, height of 1,484 meters with no change in height in the last 12 hours.

The 700 mb Constant Pressure Chart at 0000Z on June 2, 1999 (attachment 7), provided approximate conditions at 10,000 feet. The chart depicted a low pressure center over Iowa, with a trough extending from the low southwest into west Texas. A second trough extended from the low in Iowa through central Arkansas into northern Louisiana. Winds were from the west-southwest at 25 to 40 knots in that trough. The station model over Arkansas indicated west-southwesterly winds of 35 knots, temperature 10 degrees C, a temperature-dew point depression of 16 C, a height of 3,123 meters, and a 10 meter height fall in the previous 12 hours.

The 500mb Constant Pressure Chart at 0000Z (attachment 8) provided conditions at approximately 18,000 feet. The main low pressure system was depicted over Iowa, with a trough of low pressure extending to the south depicted in the contour lines. The station model over Arkansas depicted westerly wind at 30 knots, temperature of -9 degrees C, a temperature-dew point depression greater than 29 degrees, a height of 5,820 meters, and a 10 meter height rise in the previous 12 hours.

The 300mb and 250mb Constant Pressure Charts for 0000Z (attachments 9 and 10) depict the conditions at approximately 30,000 and 34,000 feet respectively, indicating the presence of the jet stream.

An upper air plot of maximum winds based on the 0000Z sounding data on June 2, 1999 (attachment 11), and valid at 0100Z depicted the location of jet streams across North America. The strongest winds associated with the subtropical jet stream were located near the U.S.-Mexican border. There was a

slight jet maximum approaching Arkansas from Oklahoma and northern Texas. Winds with this maximum were 70 to 80 knots at 38,000 to 39,000 feet.

2.0 Surface Observations

Little Rock National Airport - Adams Field (KLIT), is located at N34°43'55" W92°12'57" at an elevation of 260 feet. It is situated immediately south of the Arkansas River, immediately north of Interstate 440 (I-440), and is along the eastern boundary of metropolitan Little Rock, Arkansas.

Weather observations are made by an Automated Surface Observation System (ASOS) which is augmented by certified weather observers. The ASOS location is near the mid field west of runway 4L and 22R. The augmentation and backup is performed by Federal Aviation Administration (FAA) contract with Met-Tech Inc., which maintains a station located on the 3rd floor of the main terminal.

The official weather observations during the period prior to and after the accident that were transmitted are included below (attachment 12).

Special weather observation for Little Rock at 0423Z, winds from 180 degrees at 09 knots, visibility 7 miles with thunderstorms, a few clouds at 7,000 feet in cumulonimbus clouds, ceiling broken at 10,000 feet, temperature 25 degrees C, dew point temperature 23 degrees C, altimeter 29.86 inches of mercury (Hg). Remarks: ASOS observation, thunderstorms began at 23 minutes past the hour, frequent lightning in-cloud and cloud-to-cloud located from the west through the northwest, thunderstorms west through northwest, moving northeast.

Hourly observation for Little Rock at 0453Z, wind from 280 degrees at 18 knots, gusting to 26 knots, visibility 1 mile in thunderstorm and heavy rain and mist, a few clouds at 3,700 feet with cumulonimbus clouds, ceiling overcast at 5,000 feet, temperature 19.4 degrees C, dew point 16.7 degrees C, altimeter 29.98 inches of Hg. Remarks: ASOS observation, peak wind from 290 degrees at 35 knots at 0433Z, wind shift at 0431Z, thunderstorms began at 0423Z, rain began at 0424Z, sea level pressure 1015.2 mb, frequent lightning in-cloud and cloud-to-cloud located west through northwest, occasional lightning in-cloud, cloud-to-cloud, and cloud-to-ground located east, thunderstorms east moving northeast, precipitation since last hourly report 0.55 inches.

Special observation for Little Rock at 0455Z, wind from 290 degrees at 13 knots gusting to 26 knots, visibility 3/4 of a mile in thunderstorm and heavy rain and mist. Ceiling broken at 1,500 feet, broken clouds at 3,500 feet, clouds overcast at 5,000 feet, temperature 19 degrees C, dew point 17

degrees C, altimeter 29.98 inches of Hg. Remarks: ASOS observation, pressure rising rapidly, precipitation since the last hourly report 0.21 inches.

Special observation for Little Rock at 0458Z, wind from 290 degrees at 10 knots gusting to 76 knots, winds varying from 210 degrees to 030 degrees, visibility 1/2 mile in thunderstorm, small hail, heavy rain, and mist. Ceiling broken at 1,200 feet in cumulonimbus clouds, broken clouds at 3,500 feet, overcast at 5,000 feet, temperature 20 degrees C, dew point 15 degrees C, altimeter 29.95 inches of Hg. Remarks: ASOS observation, peak wind from 320 degrees at 76 knots at 0456Z, small hail began at 0458Z, precipitation since the last hourly report 0.61 inches.

On May 21, 1999, a NWS Station Inspection Report was filed by Jimmy Russell who preformed a complete inspection of the Little Rock ASOS augmentation program. The inspection provided an excellent rating, and found no deficiencies (attachment 13).

3.0 Weather Surveillance Radar Data

The Weather Surveillance Radar-1988, Doppler (WSR-88D) is located at North Little Rock (KLZK), located on the 352 degree azimuth at 6 miles from the geographic center of Little Rock Adams Field. The distance to the touchdown zone of runway 04R was approximately 7 miles from the radar site. The Level II[2] archive tape of the radar products was obtained from the NWS National Climatic Data Center (NCDC) located in Asheville, North Carolina and displayed on a Hewlett-Packard X-Station utilizing the Motif Interactive Radar Analysis Software (Motif-IRAS[3]) and the WSR-88D Algorithm Testing And Display System (WATADS) software packages.

3.0.1 Beam Height Calculations

Assuming standard refraction[4] of the 0.95 degree radar beam of the WSR-88D, the following table shows the approximate beam height and width information that the radar would be displaying over the Little Rock Airport for the five lowest antenna angles.

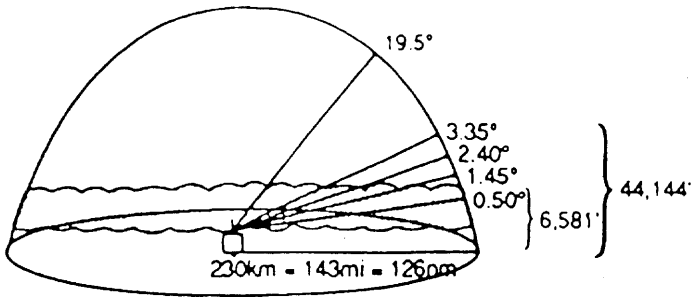
[2] Level II data are digital based data output from the WSR-88D Radar Data Acquisition (RDA).
[3] Motif-IRAS reference: Priegnitz, D.L., 1995: IRAS: Software to display and analyze WSR-88D radar data, Eleventh International Conference on Interactive Information and Processing for Meteorology, Oceanography, and Hydrology, Boston, MA, American Meteorological Society, 197-199.
[4] Standard Refraction in the atmosphere is when the temperature and humidity distributions are approximately average.

Antenna Elevation	Beam Width	Center of Beam	Top of Beam	Bottom of Beam
0.4 degrees	705 feet	978 feet	1,331 feet	624 feet
1.5 degrees	705 feet	1,795 feet	2,147 feet	1,442 feet
2.4 degrees	705 feet	2,463 feet	2,815 feet	2,110 feet
3.3 degrees	705 feet	3,130 feet	3,482 feet	2,777 feet
4.3 degrees	705 feet	3,870 feet	4,223 feet	3,518 feet

3.0.2 Volume Scan Strategy

The WSR-88D is a computer controlled radar system, which automatically creates a complete series of specific scans in a specific sequence known as a volume scan. Individual elevation scans are immediately available on the NWS Principle Users Processor (PUP). Products that require data from multiple elevation scans are not available until the end of the six minute volume scan.

The WSR-88D operates in several different scanning modes, identified as Mode A and Mode B. Mode A is the precipitation scan and has two common scanning strategies. The most common is where the radar makes 9 elevation scans from 0.50 degrees to 19.5 degrees every six minutes (see illustration below). This particular scanning strategy is documented as volume coverage pattern 21 (VCP-21). Mode B is the clear air mode, where the radar makes 5 elevation scans during a ten minute period. During the period of the accident the North Little Rock WSR-88D radar was operating in the precipitation Mode A.



Precipitation mode volume scan

3.0.3 Reflectivity

Reflectivity is the measure of the efficiency of a target in intercepting and returning radio energy. With hydrometers[5] it is a function of the drop size

[5] Hydrometers are any product of condensation or sublimation of atmospheric water vapor,

distribution, number of particles per unit volume, physical state (ice or water), shape, and aspect.

Reflectivity is normally displayed in decibels (dBZ), and is a general measure of echo intensity. The chart below relates the NWS video integrator and processor (VIP) intensity levels which were originally developed for the WSR-57 radar versus the WSR-88D's display levels, precipitation mode reflectivity in decibels (dBZ), and convective rainfall rates.

NWS VIP/DBZ CONVERSION TABLE

NWS VIP	WSR-88D LVL	PREC MODE DBZ	RAINFALL
0	0 1 2	< 5 5 to 9 10 to 14	
1 Very Light	3 4 5	15 to 19 20 to 24 25 to 29	.01 in/hr .02 in/hr .04 in/hr
2 Light to Moderate	6 7	30 to 34 35 to 39	.09 in/hr .21 in/hr
3 Strong	8	40 to 44	.48 in/hr
4 Very Strong	9	45 to 49	1.10 in/hr
5 Intense	10	50 to 54	2.49 in/hr
6 Extreme	11 12 13 14 15	55 to 59 60 to 64 65 to 69 70 to 74 > 75	> 5.67 in/hr

whether formed in the free atmosphere or at the earth's surface; also, any water particles blown by the wind from the earth's surface. Hydrometers can be classified as; (a) liquid or solid water particles suspended in the air: cloud, water droplets, mist or fog. (b) Liquid precipitation: drizzle and rain. (c) Freezing precipitation: freezing drizzle and freezing rain. (d) solid (frozen) precipitation: ice pellets, hail, snow, snow pellets, and ice crystals. (e) Falling particles that evaporate before reaching the ground: virga. (f) Liquid or solid water particles lifted by the wind from the earth's surface: drifting snow, blowing snow, blowing spray. (g) Liquid or solid deposits on exposed objects: dew, frost, rime, and glaze ice.

3.04 Composite Reflectivity

The composite reflectivity product is created by taking the highest reflectivity from each of the vertical elevation scans. Since the product is a composite of all the scans it is created near the end of the sequence. This product is also used by several NEXRAD[6] Information Dissemination System (NIDS) vendors to create national and regional radar mosaics, on which air carriers System Operational Control (SOC), including dispatch and meteorology offices use to make operational decisions. The grid resolution of the composite reflectivity image is 1 X 1 kilometer (km), or .54 X .54 nautical miles.

The composite reflectivity images included (attachment 14) are a Plan-Position Indicator (PPI) radar product at 8X magnification, set on a 124 mile radius around the radar site. The 0445Z image depicts a northeast to southwest oriented band of weather with several large areas with reflectivities greater than 54 dBZ, or Level 6 extreme activity. The area encompasses the Little Rock Airport already by this time. The geographical center of the airport is marked by an arbitrary runway symbol, which is not the actual Little Rock-Adams Field configuration. Reflectivities over the airport range from 50 to 64 dBZ, or NWS VIP levels 5 to 6. The maximum reflectivity of 65 dBZ is located 2 1/2 miles west northwest of the airport.

The 0451Z composite reflectivity image (attachment 15) continues to depict the large area surrounding the airport, and a general shift southeastward of the activity. Reflectivities over the airport range from 50 to 64 dBZ, NWS VIP level 5 to 6 activity. The maximum reflectivity of 70 dBZ is located east northeast of the airport.

At 0457Z the composite reflectivity image (attachment 16) has the main area of weather moving over the Little Rock-Adams Field. Reflectivities of 50 to 60 dBZ cover the airport, or VIP level 5 to 6 intense to extreme activity. The maximum reflectivities of 72 dBZ are located east northeast.

3.0.5 Base Reflectivity

The base reflectivity images are PPI depictions of the individual elevation scans, with reflectivities in decibels. The resolution is provided at 1° X 1 km,

[6] NEXRAD - Next generation of weather radar, now more commonly known as the WSR-88D.

and are included in this report at 8X magnification. A color scale is found on each image depicting a range of reflectivity from ND (no data) to 75 dBZ. The NTAP flight track, NWS identifiers, and a grid over the geographic center of the airport have also been overlaid on the images.

Attachment 17 is the base reflectivity at 0.4 degree elevation for the nominal time period of 0445:51Z to 0451:33Z, the radar completed its scan at this elevation at 0445:57Z. Runway 4R is located approximately 7 miles from the radar site, which would put the center of the WSR-88D radar beam at approximately 978 feet. At 0445Z American Airlines flight 1420 is heading westward between two areas of weather, with one of the cells moving across the airport and the approach path to runway 4R. The reflectivity of the area moving across the airport reaches 54 dBZ or VIP level 5 intense activity. The area approaching the airport reaches reflectivities of 61.5 dBZ or VIP level 6 extreme at approximately 5 miles from runway 4R.

Attachment 18 is the base reflectivity image at 0.4 degree elevation for the nominal time period of 0451:41Z to 0457:22Z, with the radar completing this elevation scan at this elevation at 0451:59Z. The image shows the track of American Airlines flight 1420 penetrating the area of weather with reflectivities reaching a maximum of 52 dBZ, or NWS level 5 intense activity. The maximum reflectivity of 60.0 dBZ or VIP Level 6 is located 1 1/2 miles to the northwest.

At 1.5 degrees elevation (attachment 19), the height of the center of the radar beam is at approximately 1,800 feet. The radar interrogated the area at 0453:03Z. The returns along the flight track reaching 58.0 dBZ or Level 6 extreme activity, with the maximum reflectivity of 62.5 dBZ at a distance of 1/2 mile from the runway.

At 2.4 degrees elevation (attachment 20), the center of the radar beam is at approximately 2,500 feet. The interrogated time was 0454:06Z at this elevation scan. The returns along the track reach 58.5 dBZ, with the maximum reflectivity of 62.5 dBZ within 1/2 mile.

At 3.3 degrees elevation (attachment 21), the center of the radar beam is at approximately 3,100 feet. The time of the image is at 0454:38Z. Along the flight track the returns reach 58 dBZ, with an elongated area greater than 60 dBZ less than 1/2 mile ahead and to the northwest of the track.

Attachment 22 is a four panel base reflectivity with elevation angles of 0.4, 1.5, 2.4, and 3.3 degrees for the same time period, 0451:41Z to 0457:20Z, with the NTAP flight track, grid, and NWS identifiers overlaid.

Attachment 23 is the 0.4 degree elevation for the nominal period of 0457:30Z to 0503:12Z, with the radar completing this elevation scan at 0458:00Z. The

main area of weather is over the airport and runway 4R with reflectivities of 61.0 dBZ, or VIP level 6 extreme intensity.

A time series of the line of thunderstorms moving across the region is included as attachment 24, figures A through I. The images are at 0.4 degree elevation scan at 2X magnification. The time series is for the nominal time from 0410:53Z through 0503:12Z on June 2, 1999.

3.0.6 Radial Velocity

Radial velocity is a measure of the radial component of the wind either towards (negative values) or away from the radar (positive values).

The following radial velocity products are at 8X magnification, with the same overlays as depicted with the base reflectivity images. The antenna elevation angles are 0.4 degrees. A color bar on the bottom indicates the radial velocity values from -30 to 30 meters per second (mps).

Attachment 25 is the radial velocity image for the nominal time period of 0445:51Z to 0451:33Z, with this scan taken at 0446:29Z. At the center beam altitude of approximately 980 feet, winds from the northwest at 15 mps or approximately 30 knots are indicated over the runway. At approximately 2 to 3 miles north of runway 4R and 3 miles east, two velocity couplets are indicated. Another velocity couplet is also indicated 5 miles east northeast.

Attachment 26 covers the period from 0451:41Z - 0457:22Z, with the volume scan for radial velocity completed at 0452:30Z. The radial velocity wind speed indicated at that time over runway 4R indicate winds of 18 mps (36 knots). Within 1/2 mile the winds reach 30 mps (60 knots). To the east northeast of the airport at 5 miles another velocity couplet is observed.

Attachment 27 covers the period from 0457:30Z to 0503:12Z, with the volume scan completed at 0458:32Z. The radial velocity of winds of 5 to 10 mps (10-20 knots) were indicated over the runway. A velocity couplet was located less than 1 mile southeast of the flight track.

A four panel radial velocity image with time periods of 0440Z, 0445Z, 0451Z, and 0457Z on June 2, 1999 is included as attachment 28. The four panel chart is present with a 8X magnification, with the units in knots along the right margin.

3.0.7 Velocity Azimuth Display Wind Profile (VWP)

The velocity azimuth display wind profile (VWP) provides a vertical depiction of wind speed and direction above the radar site. Attachment 29 is the VWP display from 0353Z to 0451Z. At 0451Z the winds at 2,000 feet were southeasterly at 30 knots, with the maximum winds observed at 3,000 feet from 281 degrees at 44 knots. Winds remained westerly with increasing altitude.

3.0.8 Combined Shear

The combined shear product on the WSR-88D has provided useful in detecting severe weather events, such as mesocyclones and tornadoes. Thresholds values of 80 units of combined shear are an indication of storm intensification.

Attachment 30 is a four panel combined shear product at 0440Z, 0445Z, 0451Z, and 0457Z on June 2, 1999, which was produced by the North Little Rock NWS Forecast Office. The 1.5 degree elevation scan is utilized in the creation of this product. The combined shear product at 0440Z indicated values in the 80 unit range south of the Little Rock-Adams Field. By 0445Z the values of 90 units are observed 6 miles south southeast of the airport, and 5 miles to the northwest values of 50 units are observed. At 0451Z, values of combined shear of 70 units or greater are observed north, south, and southeast of the airport. At 0457Z, the airport is impacted with values of 70 units.

4.0 Lightning Data

As previously discussed in the synoptic setting above, the American Airlines display of the National Lightning Detection Network depicted 1,177 lightning strikes between 0445Z and 0500Z over the state of Arkansas. In order to obtain bearing and distances of the lightning strikes to the Little Rock Airport, Global Atmospherics, Incorporated “STRIKEFax” Lightning Verification Reports were obtained and documented. Global Atmospherics, Inc. operates the only officially recognized National Lightning Detection Network (NLDN), and is American Airline’s source for obtaining their lightning data.

Within 20 miles of the geometric center of the Little Rock Airport the NLDN detected 903 cloud-to-ground lightning strikes between 0436Z and 0451Z (attachment 31). A cluster of lightning strikes is noted occurring from west through northeast of the airport, with the tightest cluster to the north-northeast between 12 and 18 miles. The plot is reported with a median accuracy of 500 meters or approximately 1/4 mile. The attachment also provides details of the lightning strikes including the time, coordinates, amperage, polarity, bearing and range from the Little Rock Airport.

Within 5 miles the NLDN detected 46 cloud-to-ground lightning strikes between 0446Z to 0451Z (attachment 32).

5.0 Upper Air Data

The 0000Z upper air sounding from North Little Rock (KLZK) on June 2, 1999, hodograph, and observed sounding parameters are included as attachment 33. The wind information from the sounding provided the following:

Height (ft)	Wind direction	Wind Speed (kts)
1,000	191	14
2,000	210	20
3,000	231	24
4,000	241	27
6,000	264	20
7,000	270	21
8,000	274	25
9,000	273	26
12,000	267	27
14,000	260	24
16,000	252	22
20,000	246	21

The convective potential provided the following indices based upon the sounding:

Lifted Index	- 8
Showalter Index	- 3
K-Index	25
Total Totals Index	51
Sweat Index	426
CAPE[7] above the inversion	3,062 J/Kg.
Cap[8] strength	1.1° C

[7] CAPE - Convective Available Potential Energy. A measure of the amount of energy available for convection, reported in joules per kilogram (j/kg). CAPE is directly related to the maximum potential vertical speed within an updraft.

[8] Cap - capping inversion, a layer of relatively warm air aloft which suppresses or delays the development of thunderstorms. Air parcels rising to this layer become cooler than the surrounding air, which inhibits their ability to rise further. As such, the cap often prevents or delays thunderstorm development even in the case of extreme instability. However, once the cap is removed or weakened, then explosive thunderstorm development can occur.

Height of LFC[9]	873 mb, 3,851 feet
Height of tropopause	52,100 feet with temperature of -68.1° C
Height of equilibrium level	40,800 feet
Freezing level	14,304 feet
Storm Motion	259° 25 knots
Energy/Helicity Index	2.79
SR Helicity	177 (M/S)2

6.0 Low-Level Wind-shear Alert System (LLWAS)

The Little Rock-Adams Field Airport was equipped with a FAA Type FA-10240 Low Level Wind Shear Alert System (LLWAS), or often referred to as a LLWAS-2 system which was operational at the time of the accident. The Little Rock LLWAS had on March 29, 1999, completed a pole relocation and replacement, with electronic and software upgrades.

The Little Rock LLWAS consists of six wind sensor remote stations, each located strategically around the airport property. The location of the Little Rock sensors are as follows: the center-field or sensor 1, is located east of the approach end of 22R midway between runways 22R-4L and 22L-4R at a height of 70 feet agl; sensor 2 is north of the airport and the center-field wind sensor at a height of 140 feet agl; sensor 3 is located northeast of the airport off 4R-22L at a height of 150 feet agl; sensor 4 is located south of the airport in Genevia, sensor 4 is for aircraft approaching runway 4R at a height of 120 feet agl; sensor 5 is also located south of the airport off Interstate highway 440, between the approach to 4L and 4R at a height of 120 feet agl; sensor 6 is located northwest of the airport at a height of 150 feet agl. The configuration of the system and latitude and longitude of the sensors is included as attachment 34.

Sensor	Identifier	Coordinates and Sensor Height (agl)
1	C	N34°43'54" W92°12'57" 70 ft
2	N	N34°45'09" W92°12'53" 140 ft
3	NE	N34°44'16" W92°11'00" 150 ft
4	*	N34°42'27" W92°13'25" 120 ft
5	S	N34°43'00" W92°14'07" 120 ft
6	NW	N34°44'45" W92°15'02" 150 ft

* sensor 4 is hidden and not identified on the tower cab display

[9] LFC - Level of Free Convection.

Each remote station collects wind speed and direction data at its location and transmits the data back to the master station or center-field station. Besides collecting wind speed and direction data, the center-field station also provides gust data. This data is displayed in the Air Traffic Control Tower (ATCT). The Little Rock LLWAS Tower display is depicted as attachment 35, with the display as what was recorded at 0455:00Z on June 2, 1999. The display provides wind information at five sensors and the center-field average, for a total of six sensor readings. The top display is the 2-minute center-field average (CFA) and the gust value and is used by ATC as a source of wind information for departing and landing aircraft. The second line is the 10-second or instantaneous center-field reading. Line 3 displays the information from the north sensor; line 4 the northeast sensor; line 5 the south sensor; line 6 the northwest sensor data. In normal operation, only the center-field average and gust value will be highlighted, with the boundary sensors toggled on or off as desired by the controller or when a wind shear alert occurs. The wind shear alert will also be accompanied by an audible alert to the controller.

The ATC instructions on the LLWAS are located in 7110.65L "Air Traffic Control Handbook", and provides instruction on how the controller should provide wind shear alerts to the pilot. Attachment 36 shows the phrases to be used.

The LLWAS information recorded on the night of the accident are presented in attachment 37, and provides the center-field wind average, gusts factor, and the five boundary wind sensor data. Wind shear alerts[10] are noted by an asterisk. The fourth sensor is hidden and is not depicted on the attachment 31, but is utilized in the center-field wind average. The time of the LLWAS data is from 04:41:00Z to 04:57:30Z June 2, 1999, at 10-second intervals. A pictorial representation of the LLWAS data is also included from 0448:40Z to 0454:50Z.

The current LLWAS algorithm[11] (attachment 38) utilizes edge and triangle alarms, which are dependent on the geometry of the six sensors. The LLWAS system no longer issues alerts based solely on vectoral differences between any remote station and the center field. The algorithm uses a combination of network means (NMN) and divergence detection methods (TED) whose thresholds are variably set to reflect the geometric properties of each triangulation element (triangle and edge), to obtain a high microburst detection probability without incurring an unacceptable false alarm ratio. The algorithm also uses data smoothing to reduce short term random variations in the measured data. This filtering reduces the noise level of the data by a

[10] Wind Shear Alerts - It should be noted that the LLWAS issues wind shear alerts, not strong wind alerts. Strong winds in themselves are not an indication of wind shear.

[11] The current LLWAS Algorithm is defined in the report by F. Wesley Wilson, Jr. and Larry B. Cornman, Six Station LLWAS Wind Shear Detection Algorithm Preliminary Report, the National Center for Atmospheric Research, Boulder Colorado, June 4, 1987, revised November 20, 1987.

multiplicative factor. The current LLWAS is estimated at having a detection probability[12] of 80% with a false alarm ratio of 10% to 20%.

A Sensor Performance Evaluation (SPE) was requested after the accident to ensure the reliability of the data from the system. The SPE analysis took the Little Rock archive data based on a twenty-day sample from May 15 to June 2, 1999 (attachment 39). The SPE analysis determined that all of the LLWAS remote sensors were working properly at the time of the accident. The FAA LLWAS Program Office reports that the current system provides optimum wind shear protection for Runways 4R-22L for a six-sensor LLWAS. Seven of the ten computational "triangles" used by the LLWAS algorithm provide coverage to Runways 4R-22L. In addition, nine of the fourteen computational "edges" provide coverage to this runway.

7.0 Automated Surface Observation System (ASOS)

The ASOS system continuously monitors the weather conditions and depending on specific criteria will issue a special report (SPECI), however, between 47:20 and 53:20 after the hour, the system is locked out from issuing any reports. ASOS editing was also discussed in that special care and monitoring is required as the system may remove the earlier reported data. The 5-minute ASOS observations are not being transmitted and are therefore not "official observations" according to NWS Federal Meteorological Handbook Number 1 (FMH1). The 5-minute ASOS observation that was recorded on the system at the time of the accident was as follows:

Little Rock 5-minute ASOS weather observation at 0450:31Z, winds from 290 degrees at 16 knots gusting to 28 knots, visibility 1 1/2 miles in thunderstorm and heavy rain and mist, a few clouds at 3,700 feet, ceiling overcast 5,000 feet, temperature 18.9 degrees C, dew point 16.7 degrees C, altimeter 29.94 inches of hg. Remarks: ASOS observation, peak wind from 290 degrees at 35 knots at 0433Z, wind shift at 0431Z, thunderstorm began at 0423Z, rain began at 0424Z, sea level pressure 1014.0 mb, frequent lightning in-cloud, and cloud-to-cloud, west through northwest, occasional lightning in-cloud, cloud-to-cloud, and cloud-to-ground east, thunderstorm west through northwest, thunderstorm east moving east, precipitation since last hourly observation 0.37 inches.

The ASOS system provided the following 1-minute and 15-minute precipitation measurements.

[12] Detection Probability reported in "Six Station LLWAS Wind Shear Detection Algorithm Preliminary Report", by F. Wesley Wilson and Larry B. Cornman, NCAR, June 4, 1987.

ASOS WIND INFORMATION/ PRECIPITATION AMOUNTS

	Time	2-min	5-sec Gust	1-min PRECIP	15-min PRECIP
	0430Z	203° 08kt	244° 09kt	.00	T
	0431Z	241° 11	274° 20	.00	
	0432Z	273° 19	278° 29	.00	
	0433Z	291° 25	295° 35	.00	
	0434Z	298° 27	290° 33	T	
	0435Z	298° 26	289° 27	T	
	0436Z	289° 21	281° 25	.01	
	0437Z	286° 15	285° 18	.00	
	0438Z	304° 17	318° 18	.01	
	0439Z	320° 17	336° 20	.02	
	0440Z	320° 17	336° 20	.01	
	0441Z	338° 17	333° 22	.01	
	0442Z	351° 18	356° 27	.01	
	0443Z	359° 21	360° 28	.02	
	0444Z	352° 20	357° 20	.02	
	0445Z	320° 17	336° 20	.03	0.14
	0446Z	322° 14	333° 16	.03	
	0447Z	328° 15	329° 26	.06	
	0448Z	314° 14	283° 11	.07	
	0449Z	296° 12	291° 20	.03	
	0450Z	285° 16	302° 22	.04	
#	0451Z	281° 18	291° 21	.04	Accident time
	0452Z	284° 19	287° 24	.06	
	0453Z	281° 18	287° 21	.08	
	0454Z	277° 14	264° 14	.13	
	0455Z	287° 13	296° 18	.08	
	0456Z	299° 23	**317° 76**	.15	
	0457Z	308° 20	281° 16	.14	
	0458Z	291° 10	241° 21	.11	
	0459Z	297° 09	012° 08	.05	
	0500Z	358° 09	023° 14	.02	1.09

Notes: 0436Z was the first ASOS indication of any measurable precipitation greater than trace amounts (trace defines less than 0.01 inches) prior to the accident. The time of the accident is noted by "#" symbol.

The ASOS system is maintained by the NWS and is continually being monitored for quality control and system status. The NWS Electronic Systems

Analyst was contacted and the system inspected. The basic ASOS system has a routine maintenance program with service checks scheduled monthly, quarterly, semiannually and annually. On Wednesday June 3, 1999, the technician was contacted for a problem that was reported with the ceilometer. On June 4, 1999, the technician inspected, cleaned, and calibrated the ceilometer. The calibration showed all parameters to be well in tolerance and the system returned to operational status. The NWS technician provided a statement of his findings (attachment 40).

The reliability of the ASOS wind anemometer was examined and was determined to have a low failure rate and is rated for 120 knot winds. The anemometer undergoes a preventive maintenance inspection every six months. The last inspection was in April 1999.

8.0 Satellite Imagery

Geostationary Operations Environmental Satellite number 8 (GOES-8) imagery was displayed on the National Transportation Safety Board's Man Computer Interactive Data Access System (McIDAS) workstation. The satellite imagery indicated the following cloud features:

The GOES-8 infrared image (band 4) with a four kilometer resolution were documented from 0402Z through 0502Z on June 2, 1999, at approximately 15 minute intervals. A color enhancement curve was applied to accent the higher and colder cloud tops associated with the cumulonimbus clouds, and white squares indicate Dallas-Fort Worth and Little Rock-Adams Field airports. Attachment 41 is the 0402Z infrared image and displays several large convective complexes, one to the southwest of the Dallas-Fort Worth area and the second over northeast Texas, southeast Oklahoma, and western to central Arkansas. The planned route of American Airlines 1420 is between these two convective complexes.

Attachment 42 is the 0445Z infrared image, and attachment 43 is the 0502Z infrared image with the same magnification.

Attachment 44 is the infrared satellite image at 0445Z on June 2, 1999, with a magnification of 4X, the enhanced cloud tops of the convective complex over Arkansas is located west of Little Rock at this time period. The radiative temperatures observed over Little Rock (in yellow area) was 214.7 degrees Kelvin (K) or -58.5 degrees C. Based upon the 0000Z sounding from North Little Rock (KLZK) this would put clouds tops at 40,000 feet. The blue area to the north and west of Little Rock had a radiative temperature as low as 205.4 degrees K or -65.3 degrees C, or cloud tops of 50,000 feet.

Attachment 45 is the infrared satellite image at 0502Z on June 2, 1999, (4X magnification) the enhanced cloud tops are over the Little Rock area by this time. The radiative temperature over Little Rock was observed at 210.7 degrees K or -62.46 degrees C, which relates with clouds tops of approximately 48,000 feet. The statistical analysis of radiative temperatures provided the following data:

Minimum	207.9° K	-65.26° C
Maximum	215.8° K	-57.36° C
Mean	213.4° K	-59.76° C
Standard Deviation	2.040	
Tropopause	110 mb	-68.1° C

The moisture channel or band 3 imagery with a wavelength of 6.8 microns was also examined. Attachment 46 is the moisture channel image at 0502Z on June 2, 1999. Little Rock and Dallas-Fort Worth are indicated by blue squares.

9.0 Terminal Aerodrome Forecast (TAF)

The NWS Forecast Office in North Little Rock issued the following Terminal Aerodrome Forecast (TAF) at 2330Z on June 1, 1999. The TAF was valid for a 24-hour period beginning at 0000Z June 2, 1999, until 0000Z the following day. Forecast for Little Rock Airport beginning at 0000Z, winds from 180 degrees at 15 knots gusting to 25 knots, visibility greater than 6 miles, ceiling broken at 8,000 feet. Temporary condition between 0000Z and 0400Z of visibility 5 miles in thunderstorms, light rain, and mist ceiling overcast at 3,000 feet in cumulonimbus clouds. From 0400Z winds from 230 degrees at 12 knots gusting to 20 knots, visibility greater than 6 miles, scattered clouds at 1,500 feet, ceiling overcast at 3,500 feet. Temporarily between 0400Z and 0800Z winds variable at 25 knots gusting to 40 knots, visibility 3 miles in thunderstorms, light rain and mist, ceiling broken at 1,500 feet in cumulonimbus clouds. From 0800Z, winds forecasted from 230 degrees at 10 knots, visibility greater than 6 miles, scattered clouds at 1,500 feet, ceiling overcast at 3,500 feet. Temporarily between 0800Z and 1200Z, visibility 3 miles in mist, ceiling broken at 1,500 feet and broken clouds at 4,000 feet. From 1200Z, winds forecasted at 230 degrees at 5 knots, visibility greater than 6 miles, scattered clouds at 2,000 feet, scattered clouds at 4,000 feet. Temporarily between 1200Z and 1400Z, visibility 3 miles in mist. From 1800Z, winds from 270 degrees at 6 knots, visibility greater than 6 miles, scattered clouds at 4,000 feet, scattered clouds at 25,000 feet.

The forecast was amended at 0358Z, and valid from 0400Z until 2400Z on June 2, 1999. Beginning at 0400Z, winds forecasted from 200 degrees at 12 knots gusting to 20 knots, visibility greater than 6 miles, scattered clouds at

2,500 feet, ceiling overcast at 6,000 feet. Temporary condition between 0400Z to 0600Z, winds variable at 25 knots gusting to 40 knots, visibility 1 mile in thunderstorm, heavy rain and mist, ceiling overcast at 1,500 feet in cumulonimbus clouds. The forecast from 0800Z through 2400Z was unchanged from above.

10.0 In-Flight Weather Advisories

The NWS had two In-Flight Weather Advisories[13] current during the time surrounding the accident (attachment 47). Both advisories were issued for severe thunderstorms, one in the form of a Convective SIGMET (WST) and the other a Severe Weather Watch (AWW).

The NWS Aviation Weather Center located in Kansas City, Missouri issued Convective SIGMET 15C at 0355Z which was valid until 0555Z on June 2, 1999. The area encompassed sections of Arkansas and Oklahoma. The area was enclosed by the points 40 miles east of Razorback VOR, AR (RZC) to 30 miles southeast of Little Rock (LIT) to 10 miles north northwest of El Dorado, AR (ELD) to 70 miles south of McAlester, OK (MLC) then back to 40 miles east of Razorback (RZC). The SIGMET was issued for an area of severe thunderstorms[14] moving from 320 degrees at 20 knots, with tops above 45,000 feet. Hail to 2 inches, and wind gusts to 70 knots were possible. A Convective SIGMET implies severe or greater turbulence and microburst[15]/windshear.

American Airlines flight 1420 received the information contained in the Convective SIGMET 15C from the Fort Worth Air Route Traffic Control Center (ARTCC) at 0401Z and at 0404Z on its issuance and were advised that Hazardous In-flight Weather Advisory Service (HIWAS) had further information in its broadcast.

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[13] The NWS issues inflight weather advisories designated as Severe Weather Forecast Alerts (AWW's), Convective SIGMET's (WST's), SIGMET's (WS's), Center Weather Advisories (CWA's), and AIRMET's (WA's). Inflight advisories serve to notify en route pilots of the possibility of encountering hazardous flying conditions which may not have been forecast at the time of the preflight briefing. Whether or not the condition described is potentially hazardous to a particular flight is for the pilot and/or aircraft dispatcher in a FAR Part 121 operation to evaluate on the basis of experience and the operational limits of the aircraft.

[14] Severe thunderstorm - A thunderstorm with winds measuring 50 knots (58 mph) or greater, 3/4 inch hail or larger, or tornadoes. Severe thunderstorms may also produce torrential rain and frequent lightning.

[15] Microburst - A severe localized wind blasting down from a thunderstorm. It covers an area less than 2.5 miles (4 kilometers) in diameter and is of short duration, usually less than 5 minutes.

The NWS Storm Prediction Center located in Norman, Oklahoma issued Severe Weather Forecast Alert (AWW) number 357 at 0223Z on June 2, 1999, for severe thunderstorms. The watch covered portions of northern Texas, northwest Louisiana, Arkansas, and southeast Oklahoma and was valid until 0800Z. The severe thunderstorm watch extended from 105 miles east and west to a line from 20 miles west southwest of Shreveport, Louisiana, to 25 miles east northeast of Harrison, Arkansas. The advisory was issued for a few severe thunderstorms with hail to 2 inches, extreme turbulence, and surface wind gusts to 70 knots. A few cumulonimbus with maximum tops to 50,000 feet, with a mean storm motion from 280 degrees at 20 knots. A brief of severe weather watch number 357 was in American Airlines flight 1420 weather document (see section 12.0 Preflight Weather Package).

In the technical discussion of the meteorological parameters and reasons on why Weather Watch (WW) 357 was being issued by the NWS Storm Prediction Center, the bulletin referred to a few severe thunderstorms may continue into early tonight in the unstable air mass. The bulletin advised that although supercells[16] were possible, large hail and damaging winds appeared to be the main threat.

At 0559Z the NWS Storm Prediction Center issued Weather Watch number 358 for northern Mississippi and southeastern Arkansas. The technical discussion referred to the evolving Bow Echo[17] over southeastern Arkansas moving eastward into northern Mississippi as the main threat for severe weather. The advisory mentioned that the moderate instability[18], abundant low level moisture, and dry intrusion aloft indicated the continued threat of damaging winds.

[16] Supercell - A severe thunderstorm characterized by a rotating, long-lived, intense updraft. Although not very common, they produce a relatively large amount of severe weather, in particular, extreme large hail, damaging straight-line winds, and practically all violent tornadoes.

[17] Bow Echo - A radar echo which is linear but bent outward in a bow shape (Fig. 1 - Attachment 47). Damaging straight-line winds often occur near the "crest" or center of a bow echo. Areas of circulation also can develop at either end of a bow echo, which sometimes can lead to tornado formation - especially in the left (usually northern) end, where the circulation exhibits cyclonic rotation.

[18] Instability - The tendency for air parcels to accelerate when they are displaced from their original position; especially, the tendency to accelerate upward after being lifted. Instability is a prerequisite for severe weather - the greater the instability, the greater the potential for severe thunderstorms. Often reported in by Lifted Indices.

11.0 Public Weather Warnings

At 0256Z the North Little Rock NWS Forecast Office issued a severe thunderstorm warning for Saline, Pulaski, and Grant Counties in central Arkansas. This included the Little Rock - Adams Field Airport. The warning was valid until 0345Z. The warning indicated that at 0246Z a line of strong to severe thunderstorms extended from 10 miles east of Sheridan to near Haskell, Arkansas. The line was moving northeast at 30 miles per hour. The main threat in the warning area was for strong damaging winds, which may occur downing trees, or tree limbs and power lines. The warning also warned of the potential for hail and for parties to seek shelter indoors.

A second warning was issued by the North Little Rock NWS Forecast Office at 0417Z on June 2, 1999. The severe thunderstorm warning was issued for Pulaski County, Arkansas, which includes the Little Rock - Adams Field Airport. The warning was valid until 0520Z. The warning indicated that at 0414Z (1114 PM CDT) doppler weather radar indicated a severe thunderstorm 12 miles south of Conway, or 4 miles west of Morgan, Arkansas, moving east at 30 miles per hour (26 knots). Specific locations in or near the path of this storm included:

Levy	around 0435Z
North Little Rock	around 0435Z
Sherwood	around 0440Z
Gravel Ridge	around 0440Z
Jacksonville	around 0450Z

The main severe weather threat was indicated as strong gusty winds, with some wind damage likely such as downed trees, tree limbs, or power lines. The storms also had the potential for hail. The general public were warned for their protection to go indoors until the storm passes.

The Little Rock Adams Field ATC controller received this weather warning from the NWS and broadcast the advisory at 0428Z to a Cessna Centurion. At 0434Z American Airlines flight 1420 reported on frequency, but did not receive the weather warning.

12.0 Preflight Weather Package issued to the Flight Crew

The following information was issued at 0305Z and provided to the Flight Crew before departure at Dallas Ft. Worth as part of the weather-briefing printed out (attachment 49) with the flight plan:

> Map features for the south central United States, valid on June 1, 1999, from 2358Z to 2300Z on June 2, 1999. Cold front located from

western Missouri, southwestward across east-central Oklahoma into southwest Texas, will move very southeastward to a location from southern Missouri southwestward through southeastern Oklahoma into north-central Texas by daybreak Wednesday. A very warm and moist airmass is in place to the east of this front across eastern Oklahoma, Arkansas, central-eastern Texas, and Louisiana.

Thunderstorm outlook - scattered to broken thunderstorms from eastern Oklahoma, southwest into north-central of Texas will move slowly east to east-southeastward overnight and weaken about daybreak. By Wednesday afternoon thunderstorms expected to develop from the Red River northward into the Central Plains. Issued by American Airlines Weather Services.

CURRENT OBSERVATIONS

Little Rock Airport observation at 0253Z, winds from 180 degrees at 9 knots, visibility 7 miles in thunderstorm, scattered clouds at 5,000 feet in cumulonimbus clouds, ceiling broken at 7,500 feet, overcast clouds at 12,000 feet, temperature 26 degrees C, dew point 23 degrees C, altimeter 29.84 inches of Hg. Remarks: ASOS, thunderstorm began at 0200Z, ended 0224Z, and began again at 0252Z, rain ended at 0224Z, sea level pressure 1010.3 mb, thunderstorm east moving east, occasional lightning in-cloud, and cloud-to-cloud south through southwest, thunderstorm south through southwest moving northeast, precipitation since last hourly observation 0.04 if an inch, temperature 25.6 degrees C, dew point 23.3 degrees C, barometric tendency pressure rising 0.16 mb over the last 3 hours.

THUNDERSTORM SIGMEC

Enroute thunderstorm SIGMEC[19]. Valid from 0255Z through 0800Z on June 2, 1999. Over Texas, Louisiana, Arkansas, and Oklahoma. Coverage widely scattered area of thunderstorms located from 10 miles northeast of Fayetteville, AR, to Little Rock, AR, to Texarkana, AR, to Paris, TX, to Fayetteville, AR, then back to 10 miles northeast of Fayetteville. Thunderstorms moving to the east at 20 knots. Maximum tops at and above 50,000 feet. Outlook, thunderstorms increasing through 0600Z and then decreasing. Issued by American Airlines Weather Services.

[19] SIGMEC is the American Airlines Weather Services issued advisory on Significant Meteorological Conditions.

Weather Watch number 357 valid until 0800Z for severe thunderstorms. Axis along and 100 miles east and west of a line from 27 miles east southeast of Longview, TX to 68 miles south southeast of Springfield, Mo.

Convective SIGMET number 11 Central, valid until 0455Z. Valid over portions of Arkansas, Oklahoma, and Texas. Enclosed by the coordinates from 20 miles east northeast of Razorback VOR, AR, to 40 miles southeast of Little Rock, AR, to 60 miles northwest of Longview, TX, to 40 miles south of McAlester, OK, to 20 miles east-northeast of Razorback VOR. Area of severe thunderstorms moving from 300 degrees at 20 knots, with tops above 45,000 feet. Hail to 2 inches and wind gusts to 70 knots possible.

TERMINAL AERODROME FORECASTS

Terminal Aerodrome Forecast for Little Rock Airport issued on June 1, 1999, at 2330Z, and valid from June 2, 1999, from 0000Z to 2400Z. Beginning at 0000Z, winds forecasted from 180 degrees at 15 knots gusting to 25 knots, visibility better than 6 miles, ceiling broken at 8,000 feet. Temporary conditions between 0000Z and 0400Z of visibility 5 miles in thunderstorm, light rain and mist, ceiling overcast at 30,000 feet in cumulonimbus clouds. From 0400Z, winds from 230 degrees at 12 knots gusting to 20 knots, visibility better than 6 miles, sky condition scattered clouds at 1,500 feet, ceiling overcast at 3,500 feet. Temporary conditions between 0400Z and 0800Z of winds variable at 25 knots gusting 40 knots, visibility 3 miles in thunderstorms, light rain, and mist, ceiling broken at 1,500 feet in cumulonimbus clouds. Forecast from 0800Z, winds from 230 degrees at 10 knots, visibility better than 6 miles, scattered clouds at 1,500 feet, ceiling overcast at 3,500 feet. Temporary between 0800Z and 1200Z of visibility 3 miles in mist, ceiling broken at 1,500 feet, with a second broken layer at 4,000 feet. From 1200Z, winds from 230 degrees at 5 knots, visibility better than 6 miles, scattered clouds at 2,000 feet and 4,000 feet. Temporary conditions between 1200Z and 1400Z of visibility 3 miles in mist. From 1800Z, winds from 270 degrees at 6 knots, visibility better than 6 miles, scattered clouds at 4,000 feet and scattered clouds at 25,000 feet.

LITTLE ROCK FIELD CONDITION REPORTS

At 0307Z (2207 CDT) all runways were reported open and wet, with 0.00 inches in water, with no braking action reports.

13.0 Enroute Weather Updates

At 0340Z American Flight 1420 blocked out from Dallas Ft. Worth airport, and after a few minutes received a radio close-out for the weight and balance figures. The Flight reported an off-time of 0353Z.

At 0354Z, the dispatcher providing flight-watch sent the following message to the crew: "Right now on radar there is a large slot to Little Rock. Thunderstorms are on the left and right, and Little Rock is in the clear. Sort of like a bowling alley approach. Thunderstorms are moving east-northeastward towards Little Rock and they may be a factor for our arrival. I suggest expediting our arrival in order to beat the thunderstorms to Little Rock if possible. Regards, B. Trott, Flight Dispatcher desk 6. Please acknowledge message, end."

At 0357Z the flight crew requested the Little Rock weather through ACARS. They received the 0253Z Little Rock observation which was already in their preflight briefing paperwork.

At 0401Z and 0404Z Convective SIGMET 15C was broadcast on the Forth Worth ARTCC Quitman sector.

At 0411Z, flight dispatch sent by ACARS a revised fuel burn with the notation of the two destination alternate airports of Nashville, TN (BNA) and Dallas-Ft. Worth, TX (DFW), with additional fuel added for enroute weather deviations.

At 0434Z upon contacting the Little Rock Adams Field tower, American Airlines flight 1420 was advised of a thunderstorm northwest of the airport and provided the wind at 280 degrees at 28 knots gusting to 44 knots.

At 0439Z the tower controller advised the flight of a low level wind shear alert.

At 0446Z the controller advised that heavy rain was occurring at the airport and the current ATIS was no longer current. The visibility was reported less than one mile, with runway visual range on 4R at 3,000 feet.

At 0447Z the control tower advised American Airlines flight 1420 of the current winds, a low level wind shear alert, and a report that runway visual range was at 1,600 feet.

The on-time was transmitted by ACARS upon the main gears touching down at Little Rock at 0450Z.

14.0 Interviews

Several individuals were interviewed who were directly involved in providing weather support during the time of the accident and its aftermath, including witnesses regarding the weather conditions. Those interviews are included as attachments and are summarized below.

14.0.1 Interview of NWS Radar Meteorologist

The Weather Group visited the National Weather Service Forecast Office located at North Little Rock Airport, AR on June 3, 1999. The group received two briefings from NWS personnel.

Mr. George R. Wilken, Science and Operations Officer, at the facility provided a thorough briefing on the WSR-88D radar data captured before and during the accident time. The WSR-88D radar provides a volume scan of the atmosphere with a range of 240 miles. The volume scan process takes six minutes to collect and process a complete three-dimensional view of the atmosphere within the line-of-sight range of the radar. The radar is located 6 miles north-northwest of the Little Rock National Airport.

The first images shown to the group were composite reflectivity (reflected signals that display the water content of the atmosphere). The second images shown were radial velocities (components of the wind speed that are either coming directly towards the radar or directly away from the radar). A third set of products was the combined shear displays. Team members received copies of wind profiles of the atmosphere, radar observation data (RAOB), raw information about atmospheric stability products, as well as the color images with .54nm resolution.

Mr. Jimmy Russell, Data Acquisition Program Manager, provided printouts of Automated Surface Observation System (ASOS) data for Little Rock Airport. Data included official observations (METAR and SPECI), 5-minute observations, one-minute data for winds, and precipitation.

14.0.2 Interview of Federal Contract Weather Observer On Duty

Weather Group met with Mr. Don Presley at his office on the third floor at LIT main terminal. Mr. Presley is the Manager for Met-Tech Inc. at Little Rock, the contracted weather observers for the FAA. The observers on duty was Carol Burgess during the evening of June 1, 1999, and was relieved a little before the accident by Claude Johnson. The ASOS unit is located near the approach end

of runway 4L. Mr. Presley stated that there have been no reported problems with the ASOS unit, and the augmentation station had just recently passed an inspection on May 21, 1999. Observers augment the observations, having roof access on the north side of the terminal building with limited (obstructed) viewing to the south. Mr. Presley stated that RVR readings must be obtained from the tower or TRACON and the observer will not delay the transmission of an observation for the RVR reading. He stated that this location provides level "A" service even though contracted for "B" level service.

The weather observer on duty at the Little Rock Airport-Adams Field at the accident time was interviewed in person on June 4, 1999. The following is a summary of that interview (attachment 50).

The weather observer has been a certified weather observer since August 1975. He worked at the Little Rock Flight Service Station from 1975 until 1992. From 1992 to 1994 he worked at the Jonesboro, Arkansas Flight Service Station. He retired in 1994 and returned to Little Rock in 1994 and has been a contract weather observer at Adams Field since then.

On the accident day he was scheduled to work from midnight to 0800 on June 2, 1999. He said he arrived at the observatory at approximately 0410Z. He said it was raining lightly when he arrived at the airport. The observer stated that it was his normal practice to arrive early for his shift to familiarize himself with the existing weather before assuming shift responsibility. The observer said that after he arrived he talked to the observer on duty for a few minutes and about 0430Z walked outside to observe the current weather conditions. He stated that at approximately 0446-0447Z, he told the on duty observer that she could depart and he would assume the weather observing responsibility. This included taking the hourly observation which is disseminated at Little Rock at 53 minutes past the hour. He said that the ASOS visual and audio alerts for the hourly observation goes off at 47:20 but couldn't recall if the alerts had gone off before the previous observer had departed.

A discussion then took place which included both the weather observer and the manager of the contract weather office explaining to the interviewers the meaning of the alerts and the manner in which ASOS works for the hourly observations. They stated that ASOS starts processing for the hourly observation at 47:20. They said that from 47:20 to 53:20 the observer was able to edit the ASOS observation and add remarks to the observation but that it was not possible to transmit it until 53:20. They said it was normal practice to wait until near the end of the 6-minute period to edit the ASOS since the ASOS could change the entry before transmission if edited too soon. They stated that it was not possible for an observer to generate a special observation during that 6-minute period.

The observer was asked to recall his actions around the accident time. He said that at about 04:47:22Z (an ASOS alert), he walked outside by the rain gauge and evaluated sky, visibility, and present weather conditions. Then he came back into the observatory to complete the observation. The observer said that he edited the ASOS observation and added remarks. He said he then logged into ASOS as the weather observer on duty. The observer said that the 0453Z observation accurately described the weather conditions at that time.

The ASOS edit log around the accident time was then reviewed with the observer. An entry at 0447:22Z (22:47:22 CST) which began as AUTO SPCL OBS CANCELLED was discussed. The observer said he didn't remember seeing that observation.

A group discussion ensued and it was explained that since the special observation was generated during the hourly observation time period, the ASOS software canceled the observation in preparation for the hourly report. It was postulated that the special was generated for the wind shift which initially occurred at 0431Z. The observer and station manager again stated that it was not possible for ASOS or an observer to generate a special observation during the period 47:20 to 53:20.

The edit log was further reviewed. An entry at 0449:32Z (22:49:32 CST) indicated that ASOS reset the surface visibility from 7 miles to 1 3/4 miles. The observer said that he had not agreed with that visibility and edited ASOS to change the visibility to 1 mile which was indicated on the 0453Z observation.

The observer said that at about 0455Z, the tower called and asked if he was taking a special observation. The observer stated that he told the tower that he was already in the process. He said that the tower did not indicate to him that an accident had occurred. He said that if an observer initiated a special observation, the observation would be transmitted almost immediately. However, if ASOS generates a special, it takes about 2-3 minutes for the observation to be transmitted. He stated he took another special at 0458Z for the occurrence of small hail.

The observer said that he learned of the accident at about 10 minutes after the hour from Airport Security. He said that he then observed lights in the accident area.

Concerning transmission of observations to the tower, the observer said that after an observation is transmitted on ASOS, it is typed into a second system called Information Display System (IDS). He said it was normal practice to type the main body of the observation along with aviation pertinent remarks.

Concerning reporting RVR, the observer said that when the visibility goes to 1 mile or less, the observer calls the tower to get a RVR reading to insert into the hourly or special observation. He said that due to the weather it was not practical to insert RVR on the 0453Z observation.

Finally, he said that he was not familiar with the ASOS 5-minute observation.

Present during the interview: Skeen, Slye, and Presley.

14.0.3 Interview of Weather Observer Relieved Prior to the Accident

The weather observer on duty at the Little Rock Airport-Adams Field who worked the swing shift on the evening of June 1, 1999, Carl Burgess was interviewed in person on June 5, 1999. The following is a summary of that interview (attachment 51).

The weather observer was certified in May 1990. She worked at Jonesboro from June 1990 until 1993. In 1993, she began working at Little Rock Airport-Adams Field and has been a contract weather observer at Adams Field since then.

She stated that she came to work on June 1, 1999, at 1600Z. She characterized the weather during her shift as routine with a normal workload.

The observer said that the observer working the midnight shift arrived at the observatory at about the time that she was taking a special observation.

She stated that she initiated the special observation when the thunderstorm began at the airport. In addition, she stated that she edited the ASOS observation to drop the visibility to 7 miles from the 10 miles being reported on the ASOS. She said that she inserted CB following the ASOS entry SCT070. After reviewing the observation, she was unable to explain why FEW070 was on the observation. She explained that the ASOS may have made the change before the observation was transmitted.

The observer said that she departed the observatory about the time that the hourly observation period was to begin. Prior to leaving, she asked the oncoming observer if he was sure that she could leave. She said that he said yes. She couldn't remember if the ASOS alert had sounded.

Concerning the weather conditions, she stated that it was raining when she left the terminal. She said the intensity of the rain was not light and not torrential. In addition, she said that the wind picked up but was not able to estimate the velocity. She said that lightning and thunder was occurring as she

went to her car. As she drove out of the airport, she stated that the wind increased and that it was raining heavily. She said that she didn't hydroplane and didn't notice the amount of water on the road. She gave a rough estimate of the visibility as at least 1/4 mile on the airport road (Grundfest Road). She didn't see an airplane when departing.

Present during the interview: Skeen, Eick, Slye, and Presley.

14.0.4 Interview of Releasing Flight Dispatcher

A telephone interview was conducted with the weather group and the flight dispatcher releasing American Airlines flight 1420, Mr. Bill Trott, on June 5, 1999. Present with the request of Mr. Trott at the interview was Mr. John Plowman, President of TWU Local 542.

Background: Majored in Aeronautical Science from Embry-Riddle Aeronautical University in Daytona Beach, Florida and had obtained his private, commercial, instrument, multi-engine ratings and his dispatch certificates. Mr. Trott's dispatch certificate number is 215-94-4694, issued on Sept. 15, 1989.

Work Background: Began as an intern (flight coordinator) at Federal Express, stayed one year before going to American Eagle as a dispatcher on September 30, 1991. He was then hired by American Airlines as an assistant flight dispatcher on April 8, 1996 and promoted to dispatcher on August 31, 1996. His last recurrent training was in April 1999. This mainly concerned American's new equipment, the Boeing 737. He could not recall what weather training was included in that recurrent.

He stated his normal duty cycle was 6 days on with 3 days off, and on the day of the accident he was working the 3rd or 4th day of his duty cycle. He stated he had gotten plenty of rest before duty, and met all duty rest requirements. He arrived at work early, at 9:50 PM local, on June 1st, 1999. His turnover briefing briefly covered the weather, but he did not go to American Airlines Weather Services for any specific weather briefings. The shift turnover briefing also covered problems with other operating flights, current weather impacting the Dallas and Chicago hub operations and NOTAMs. He said he knew it would be a challenging shift due to the line of thunderstorms that stretched from Dallas to the Chicago area, but workload was manageable. Two inbound flights were holding in the ORD area as he began his shift.

He said he normally handled 20 to 30 flights, which mostly required flight following. He was covering Desks 5 and 6, which covered mainly the ORD and DFW hubs and flights from these hubs on to the northeast and east.

With regards to being contacted by the Flight Crew of American flight 1420, he stated he had been contacted by the First Officer regarding the equipment delay and his duty time. The First Officer stated that if things were not corrected they would be canceling soon, because of their duty time. He was in the process of building a new route when he received the equipment substitution for flight 1420 and he released the flight. Based upon the radar data he observed, he used long distance alternates due to a line of thunderstorms along the Arkansas-Oklahoma border, and also added additional en-route fuel. Thus, he had added two alternate airports which included Nashville (BNA) and Dallas Ft Worth (DFW).

He was aware of the thunderstorms impacting operations and specifically ran a flight following program overlaying the route and weather to ensure a safe flight. He then issued flight 1420 a message stating that the route was clear of the main areas of weather and Little Rock looked clear at the destination time, and provided a new fuel over destination.

He did not recall seeing the Little Rock amended terminal forecast that was issued at 0358Z.

During his flight following, he felt that the flight could reach LIT before the thunderstorms moved in and monitored the Aircraft Situation Display (ASD), radar composites and the National lightning display.

His first notification of a problem was when he received a phone call from the American Airlines Operations agent in Little Rock at 0515Z, advising him of an overrun. He then advised his Sector Manager and Systems Operations Control Center Manager. Upon calling the Little Rock Air Traffic Control Tower for further information on the overrun, he became aware of the severity of the situation upon hearing the tone of the controller's voice and the words "an aircraft on fire." He then updated the Sector and System Operations Control Managers of the situation, began saving the flight history, and started making his emergency notifications.

At the time he had 7 flights still in the air he was flight following, determined they were all right and at 0605Z he transferred his flights to desk 7, and at 0614Z was removed from duty. He was then told to relax, brought to the Center Manager's area for a briefing on what happened, scheduled for a drug testing, and then brought into the "war room." In reflection, he felt he had provided all available support and that it was a safe and legal operation.

Present during the interview from the weather group: Eick, Robinson, Vines, Waterman, and Miner.

14.0.5 Eyewitness Account on Aircraft Approaching to Land

Hector Casanova, an ASI with the SCR-A at Arlington, Texas, received the following information at 1430 CDT on Wednesday June 2, 1999, during a telephone interview with Mr. James Heward, a witness to the aircraft while approaching to landing.

Mr. Heward is a cross country truck driver of a large "18 wheeler. " He stated that he was driving his truck in the vicinity of Little Rock on Interstate 440 proceeding towards Hot Springs, Arkansas. He reported that at about 5 to 10 minutes before midnight last Tuesday, he "got caught in torrential rain" and was following another 18 wheeler at "no more than 25 or 30 mph in 6th gear" when a jetliner crossed in front of his truck from left to right. He estimated that the airplane was flying at an altitude "of no more than 10 to 20 feet above the top of his truck." He added that the airplane was "coming in cocked with the wings tilted to the right." He added that he could see the top side of one of the wings.

He reported that there were three "18 wheelers" in trail trying to make it through the storm. His truck was in the middle of the other two. The truck in front of him was blown from the center lane into the left lane just prior to them seeing the airplane fly over. All of the trucks were tilted because of the strong gusty winds, which he estimated to be somewhere between 70 to 90 mph. Besides the pouring down rain, they were also getting intermittent golf ball size hail striking the cab and the trailer. The lightning was almost continuous. About 3 to 5 minutes after seeing the airplane, the lightning decreased and "it got very, very dark."

The truckers were talking on their radios (I assumed CB radio, but did not confirm). One of them made a comment about the low flying jet and one of them said that the "airport is just to our right" All 3 of the trucks were loaded and all of the drivers feared that the winds was going to turn them over. Traffic on that portion of the Interstate was very light at that time of the night, probably due to the severity of the weather.

Mr. Heward stated that he thought that he heard sound of the accident. He recalled a "big flash and a big boom." At that time he was not sure because of all the lightning and thunder if what he heard was the impact or not.

Mr. Heward is the deputy fire chief of his community fire department. He stated that he knows how important eyewitness accounts are. He stated that it took him about 3 hours to finally talk to someone that would take a statement from him. I assured him that we normally have a witness group to gather just this type of information. I gave him my name and phone number just in case he was not called. He said that God willing he will be home by Friday; however, he

will be on the road again by Sunday. He will be willing to file a statement or talk to any of the investigators on the case.

The above report was not tape recorded. It was derived from my handwritten notes. Some of the key points were read back to Mr. Heward, and he either confirmed or expanded the details of his experiences. In my opinion Mr. Heward was frustrated that it had taken him so long to talk to someone in the NTSB, but he was very composed and very factual about his accounts. For his persistence and contributions to aviation safety I sent him a thank you note with one of our NTSB patches. Nothing follows. HRC

14.0.6 Eyewitness Report in the Terminal

Mark George, an investigator in the Survival Factors Group, interviewed Mr. Randy Goode on June 6, 1999 in the North Little Rock, Riverfront Hilton. Mr. Goode witnessed the weather at the time of American Airlines flight 1420's touchdown. Present were: Mark George, Melanie Wahrmund (AAL), Debbie Roland (APFA), Barbara Phillips (FAA), and Jason Fedok (NTSB).

Mr. Randy Goode was in the terminal waiting for his wife, Cindy Goode (Passenger in 33E) to arrive on American Airlines flight 1420. Mr. Goode recalled the time of touchdown of the flight as 1151 PM CDT and 0010 AM CDT when the fire trucks came down the runway. He was standing at gate 2 looking out and said the trucks went to the right.

Mr. Goode stated that 45 minutes before he arrived at the airport, the weather was clear, but it looked like it was going to rain. As he parked outside and walked in, the wind started picking up. The monitors at the airports had weather advisories about the time 1420 was scheduled to land. He was looking out the West side of the airport and had placed his hands on the windows. He stated "it (thunder) felt like it would break the glass vibrating". The carts outside looked like they would fall over and break the glass. He stated the hail on the west side cracked the glass on the windows and looked like it was coming straight across and hitting the glass directly. At this time he had just turned away, people started clapping because the airplane had just landed. He watched the wind blow sheets of water across the runway (ramp). And stated it looked like it was in a ditch-blowing across the runway. Hail started just before landing and was really hard just when the aircraft touched down. The thunder was sounding at the same time the lightning happened. Lightning was the cloud to cloud type just on the East side after the flight landed.

When the fire truck went out it was just sprinkling outside. The water was four or five inches deep on the runway (ramp) and you could tell where the fire truck had driven through the water. Lots of lightning. As soon as the plane

landed, the lights started going on and off in the airport. Alarms were heard sounding and then went off and came on again. Seemed to be coming from the Delta side.

A woman from American took off in a truck and went down the runway and was gone 5 or 10 minutes. She came back and said for everyone to go to the Imax. The media was already there. The gate agent (short heavy set lady with dark hair) told him the plane was stuck in the mud. He did not learn his wife was okay until 0500 AM local.

14.0.7 American Weather Service Meteorologists Statements

The American Airlines Weather Services Meteorologist responsible for preparing the weather services, products, and briefings were asked to provided statements regarding their actions on the evening shift of June 1, 1999. These weather products were used in the weather package, preflight planning, and dispatch release stages (attachments 52 and 53).

Meteorologist Mr. Milo A. Milovich worked the west or desk B, for the shift from 2000Z to 0400Z prior to the accident. His duties were in support of flight dispatch and followed the American Airlines Enhanced Weather Information System (EWINS) policy and procedures manual. Mr. Milovich advised he became aware of the NWS Weather Watch (WW) after 0239Z on June 2, 1999, through the unsolicited message alert on the meteorology desk B. The weather watch was valid from 0245Z through 0800Z on June 2, 1999. Mr. Milovich advised that his weather workstation radar composite also displayed the box graphically shortly after issuance. He was not aware of the NWS weather warnings issued for the Little Rock terminal area since they are not available on the aviation weather circuits and not available to him. Mr. Milovich stated he did not issue a Terminal SIGMEC advisory for Little Rock as Thunderstorm SIGMECs were being issued for the activity.

The American Airlines Meteorologist working the enroute desk also submitted his statements regarding his actions on the evening of the accident. Mr. William A. Orvis was working the enroute desk until 0400Z. Mr. Orvis stated as part of his normal actions he provided graphic forecast snapshots of thunderstorm activity through the American Airlines flight planning guidance charts. Mr. Orvis also issued a notice to all flight dispatch officers of the NWS's issuance of severe thunderstorm watch number 357 for Arkansas on its issuance at 0239Z. He then followed the NWS advisory with a company Thunderstorm SIGMEC for an area covering the western half of Arkansas that was valid through 0800Z. Mr. Orvis was not aware of any actions taken by the North Little Rock NWS Office. He stated that information, nor similar local

warnings for any other areas are not normally received by the American Airlines Weather Services office.

14.0.8 NWS Aviation Forecaster Statement

The Aviation Forecaster on duty at the NWS Forecast Office at North Little Rock during the evening of June 1, 1999, was asked to submit a statement of his actions regarding weather support. A summary of that statement is included below, with his statement added as attachment 54.

Mr. Gregory S. Meffert was the Aviation Forecaster on duty on the evening of the accident from the period 0300Z to 0459Z. During that time frame the Center Weather Service Unit (CWSU) in Memphis, Tennessee was closed. His duties included monitoring and amending as necessary the terminal aerodrome forecasts for Little Rock.

Mr. Meffert indicated that when he assumed the aviation forecasting responsibilities at 0300Z through a re-delegation of duties during the on-going severe weather episode. By 0350Z, it was apparent to him that the line of thunderstorms with very heavy rain would impact the Little Rock airport within the next hour. After reviewing the current forecast for the airport, which had forecast thunderstorms during the period, and reviewing the WSR-88D radar data determined the activity was stronger than that reflected in the forecast and amended the TAF at 0358Z. The revised forecast lowered visibility to 1 mile in thunderstorm and heavy rain, and shortened the time period of the thunderstorm occurrence from 0400Z through 0600Z. Based upon the rapid movement of the line of thunderstorms he expected the impact of the weather to be less than one hour at the airport.

He received the automated weather observation of a wind gust to 76 knots at 0456Z, and upon receiving that information called to advise the Warning Coordination Meteorologist (WCM) of the forecast office, who was monitoring the severe weather situation at home (off duty). While communicating with him, he heard a report on his scanner the emergency vehicles responding at the airport.

At 0505Z he briefed the next aviation forecaster of the situation and of the conditions as he assumed responsibility for the shift. Mr. Meffert then went back to assume the duties of the public forecaster.

15.0 Air Traffic Control Weather Support

Weather data provided and related conversation between the flight and ATC recorded during the period:

Agencies making transmission	Abbreviations
Local Controller	LC1
American Airlines flight 1420	AAL1420
Memphis ARTCC	ZME

ATIS: "...All aircraft, hazardous weather information for the Little Rock area available on HIWAS, Flight Watch or Flight Service. Departing aircraft contact tower on one one eight point seven for clearance and taxi, advise on initial contact, you have Romeo.

Good evening, Little Rock Adams Field information Romeo 0422 Zulu special observation, wind one niner zero at one four, visibility seven, thunderstorm, a few clouds at seven thousand, cumulonimbus, ceiling one zero thousand broken, temperature two five, dew point two three, altimeter two niner eight eight, frequent lightning in cloud, cloud to cloud, west through northwest, moving northeast. ILS runway two two left approach in use. Notices to Airmen, ILS Runway two two right, four left out of service. Attention all aircraft, hazardous weather information for the Little Rock area available on HIWAS, flight watch or flight service. Departing aircraft contact tower one one eight point seven for clearance and taxi. Advise on initial contact you have Romeo..."

0434:11Z	LC1	“we have a thunderstorm just northwest of the airport moving uh through the area now the wind is two eight zero at two eight gust four four and uh I'll have new weather in just a moment I'm sure.”
0434:24Z	AAL1420	“Now we can see the uh lightning and uh you want to repeat the winds again.”
0434:29Z	LC1	“Right now the wind current wind is two niner zero at eight gusts four four.”
0439:07Z	LC1	“American fourteen twenty uh your equipment's a lot better than what I have how is the final for two two left lookin'?”
0439:12Z	AAL1420	“Okay we can uh see the airport from here we can barely make it out but uh we should be able to make two two uh that storm is moving this way like your radar says it is but a little farther off than you thought”

0439:23Z	LC1	“American fourteen twenty roger would you want to just a shoot a visual approach”
0439:28Z	AAL1420	“uh at this point we can't really make it out we're going to have a stay with you as long as possible”
0439:32Z	LC1	“American fourteen twenty roger and the winds kind of kicked around right now its three three zero at a one one”
0439:42Z	AAL1420	“okay well that's a little bit better than it was”
0439:45Z	LC1	“and uh right now I have a wind shear alert centerfield wind is three four zero at one zero north boundary wind is three three zero at two five northwest boundary wind zero one zero at one five”
0440:01Z	AAL1420	“is it possible to get runway four”
0440:02Z	LC1	“American fourteen twenty yes sir we can do runway four if you would prefer to do that”
0440:07Z	AAL1420	“(unintelligible) we would rather do the headwinds sir”
0440:10Z	LC1	“I'm sorry say again American fourteen twenty”
0440:12Z	AAL1420	“yeah we're going to want the headwinds of course -- runway four”

Non-pertinent conversation

0442:26Z	LC1	“American fourteen twenty it appears we have uh a second part of the storm moving through the winds now three four zero at one six gust gust three four”
0442:34Z	AAL1420	“roger that”
0442:56Z	AAL1420	“American fourteen twenty did you call me”
0443:00Z	AAL1420	“Well we got the airport we're going between clouds I think its right off my uh three o'clock low about four miles”
0443:05Z	LC1	“American fourteen twenty that’s it do you want to

		shoot the visual approach or the ILS”
0443:10Z	AAL1420	“we’ll, we’ll shoot the visual if we can do it”
0443:12Z	LC1	“American fourteen twenty cleared visual approach runway four right if you lose it need some help let me know please”
0443:16Z	AAL1420	“I’ll stay with you as long as possible”
0443:18Z	LC1	“yeah that’s fine I’m working everything American fourteen twenty”
Unrelated conversation		
0443:25Z	ZME	“I've got a couple of aircraft comin'in there wantin to know if they're going to be able to get in”
0443:27Z	LC1	“alright well I don't know American uh he came in from the south there he's on a visual approach right now but it's uh it kind of rockin' and rollin' here”
0443:35Z	ZME	“all right”
0443:36Z	LC1	“so you might want uh put it off a little bit if they can it its gots about uh because my radar is not that good by the weather you know but uh”
0443:43Z	ZME	“better than ours“
0443:44Z	LC1	“well then you don’t yeah it looks like it maybe out of here in I don’t know thirthy minutes or so it’s movin’ kind a quickly it looks like”
0443:51Z	ZME	“be there in thirty minutes or leavin' in thirty minutes”
0443:53Z	LC1	“well hopefully out of here by thirty minutes don't hold me to that because I'm not sure”
0443:54Z	ZME	“I gotcha”
0444:00Z	LC1	“American fourteen twenty you can monitor one one eight point seven runway four right cleared to land t he wind right now is three three zero at two one”

Non-pertinent conversation

0444:31Z	AAL1420	“there's a cloud between us and the airport we just lost the field and uh I've uh on this vector here I have the uh the basically last vector you gave us we're on a kind of a dog leg it looks like”

Non-pertinent conversation

0445:46Z	AAL1420	“and approach American fourteen twenty we know you're doing your best but we're getting pretty close to this storm we'll keep this in tight if we have to”

Non-pertinent conversation

0446:52Z	LC1	“American fourteen twenty right now we have uh heavy rain on the airport the current weather on the ATIS is not correct I don't have the current weather for you but the visibility is uh less than a mile the runway right four right RVR is three thousand”
0447:04Z	AAL1420	“Roger that three thousand American fourteen twenty runway four right correct”
0447:08Z	LC1	“American fourteen twenty that’s correct sir and runway four right cleared to land the wind three five zero at three zero gust four five”
0447:16Z	AAL1420	“zero three zero at four five American fourteen twenty”
0447:53Z	LC1	“wind shear alert centerfield wind three five zero at three two gust four five north boundary wind three one zero at two niner northeast boundary wind three two zero at three two”
0448:13Z	LC1	“American fourteen twenty the runway four right RVR now is one thousand six hundred”
0448:25Z	AAL1420	“American fourteen twenty we’re established inbound”
0448:28Z	LC1	“American fourteen twenty roger runway four right cleared to land and the wind three four zero at three one north wind north boundary wind is three zero zero at two six northeast boundary wind is three two

		zero at two five and the four right RVR is one thousand six hundred”
0448:42Z	AAL1420	“American fourteen twenty thanks”
0449:11Z	LC1	“wind is three three zero at two eight”
0449:32Z	LC1	“wind three three zero at two five”
0449:53Z	LC1	“wind three two zero at two three”
0450:54Z	LC1	“American fourteen twenty report clear of the runway please”
0451:16Z	LC1	“Amer American fourteen twenty tower”
0451:31Z	LC1	“American fourteen twenty tower”

16.0 Airport Surveillance Cameras

Two of the Little Rock Airport Surveillance cameras recorded the environmental conditions surrounding the time of the accident and were examined for supporting data. The film footage is date and time stamped by the video image multiplexer with the time set every Sunday according to the clock at the U.S. Navy Observatory in Washington, D.C. The multiplexer was last set on May 30, 1999. On June 4, 1999, the time was checked and had drifted off 20 seconds over the week. The tapes were reviewed and provided the following details in the investigation (time is left as CDT in this section). A copy of the security tape with views of the ramp and the environmental conditions was put on Compact Disk (CD) and is included as attachment 55.

The locations of the camera’s and the area being viewed are described and documented in attachment 56.

Details of Camera 11 near gate 8;

Mounted on top of concourse near gate 8. The camera views airport boundary fence, Airport Operations Area (AOA) Gate 30 facing northeast toward departure end of Runway 4R at Little Rock Airport. On June 1, 1999, at approximately 2339 CDT, water can be seen flowing from roof of air cargo facility building on the southwest side. At 2341 CDT, winds were moving water causing it to blow in a snake-like-pattern toward the building at the same time

lightning could be seen. At 2347 CDT, visibility was lowered due to heavy rain, and blowing rain. At 2350 CDT, heavy/blowing rain could also be seen. At 2351 CDT, a flash of lightning could also be seen. At 2352 CDT, visibility deteriorated quickly, and visibility of the air cargo building was lost. At 2354 CDT, a power failure (electrical power) occurs, causing lights on and near the cargo building to go out. At 2355:40 CDT, the crash/fire/rescue trucks were observed traveling east between the air cargo building and camera 11. At 2358 CDT, electrical power was restored and visibility had improved.

Camera near AOA gate entrance closest to Concourse Gate 2;

Mounted near cooling box just west of AOA Gate 1 facing northeast. At 2339 CDT, heavy rain was observed. At 2341:36 CDT, the rain was observed blowing from left to right. Large streaks of rain can be seen and are bouncing from the pavement. At 2348 CDT, heavy rain can be seen. At 2349 CDT, a lightning flash was observed. At 2350 CDT, heavy rain continues. At 2352:45 CDT, visibility diminished rapidly as rain intensity increased. At 2353 CDT, visibility decreased to less than 30 ft. At 2354 CDT, electrical power was lost.

17.0 Wind-Shear Research

Fred H. Proctor, Ph.D. with NASA Langley Research Center in Hampton, Virginia conducted some initial wind shear modeling of the Little Rock weather event. The NASA modeling report will be added as a future addendum once completed. A brief summary of the NASA modeling and radar data was sent August 31, 1999, and is as follows:

- Our analysis of the observed data and modeling simulations do not show this accident to be attributed to wind shear. However, strong crosswinds from convective storms are a possible contributor.
- The strong crosswinds were induced by a “bow echo pattern” (sometimes called a LEWP). Strong winds were further enhanced by a “bookend cell” (located at the southern end of the bow-echo pattern) which passed near the airport at the time of the accident. This cell was also associated with heavy rainfall and hail.
- The Bow-echo system tended to produce large-scale outflow rather than hazardous microbursts. From the model simulations of the bow-echo system, the windshear hazard was minimal, with peak low-level F-Factors of about 0.1 (windshear with F-Factor’s greater than 0.13 is deemed a “must alert” for onboard look-ahead windshear detectors).
- Although TDWR gives products for gust front prediction and microburst windshear, we are not aware of products which give alerts for hazardous crosswind.

- Both NEXRAD and LLWAS systems were able to measure the strong winds prior to the accident. (The LLWAS windshear alerts are suspect due to the crude spacing between sensors).
- Closing comment, perhaps products should be developed using data from these platforms for alerting for the potential of hazardous crosswinds.

Attachment 57 is the Preliminary Report issued by Fred Proctor, PhD. On the "Investigation of the Storm Associated with the 1 June 1999 Aircraft Accident at Little Rock Arkansas'.

18.0 Terminal Weather Information for Pilots (TWIP)

Since 1991, American Airlines has participated in the development and implementation of TWIP. TWIP is an FAA data-link program to provide text and text-graphic weather information at airports with Terminal Doppler Weather Radar (TDWR) and ARINC Pre-departure Clearance Delivery Service (PDCS). TWIP provides a description of convection, precipitation, and windshears/microbursts within 15 miles of the airport. The information is provided to the pilots directly from the TDWR and is updated every minute. American Airlines dedicates four of ten pages in the meteorology section on the use of the TWIP system. American Airlines entire fleet is TWIP compatible.

Little Rock National Airport is not an airport with TWIP capability.

19.0 Astronomical Data

Sunset:	0117Z (2017 CDT)
End of Civil Twilight:	0147Z (2047 CDT)
Altitude of Sun:	-30.2 degrees below horizon
Magnetic Bearing to Sun:	336.3 degrees
Altitude of Moon:	15.4 degrees
Magnetic Bearing to Moon:	126.7 degrees
Percent Illumination:	92 percent

[original signed]

Donald E. Eick
Meteorology Group Chairman

John F. Robinson
Neal R. Vines
Robert G. Waterman
Warren Qualley
Timothy H. Miner
William R. Slye
James T. Skeen

Attachments:

1. NWS Surface Analysis Chart for 0300Z on June 2, 1999
2. NWS Surface Analysis Chart for 0600Z on June 2, 1999
3. NWS Radar Summary Chart for 0435Z on June 2, 1999
4. NWS Radar Summary Chart for 0535Z on June 2, 1999
5. National Lightning Display between 0445Z to 0500Z on June 2, 1999
6. NWS 850 mb Constant Pressure Chart at 0000Z on June 2, 1999
7. NWS 700 mb Constant Pressure Chart at 0000Z on June 2, 1999
8. NWS 500 mb Constant Pressure Chart at 0000Z
9. NWS 300mb Constant Pressure Chart at 0000Z
10. NWS 250 mb Constant Pressure Chart at 0000Z
11. Jet stream analysis 0000Z
12. Weather observations issued for the period
13. ASOS Augmentation Inspection
14. Composite reflectivity at 0445Z
15. Composite reflectivity at 0451Z
16. Composite reflectivity at 0457Z
17. WSR-88D base reflectivity for 0.4 degrees at 0445Z
18. WSR-88D base reflectivity for 0.4 degrees at 0451Z
19. WSR-88D base reflectivity for 1.5 degrees at 0451Z
20. WSR-88D base reflectivity for 2.4 degrees at 0451Z
21. WSR-88D base reflectivity for 3.3 degrees at 0451Z
22. WSR-88D four panel base reflectivity display at 0451Z
23. WSR-88D base reflectivity for 0.4 degrees at 0457Z
24. WSR-88D Time series at 0.4 degree elevation
25. WSR-88D radial velocity for 0.4 degrees at 0445Z
26. WSR-88D radial velocity for 0.4 degrees at 0451Z
27. WSR-88D radial velocity for 0.4 degrees at 0457Z
28. WSR-88D four panel radial velocity for time 0440Z, 0445Z, 0451, 0457Z
29. WSR-88D Velocity Azimuth Display
30. WSR-88D combined shear
31. National Lightning Detection Network lightning strike data at 20 NM from 0436Z to 0451Z.
32. Lightning data at 5 NM from 0446Z to 0451Z.
33. Upper air sounding from North Little Rock (KLZK) at 0000Z on June 2, 1999.
34. LLWAS Configuration
35. Little Rock LLWAS tower display
36. ATC terminology for issuing LLWAS alerts
37. LLWAS data between 0441Z through 0457Z on June 2, 1999.
38. LLWAS Algorithm report
39. LLWAS Statistical Performance Evaluation (SPE)
40. NWS statement regarding maintenance on the ASOS.
41. Infrared satellite image at 0402Z on June 2, 1999.
42. Infrared satellite image at 0445Z.

43. Infrared satellite image at 0502Z.
44. Magnified infrared image at 0445Z.
45. Magnified infrared image at 0502Z.
46. Moisture channel image at 0502Z.
47. In-flight weather advisory plot over 0400Z infrared satellite image.
48. Bow Echo figure
49. American Airlines Flight 1420 Weather Document
50. Federal Contract Weather Observer on duty statement
51. Federal Contract Weather Observer relieved prior to accident statement
52. American Airlines Weather Services forecaster statement
53. American Airlines Weather Services en route forecaster statement
54. NWS Aviation Forecaster statement
55. Airport Surveillance Camera video CD
56. Camera location photo's
57. NASA Preliminary Draft Report on Wind Shear Modeling