Collision with Trees on Final Approach, American Airlines Flight 1572, McDonnell Douglas MD-83, N566AA, East Granby, Connecticut, November 12, 1995

Micro-summary: **This MD-83 struck trees while on short final.**

Event Date: **1995-11-12 at 0055 EST**

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

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

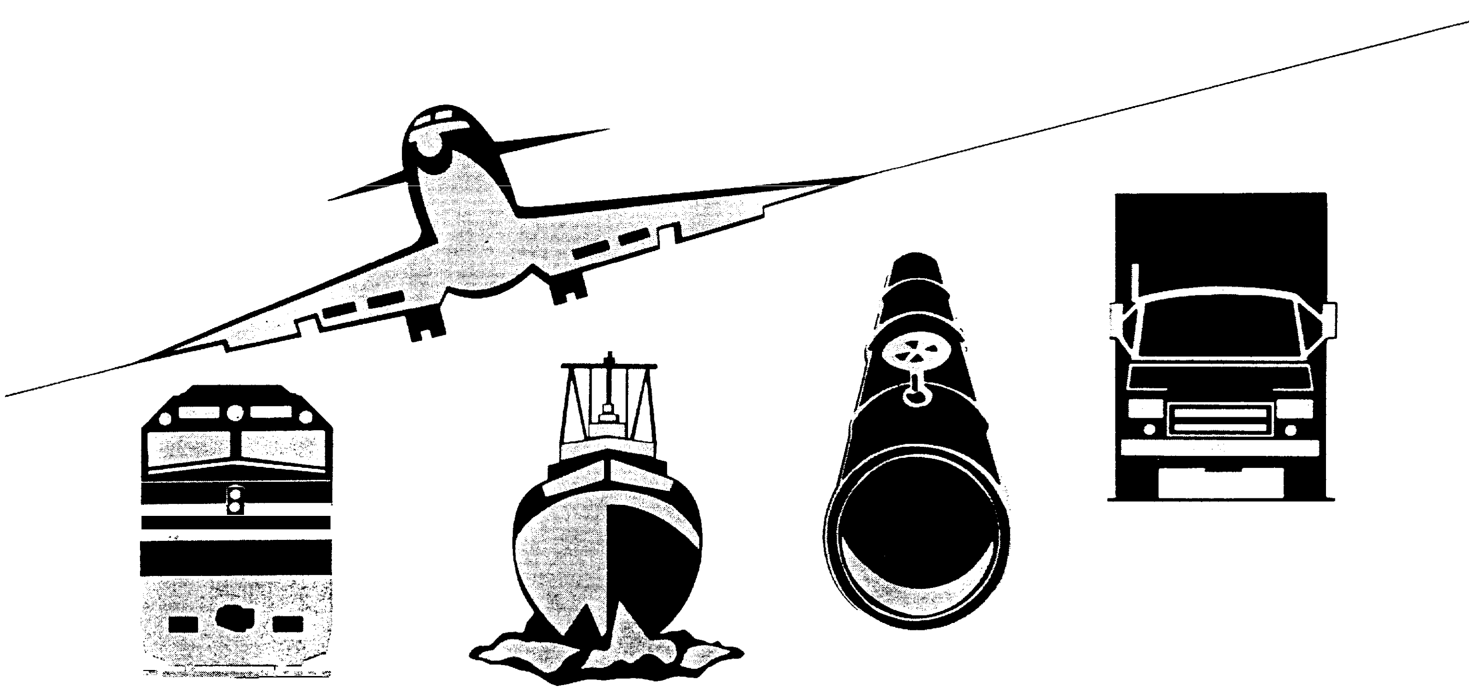
PB96-910405
NTSB/AAR-96/05
DCA96MA008

NATIONAL TRANSPORTATION SAFETY BOARD

WASHINGTON, D.C. 20594

AIRCRAFT ACCIDENT REPORT

**COLLISION WITH TREES ON FINAL APPROACH
AMERICAN AIRLINES FLIGHT 1572
McDONNELL DOUGLAS MD-83, N566AA
EAST GRANBY, CONNECTICUT
NOVEMBER 12, 1995**



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NOVEMBER 12, 1995

Adopted: November 13, 1996
Notation 6638B

Abstract: This report explains the accident involving American Airlines flight 1572, an MD-83 airplane, which was substantially damaged when it impacted trees in East Granby, Connecticut, while on approach to runway 15 at Bradley International Airport, Windsor Locks, Connecticut, on November 12, 1995. Safety issues in the report include tower shutdown procedures, non-precision approach flight procedures, precipitous terrain and obstruction identification during approach design, the issuance of altimeter settings by air traffic control, low level windshear system maintenance and recertification, and emergency evacuation issues. Recommendations concerning these issues were made to the Federal Aviation Administration.

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CONTENTS

EXECUTIVE SUMMARY

On November 12, 1995, at 0055 eastern standard time a McDonnell Douglas MD-83, N566AA, owned by American Airlines and operated as flight 1572, was substantially damaged when it impacted trees in East Granby, Connecticut, while on approach to runway 15 at Bradley International Airport (BDL), Windsor Locks, Connecticut. The airplane also impacted an instrument landing system antenna as it landed short of the runway on grassy, even terrain. Flight 1572 was being conducted under Title 14 Code of Federal Regulations, Part 121, as a scheduled passenger flight from Chicago, Illinois, to Bradley International Airport.

The National Transportation Safety Board determines that the probable cause of this accident was the flightcrew's failure to maintain the required minimum descent altitude until the required visual references identifiable with the runway were in sight. Contributing factors were the failure of the BDL approach controller to furnish the flightcrew with a current altimeter setting, and the flightcrew's failure to ask for a more current setting.

The safety issues in the report focused on tower shutdown procedures, non-precision approach flight procedures, precipitous terrain and obstruction identification during approach design, the issuance of altimeter settings by air traffic control, low level windshear alert system maintenance and recertification, and emergency evacuation issues. Recommendations concerning these issues were made to the Federal Aviation Administration.

NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C. 20594

AIRCRAFT ACCIDENT REPORT

COLLISION WITH TREES ON FINAL APPROACH AMERICAN AIRLINES FLIGHT 1572 McDONNELL DOUGLAS MD-83, N566AA EAST GRANBY, CONNECTICUT NOVEMBER 12, 1995

1. FACTUAL INFORMATION

1.1 History of Flight

On November 12, 1995, at 0055 eastern standard time (EST)[1], a McDonnell Douglas MD-83, N566AA, owned by American Airlines (AAL) and operated as flight 1572, was substantially damaged when it impacted trees in East Granby, Connecticut, while on approach to runway 15 at Bradley International Airport (BDL), Windsor Locks, Connecticut. The airplane also impacted an instrument landing system (ILS) antenna as it landed short of the runway on grassy, even terrain. Flight 1572 was being conducted under Title 14 Code of Federal Regulations (CFR), Part 121, as a scheduled passenger flight from Chicago, Illinois, to Bradley International Airport.

On November 10, 1995, at around 1700, the captain, first officer and three flight attendants reported to Washington's National Airport (DCA) to begin a 3-day flight sequence together. The scheduled departure time was at 1800 and consisted of three flight segments the first day from DCA to Nashville, Tennessee, (BNA) continuing to Chicago's O'Hare International Airport (ORD) and to Denver, Colorado (DEN). The airplane departed DCA at 1758, according to company records, flew the three segments, and arrived at DEN at 0310. The crew was on duty for 10 hours and 25 minutes, and had accumulated 5 hours and 53 minutes actual flight time. Due to the crew's late arrival in DEN, the regularly scheduled layover of 15 hours and 18 minutes was reduced to 13 hours and 35 minutes.

[1]All times in this report are eastern standard time unless otherwise noted.

At 1615, on November 11, the flightcrew departed the hotel in DEN for a scheduled check-in time of 1700. The airplane they were to fly arrived late from ORD; the inbound flightcrew reported that N566AA was a "good airplane." Flight 1572 originated in DEN and departed there at 1809, with the first officer as the flying pilot, arriving at ORD at 2047. The flight was 23 minutes late, based on the scheduled arrival time of 2024. The flightcrew stated that the airplane performed normally and that the flight was uneventful.

Originally, flight 1572 was scheduled to depart ORD for BDL at 2125. However, due to the late arrival of connecting passengers and weather, the flight was delayed about 2 hours. The airplane departed ORD for BDL at 2305, with the captain as the flying pilot. After takeoff, the American Airlines dispatcher, via the Automatic Communications and Recording System (ACARS), provided the flightcrew with updated weather and wind conditions at BDL as part of the flight plan review message. The remark, "PRESFR" (pressure falling rapidly)[2] was included on the weather sequence in the message. The flightcrew reported that the flight was uneventful during cruise, although the captain stated that he changed from a cruise altitude of FL[3]330 (about 33,000 feet) to FL350 (about 35,000 feet) to avoid an area of turbulence. According to the captain, the flight was cleared direct to BDL about 300 miles from the airport.

During the descent, the flightcrew received two messages over the ACARS relating to the BDL weather. The first message was sent by American's dispatcher at 0030 and provided the flightcrew with the altimeter setting of 29.23 inches Hg. that would cause the flightcrew's altimeters to indicate feet above field elevation (QFE), and the altimeter setting of 29.42 inches Hg. that would cause the standby altimeter to indicate feet mean sea level (msl) (QNH) at BDL.[4] At 0031, another message was sent to the

[2]Pressure Falling Rapidly (PRESFR): A fall in pressure at the rate of 0.06 inch [Hg.] per hour which totals 0.02 inch or more.

[3]Flight Level - Level of surface of constant atmospheric pressure assuming a datum of 29.92 inches Hg., expressed in hundreds of feet; thus, if the actual atmospheric pressure is 29.92 inches Hg., FL220 indicates exactly 22,000 feet. If the actual atmospheric pressure is greater (or less) than 29.92 inches Hg., FL220 will be at an altitude correspondingly higher (or lower).

[4]It is AAL's policy to set the flightcrew's altimeters to QFE and the standby altimeter to QNH when below 10,000 feet. Following the accident, neither crewmember

flightcrew by the dispatcher advising them that airplanes had been making landings at BDL, and that those airplanes had been experiencing turbulence and windshear on final approach.

At 0032, the airplane was instructed to descend to FL190 (about 19,000 feet) by the air route traffic control center (ARTCC) controller. Also at that time, the cockpit voice recorder (CVR) recorded the last part of the automatic terminal information service (ATIS) information "Victor" for BDL. This part of information Victor gave an altimeter setting of 29.50 inches Hg. and stated that the significant meteorological information (SIGMET) “X-ray three” was in effect, which reported severe turbulence below 10,000 feet. At 0033, the flightcrew received further instructions from the ARTCC controller to descend and maintain 11,000 feet and the controller announced the Bradley altimeter setting to be 29.40 inches Hg. The flightcrew acknowledged the altimeter setting and the clearance. As recorded on the CVR, the first officer then listened to the entire ATIS information “Victor” message at 0034. He then noted to the captain that the ATIS information was about 1 ½ hour old.

During the descent, at 0032:23, the captain advised the flight attendants to secure the cabin due to turbulent conditions. At 0038:45, as part of the before-landing checklist, the first officer asked, “altimeters?” The captain said, “twenty nine fifty.” The first officer stated, “they called twenty nine forty seven[5] when we started down...what ever you want.” The captain replied, “OK.” The flightcrew briefed for the VOR[6] approach to runway 15. The CVR recorded the captain stating at 0042:48, “One seventy four’s the elevation so, twenty nine, twenty three. Set and cross checked.” The first officer responded, “minus uh,” to which the captain replied,

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remembered the 0030 ACARS message or the associated altimeter settings provided them by the company. However, papers retrieved from the accident airplane included the ACARS message annotated with the handwritten ATIS information “Victor” that was copied onto the ACARS message 1 minute after that message was received.

[5]It is not known why the first officer announced an altimeter setting of 29.47 inches Hg. The ACARS message at 0030 gave a setting of 29.42 inches Hg., and the ARTCC controller gave a setting of 29.40 inches Hg. at 0033.

[6]Very high frequency omnidirectional radio range.

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"showing seventy...check seventy[7] feet difference." The flightcrew contacted approach control at 0043:41 and the flight was told to "expect [the] VOR runway [15] approach."[8] At 0045:54, approach control instructed the flight to descend to 4,000 feet. Approach control stated the winds were "one seven zero at two nine gusts three nine." A vector for the runway 15 final approach course was then issued. (See Figure 1.) At 0049:41, the approach controller cleared the flightcrew for the runway 15 approach. At 0049:57, he advised the flightcrew that the tower was temporarily closed because of a problem with one of the windows, and to report the "down time" on approach control frequency.

According to the first officer, the flightcrew intercepted the approach course at around 3,500 feet about 15 miles from the airport, and the captain began configuring the airplane for landing. The captain stated that he had the radar on the 20-mile range, observed no convective activity between their position and the airport, and then turned the radar off. The descent and approach were flown using the autopilot, and the CVR indicated that the flightcrew had selected 11 degrees of flaps prior to crossing the 10 nautical mile DME (distance measuring equipment) fix named MISTR. The captain stated that he selected the VOR/LOC (localizer) mode for the autopilot during the approach; however, due to the strong winds, the autopilot attempted to apply about a 30-degree course correction and the "autopilot couldn't hold it." Approach control then advised the flightcrew that the airplane was left of course. (See Figures 2a, 2b and 2c.) The captain stated that he changed the mode of the autopilot to HDG SEL (heading select) to manually recapture the inbound course. After crossing MISTR, the airplane was configured for landing with 40 degrees flaps and the landing gear down. At 0051:44, the captain began the descent to 2,000 feet using the VERT SPD (vertical speed) mode for pitch control on the autopilot mode control panel. Two thousand feet was the final approach fix crossing altitude. The captain stated that the airplane encountered moderate turbulence and very heavy rain during this part of the descent.

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[7]The CVR group reported the word "seventy" to be unintelligible. The accident flightcrew offered the word as being "seventy" after they reviewed the CVR.

[8]The runway 15 approach to BDL is used primarily when the winds are such that the speed and direction preclude the safe use of the airport's primary runway (06/24).

The autopilot captured the airplane's altitude at 2,000 feet, prior to their arrival at the final approach fix, named DILLN, which was 5 DME from the VOR. After passing DILLN, the captain told the first officer to set the missed approach altitude of 3,000 feet in the flight guidance control panel (FGCP). He began the descent to the minimum descent altitude (MDA)[9] of 908 feet above the field elevation, using the VERT SPD mode of the autopilot. At 0054:22, the captain asked the first officer to "give me a thousand down."

Although the tower was temporarily closed at this time, a TRACON supervisor was in the tower cab and communicated with the flightcrew. (See Section 1.18.1.1 for details.) At 0054:51, the TRACON supervisor in the tower issued a windshear alert giving winds for the centerfield, northeast boundary, and southeast boundary of the airport. At 0055:06, the first officer stated, "there's a thousand feet...cleared to land." At 0055:11, he further stated, "...now nine hundred and eight is your uh..." The captain replied, "right."

The first officer later told investigators that he had ground contact "straight down" and, as the airplane was "at the base of the clouds," he began looking for the field visually. He then looked back at his altimeter and saw that the airplane was descending below the MDA. Following a short period of flying through turbulence, at 0055:26.3, the first officer stated "you're going below your…."[10] According to the captain's interview and the flight data recorder, at this point the captain pushed the altitude hold button for the autopilot.

According to the CVR, the "sink rate" warning was heard approximately four seconds prior to the first impact with trees. At 0055:30.4, the CVR recorded a sound of impact.[11] The captain later stated that he then heard a "loud report," followed by severe turbulence.

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[9]The lowest altitude, expressed in feet above mean sea level, to which descent is authorized on final approach or during circle-to-land maneuvering in execution of a standard instrument approach procedure where no electronic glideslope is provided.

[10]During a postaccident interview, the captain stated that the first officer said, "100 below" at that time, rather than "you're going below your.…"

[11]Investigators determined that the first impact point was with trees on the top of a ridge line approximately 2.54 nautical miles northwest of the approach end of runway 15.

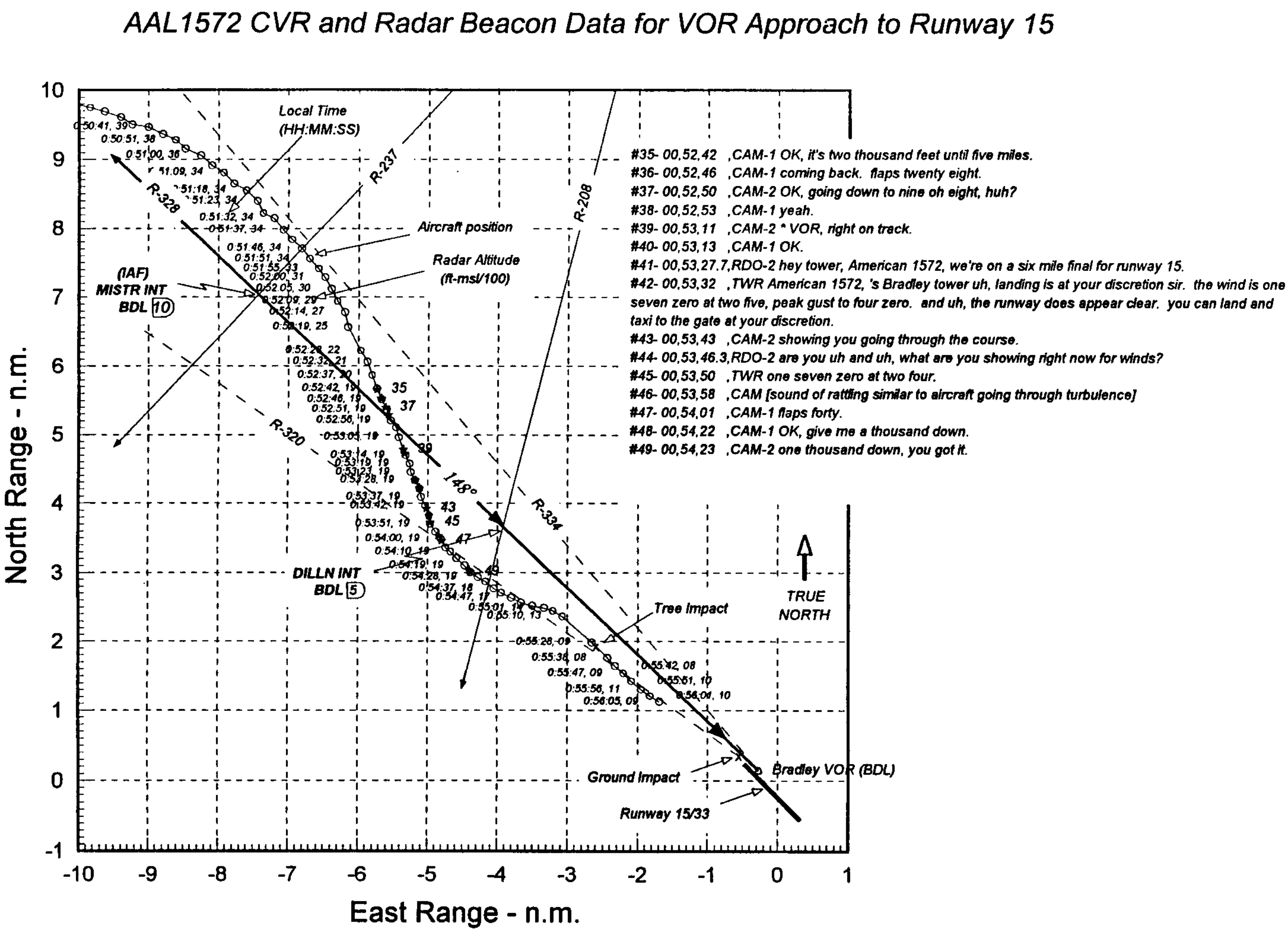

Figure 2a.—Plan view of the approach.

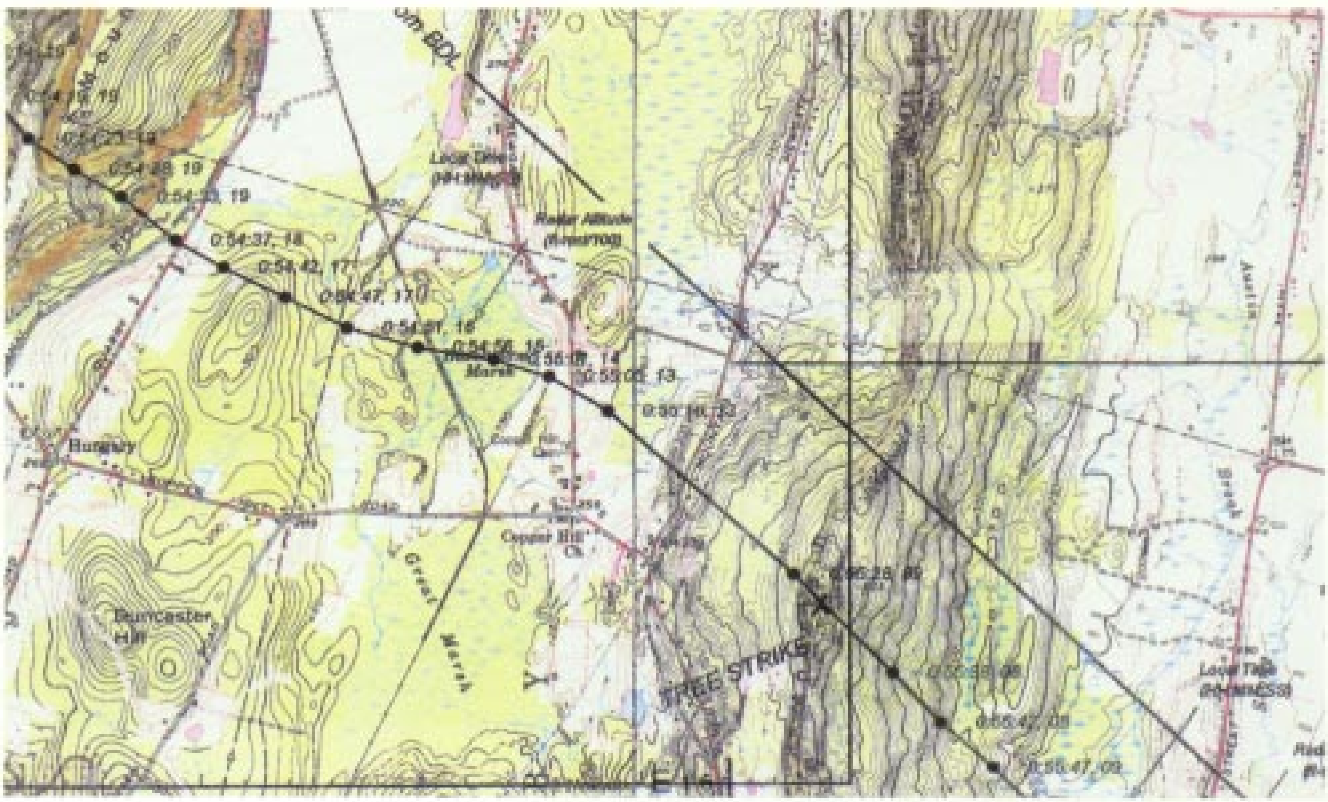

Figure 2b.--Plan view of the approach with terrain features.

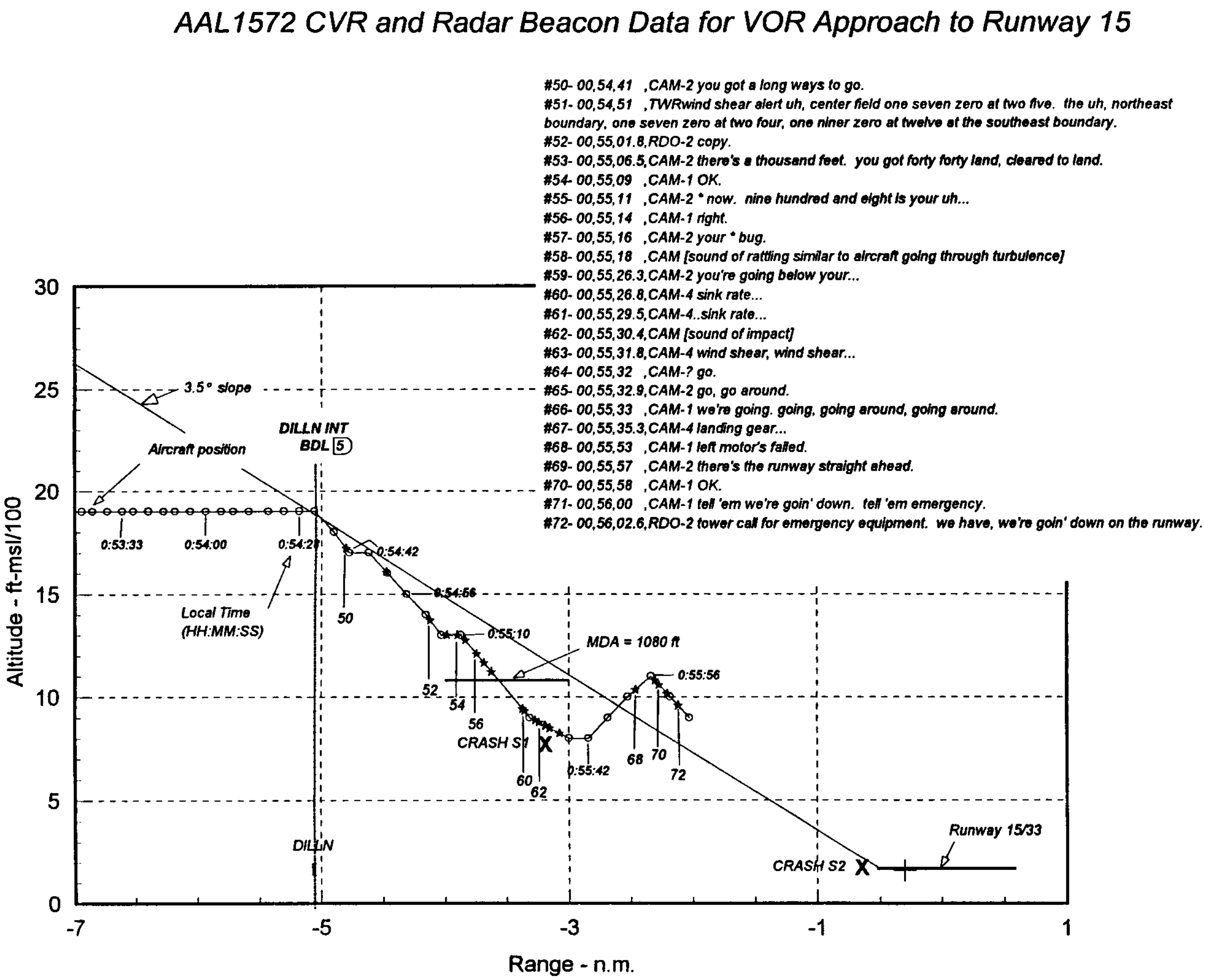

Figure 2c.--Profile view of the approach.

According to the first officer, the captain called for a go-around and "firewalled the throttles." Flaps were selected to 15 degrees, and the landing gear handle was placed in the "up" position. Both flight crewmembers reported that the on-board windshear warning system and the ground proximity warning system (GPWS) activated after the impact, which was confirmed by the CVR recording. The captain stated that in a "second or two," the turbulence stopped, and, at 0055, according to the CVR recording, he said to the first officer "Left motor's failed."

The airspeed started to decrease, and the airplane began a slow descent. The rain stopped, and the first officer saw the runway. According to the captain, the right engine was not sustaining full thrust, and, at 0056, he said, "Tell 'em we're goin down." The first officer complied. The first officer then stated to the captain, "you're going to make it," and queried whether the captain wanted the landing gear lowered. The first officer then selected the landing gear to the "down" position.

The captain stated that he then called for flaps to be lowered to 40 degrees to achieve a "balloon effect" to reach the runway. The airplane clipped the top of a tree near the end of the runway, impacted and destroyed most of the ILS antenna array located at the end of the safety overrun area for runway 33, and landed on the edge of the stopway. The airplane rolled down the stopway and continued down runway 15, stopping on the runway beyond the intersection of runway 6/24 near the tower.

An evacuation was initiated and the passengers and crewmembers exited the airplane. The initial tree strike occurred at approximately 41 degrees, 58.22 minutes north latitude and 072 degrees, 44.38 minutes west longitude during the hours of darkness. The ground elevation of the first impacted tree was 728 feet above msl, and the height of the tree where it was determined to be struck was about 770 feet msl.

1.2 Injuries to Persons

Injuries	Flightcrew	Cabincrew	Passengers	Other	Total
Fatal	0	0	0	0	0
Serious	0	0	0	0	0
Minor	0	0	1	0	1
None	2	3	72	0	77
Total	2	3	73	0	78

1.3 Damage to Airplane

According to American Airlines officials, damage to the airplane amounted to approximately $9,000,000.

1.4 Other Damage

According to FAA and Bradley International Airport officials, damage to the ILS antenna array and other airport equipment amounted to approximately $74,620.00

1.5 Personnel Information

1.5.1 The Captain

Date of birth: 07-01-56
Ratings and Certificates:
Airline Transport Pilot Certificate Number 92480401, issued 08-05-91.
Type Rating: DC-9/Airline Transport Pilot
Flight Engineer Certificate Number 92480401, issued 05-24-85
Rating: Turbojet powered/FE
Medical certificate: First Class issued 08-29-95, no restrictions
Date of hire with AAL: 04-11-85
Second in Command (SIC) time (MD80) since 09-08-86: 2,716 hours
Pilot in Command (PIC) time, (DC-9/MD80) since 08-22-91: 1,514 hours
Total flying time: 8,000 hours total, 5,000 hours civilian, 2,300 military
Total flying time last 24 hours: 10 hours
Total flying time last 7 days: 10 hours
Total flying time last 30 days: 20 hours

Total flying time last 60 days:	55 hours
Total flying time last 90 days:	55 hours
Last recurrent training:	08-21-95
Last proficiency check:	08-21-95
Last line check:	07-17-95

1.5.2 The First Officer

Date of birth: 11-16-56
Certificates and ratings:
Airline Transport Pilot Certificate Number 527063950, issued 08-27-88
Airplane Multiengine Land/Airline Transport Pilot
Airplane Single Engine Land/Commercial Pilot
Medical: First Class issued 03-13-95, no restrictions
Date of hire with AAL: 05-24-89
Second in Command (SIC) time, (MD-80) since 08-21-90: 2,281 hours
Total flying time: 5,100 hours total, 2,500 hours military, 2,600 hours civilian

Total flying time last 24 hours:	10 hours
Total flying time last 7 days:	13 hours
Total flying time last 30 days:	60 hours
Total flying time last 60 days:	123 hours
Total flying time last 90 days:	167 hours
Last recurrent training:	08-19-95
Last proficiency check:	08-19-95
Last line check:	08-21-90

1.5.3 The Approach Controller Controlling Flight 1572

Date of hire by FAA:	December, 1991
Last Tape Talk:	May 25, 1995 (no deficiencies noted)
Medical Certification:	November 6, 1995 (no restrictions or limitations)

Facility records indicated that the approach controller was current in all refresher and supplementary training. These topics included Severe Weather, Traffic & Safety Advisories, Emergencies, Seldom Used Procedures, Unusual Situations, Low Level Windshear, Winter & Summer Operations, Revised MVA Video Map, various operational bulletins, and operational error prevention bulletins. No remedial training was noted. There was no evidence of an operational error or deviation in the past 2 years.

1.6 Airplane Information

N566AA, serial number 49348, is a McDonnell Douglas MD-83 twin engine transport category airplane. At the time of the accident, the total airframe time was 27,628 hours.

Based on flight plan data, estimated fuel remaining on approach to BDL was 15,600 pounds, and estimated landing weight was 118,360 pounds with an estimated center of gravity (CG) of 18.1 percent mean aerodynamic chord (MAC). The allowable CG range from the MD-80 Approved Aircraft Flight Manual at 118,050 pounds is -0.8 percent to 33.4 percent.

The airplane was equipped with two Pratt & Whitney JT8D-219 turbofan engines with a normal takeoff thrust rating of 21,000 pounds and a maximum takeoff thrust rating of 21,700 pounds. Engine times and cycles:

	LEFT	RIGHT
Serial Number	725677	708519
Total time (hrs)	13,014	34,681
Total cycles	7,409	19,992

1.7 Meteorological Information

The National Weather Service (NWS) Surface Analysis for November 12 at 0100 showed a deep low (986 millibars) over Quebec with an occluded front extending south across Eastern New York State. A secondary low pressure center was located over New York City. There were strong southerly winds ahead of the front and strong westerly winds behind it. A large area of rain existed over New England.

1.7.1 Surface Weather Observations

Surface Weather Observations at BDL are made by the NWS during the day, and a private contractor, Midwest Weather Inc., during the evening hours. The following weather observations for BDL were made by Midwest Weather:

> November 11 at 2352: Record 2,200 feet scattered; measured ceiling 2,800 feet overcast; visibility 5 miles; light rain; temperature 61 degrees F; dew point 57 degrees F; winds 160 degrees at 28 knots gusts to 40 knots; altimeter setting 29.42 inches Hg; peak wind 160 degrees at 42 knots at 2318; pressure falling rapidly.

The observation was transmitted to the BDL Air Traffic Control Tower, at 2353.

> November 12 at 0051: Record 1,700 feet scattered; measured ceiling 2,800 feet overcast; visibility 3 miles; moderate rain; temperature 61 degrees F; dew point 58 degrees F; winds 170 degrees at 25 knots gusts to 40 knots; altimeter setting 29.35; pressure falling rapidly. Peak wind 170 degrees at 43 knots at 0018.

The observation was transmitted to the BDL control tower at 0057.

1.7.2 ATIS (Automatic Terminal Information Service) "Victor" Broadcast

BDL ATIS recordings are created by BDL Federal Aviation Administration (FAA) personnel and use weather information from the NWS or Midwest Weather, depending upon the time the weather information is formulated. ATIS broadcast "Victor," recorded at 2251, included the information below. The next ATIS broadcast was not created until after the accident.

> Bradley Airport Information Victor zero three five one Zulu [2251 EST]: Weather two thousand two hundred scattered, measured ceiling two thousand seven hundred overcast, visibility one zero, light rain, temperature six two, dew point five seven, wind one six zero at two eight gust three niner, altimeter two niner five zero, approach in use ILS runway two

> four or VOR runway one five. Notice to Airmen: runway two four and runway one five open and wet, low level windshear advisories are in effect. Taxiway tango restricted to aircraft with a wingspan of less than one hundred seventy one feet. SIGMET X-ray Three is valid for severe turbulence below one zero thousand [SIGMET X-ray Three actually noted severe turbulence below one three thousand]. Predeparture clearances are available, advise on initial contact you have Victor.

ATIS Victor broadcast continually through the time of the accident. The Air Traffic Control Handbook, FAA Order 7110.65, states that a new ATIS recording should be made "Upon receipt of any new official weather regardless of whether there is or is not a change in values." The controller responsible for updating the ATIS hourly said that he had been planning to make a new recording but was waiting for the new weather to be displayed on the SAIDS (Systems Atlanta Information Display System). He said that he left the tower about midnight, and, at that time, the most current weather conditions had not appeared on the SAIDS equipment. He did not advise the on-coming controller that the weather had not yet appeared, and that a new ATIS should be made. When he gave the briefing to the relieving controller, the new weather conditions were still not available, and the telephones to the NWS did not work. He said that in such situations, controllers usually call the airport police station, and an officer goes across the hall to the NWS office, which, in turn, calls the tower and relays the weather information. He also said that this situation has occurred many times. However, this procedure was not implemented on the night of the accident.

The relieving tower controller said that he listened to the ATIS, but he did not notice the time on it. He did not notice if the SAIDS incoming information warning light was blinking, which would have indicated that new weather information was available. He said that the environment was very noisy (wind noise), and that he heard no SAIDS incoming information warning tones.

1.7.3 Turbulence Definitions

The following definitions are given in the Forecasting Guide on Turbulence Intensity, National Weather Service Operations Manual, Chapter D-22:

Light turbulence .. Absolute value of vertical acceleration (G) >.2 G to .5 G.

Moderate turbulence .. Absolute value of vertical acceleration >.5 G to 1.0 G.

Severe turbulence .. Absolute value of vertical acceleration >1.0 G to 2.0 G.

Review of the FDR vertical acceleration trace for flight 1572 from the time of the tree strike indicates an absolute value of the maximum change in vertical acceleration of about .5 G. The absolute value of the maximum change in indicated airspeed is about 10 knots.

1.7.4 WSR-88D Doppler Weather Radar Data

The Velocity Azimuth Display (VAD) Vertical Wind Profile from the Brookhaven, New York, WSR-88D radar (70 nautical miles south of BDL) showed the following estimated values at 0055:

Height	Wind Direction (degrees)	Wind Speed (knots)
1,000	160	60
2,000	170	80
3,000	170	80

The VAD Vertical Wind Profile for 0051 from the WSR-88D Doppler Weather Radar at the National Weather Service Forecast Office, Taunton, Massachusetts (69 nautical miles east of BDL) showed:

Height	Wind Direction	Wind Speed
1,000	160	45
2,000	160	60
3,000	180	75

Estimated upper winds generated on the Safety Board's McIDAS[12] workstation, based on November 11 at 1900 upper air data, showed the following for the BDL area:

Height	Wind Direction	Wind Speed
1,000	170	51
2,000	170	54
3,000	180	56
4,000	180	60

1.7.5 Low Level Windshear Alert System (LLWAS)

A Phase II LLWAS was installed and operational at BDL at the time of the accident. The system consists of five wind sensors; one is located at the centerfield and the other four are situated around the periphery of the airport [northeast, northwest, southwest, southeast]. The system was recertified on November 12, 1995, the day of the accident, and was found to be within tolerances. According to FAA Airways Facilities personnel, recertification involves removing each sensor from its stationary base and then testing it to ensure it operates properly. The recertification process does not include checking for proper alignment of the sensors on their stationary bases.

The approximate location of the first tree strike was about 289 degrees at 1.5 nautical miles from the northwest LLWAS wind sensor, the closest sensor to the tree strike. The following wind information was recorded from this sensor:

Time	Direction/Speed	Time	Direction/Speed
0055:17	220/12	0056:57	215/20
0055:27	214/12	0057:07	215/18
0055:37	208/10	0057:17	215/16

[12]McIDAS - Man Computer Interactive Data Access System. McIDAS is an interactive meteorological analysis and data management computer system. McIDAS is administered by personnel at the Space Science and Engineering Center at the University of Wisconsin at Madison. Data are accessed and analyzed on an IBM PS/2 Model 77 computer.

0055:47	210/09	0057:27	216/15
0055:57	223/06	0057:37	210/14
0056:07	227/08	0057:47	203/12
0056:17	225/13	0057:57	201/10
0056:27	215/18	0058:07	203/10
0056:37	215/21	0056:47	214/22

FAA personnel reviewed the BDL LLWAS data from October 31 to November 12, via the FAA Site Performance Evaluation System (SPES). The analysis indicated that the northwest LLWAS sensor was misaligned by approximately 20 degrees.

On February 5, 1996, the Safety Board requested that the FAA provide information on whether the alignment of the northwest sensor was checked and whether any corrections were made. Shortly thereafter, the FAA replied that the Weather Systems Engineering Branch, AOS-250, received the latest LLWAS meteorological data (the analysis period was from January 13, 1996 to January 21, 1996) from BDL on February 14, 1996, and the northwest sensor still appeared to be misaligned. A copy of all pertinent SPES data was faxed to the airways facilities technicians at BDL on February 15, 1996, and an inspection of the northwest sensor's anemometer alignment was performed by certified LLWAS technicians at the airport. The anemometer was found to be out of alignment by 38 degrees and was corrected on February 16, 1996. The FAA indicated that the misaligned sensor did not appear to degrade the system during the analyzed period.

According to FAA Airways Facilities personnel, the SPES information is analyzed monthly. Misaligned LLWAS wind sensors as well as failed components are identified and field personnel at the affected airports are notified. However, due to staffing limitations, it may be 3 to 6 months before the alignment of the wind sensors is physically checked by field personnel.

1.7.6 NCAR Atmospheric Simulation

A theoretical atmospheric simulation was accomplished to estimate the meteorological conditions that affected flight 1572 during the approach to BDL. The simulation was performed by scientists at the National

Center for Atmospheric Research (NCAR). The simulation was run on a Cray supercomputer using averaged information from horizontal increments of about 42 meters.

The results of the simulation indicated that a pressure decrease of about 1 millibar (1 millibar = 0.03 inch of Hg.) and downdrafts of about 400 feet per minute occurred near and to the northwest (lee side) of the ridge where the airplane contacted the trees. The pressure decrease and downdrafts extended to the lee side of the ridge for a horizontal distance of about 0.3 nautical miles. According to an NCAR scientist, the decrease in pressure may have been underestimated by 2 to 3 times over distances smaller than the horizontal resolution of the simulation. The strength of the downdrafts was not underestimated.

1.7.7 SIGMETs and AIRMETs

The following SIGMETs[13] and AIRMETs[14] were applicable to the time and route of flight of the accident airplane. They were generated by the NWS Aviation Weather Center, Kansas City, Missouri.

AIRMET Tango was issued on November 11 at 2145 and was valid until November 12 at 0400:

> Turbulence - Moderate turbulence below 15,000 feet due to strong winds and cold front moving across the area. Moderate turbulence between 15,000 and 40,000 feet due to strong winds and mid/upper level trough. Conditions mainly southwestern half of area spreading across remainder of area by 0400.

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[13]Significant meteorological information. An in-flight advisory forecast issued by the NWS Aviation Weather Center that advises of weather (other than convective activity) that is potentially hazardous to all aircraft. These reports cover large geographic areas of at least 3,000 square miles.

[14]Airman's meteorological information - An in-flight advisory forecast issued by the NWS Aviation Weather Center that advises of weather (other than convective activity) that may be hazardous to light aircraft, aircraft operating under visual flight rules (VFR), and inexperienced pilots. AIRMETs include moderate icing, moderate turbulence, and IFR conditions. These reports cover large geographic areas of at least 3,000 square miles.

> Strong Surface Winds - Sustained surface winds greater than 30 knots expected.
>
> Low Level Windshear Potential throughout the entire area.

AIRMET Zulu was issued on November 11 at 2145 and was valid until November 12 at 0400:

> Icing - Occasional moderate rime icing in cloud between freezing level to 20,000 feet. At 2200 freezing level 7,000 to 9,000 feet western portions of area, sloping 10,000 to 12,000 feet eastern sections.

AIRMET Sierra was issued on November 11 at 2215 and was valid until November 12 at 0400.

> IFR - Occasional ceilings below 1,000 feet and visibility below 3 miles in precipitation and fog.

SIGMET November 2 was issued on November 11 at 1930 and was valid until November 11 at 2330:

> Moderate occasional severe rime/mixed icing in cloud and in precipitation between 12,000 and 18,000 feet.[15]

SIGMET November 3 was issued on November 11 at 2235 and was valid until November 12 at 0235:

> Moderate occasional severe rime/mixed icing in cloud and in precipitation between 12,000 and 18,000 feet. Severe mixed reported by ATR-42 near Bridgeport at 2208 (November 11).

SIGMET X-ray 3 was issued on November 11 at 1840 and was valid until 2240:

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[15]Canaan, New York, (approximate beginning of descent of flight 1572) is about 20 nautical miles east of the eastern extent of the area outlined by this SIGMET.

> Moderate occasional severe turbulence below 13,000 feet due to strong low level winds. Low level windshear also expected.

SIGMET X-ray 4 was issued on November 11 at 2240 and was valid until November 12 at 0240:

> Moderate occasional severe turbulence below 13,000 feet due to strong low level winds. Low level windshear also expected.

The SIGMETs and AIRMETs were not given to the flightcrew of flight 1572 because AAL has its own meteorology department that prepares weather information for its flightcrews.

1.7.8 Weather Information Provided Under AAL Procedures

An American Airlines meteorologist who worked the 1600 to 0000 shift on November 11 stated that a SIGMEC[16] was issued for BDL during the day on November 11, 1995, to cover low level windshear, moderate turbulence below 8,000 feet and moderate icing in clouds and in precipitation between 10,000 to 18,000 feet. The SIGMEC was valid from November 11 at 1400 to November 12 at 0300 and stated:

> Occasional moderate turbulence is expected below 8,000 feet as strong winds develop during the afternoon and evening. Low level windshear also possible. Occasional moderate icing likely especially in the evening as widespread precipitation approaches/develops across the area. Affected altitudes 10,000 to 18,000 feet.

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[16]An FAA-approved weather product issued by AAL weather staff to support AAL flight operations. SIGMECs are issued when weather conditions exist for moderate or greater icing, low level turbulence, low level windshear, and/or thunderstorm activity in the vicinity of the terminal area. The terminal area is defined as about a 25 mile radius of the airport. En route SIGMECs are issued for significant weather conditions to include moderate or greater icing or turbulence and thunderstorms. SIGMECs cover geographic areas more specific to a particular AAL route of flight than do the more wide-ranging NWS SIGMETs.

The SIGMEC was based upon the following weather conditions:

1. Observed surface winds 160 degrees at 28 knots with gusts to 40 knots.

2. Observed winds aloft were between 60 to 80 knots from the surface to 5,000 feet.

3. Surface barometric pressure was falling rapidly due to approaching low pressure system.

4. Weather radar indicated heavy rain showers and isolated thunderstorms approaching BDL from Long Island Sound.

5. Numerous reports of low level windshear and moderate turbulence were received throughout the day from heavy aircraft in the New England area due to strong and gusty winds.

A meteorologist who worked the 0800 to 1600 shift stated that the SIGMEC was issued on the evening of November 11, 1995, for icing and turbulence because of icing reports from the area of the United States from which the weather was coming and because winds were forecast to be at an intensity/shear level that would justify possible low level windshear and moderate turbulence around BDL that evening. To the best of the meteorologist's recollection, reports from larger airplanes were indicating moderate turbulence "upstream" from the area of concern.

A meteorologist who came on duty at midnight on November 12 noted that the SIGMEC for BDL was in effect. He concluded that the SIGMEC continued to be valid based upon meteorological information and pilot reports available to the meteorologist. Therefore, the meteorologist believed that no further action was required to update this SIGMEC.

The AAL meteorology staff stated that the NWS SIGMETs and AIRMETs were not provided to flight 1572 because the AAL Weather Services is the FAA EWINS (Enhanced Weather Information System)-approved source of weather information. They further stated that the

SIGMECs generated by AAL Weather Services are an approved part of the EWINS agreement with the FAA. SIGMECs are designed to cover adverse weather phenomena, such as turbulence, icing and volcanic ash activity, along a particular aircraft's route of flight. According to the AAL meteorology staff, NWS SIGMETs are not usually provided to flightcrews by dispatchers because the dispatchers use the products of the AAL meteorologists rather than the NWS and because SIGMECs provide more specific information pertinent to the route of flight.

The dispatcher of flight 1572 stated that per AAL's dispatcher procedures, the flight release contained company-generated SIGMECs, but that NWS SIGMETs were available to dispatchers by computer at the dispatch position.

The flight release information provided by the dispatcher to the flightcrew of flight 1572 included the terminal SIGMEC for BDL, and the terminal SIGMEC for Syracuse, New York (SYR) issued on November 11 at 1205 valid until November 12 at 0100, stating:

> Occasional moderate icing in clouds and in precipitation is expected from 10,000 feet to flight level 18,000 feet, as widespread precipitation develops through the afternoon. Lower limit of icing is expected to approach surface from west to east this afternoon as a wintery mix of precipitation approaches the area.
>
> Occasional moderate turbulence is also expected below 8,000 feet as strong low level southerly winds shift to strong northerly and northwesterly winds after frontal passage. Brief low level windshear is possible especially near the cold front.

An American Airlines En Route Turbulence Index of "2" was indicated at flight plan altitude from top of climb to beginning of descent. According to American Airlines meteorologists, a "2" indicates a forecast of at most moderate chop.

1.7.9 Weather Information Received Via ACARS

The following weather information was transmitted to the flightcrew during the flight via the American Airlines ACARS:

> Time 2320 - BDL 2250 surface weather observation - 2,200 feet scattered, measured ceiling 2,700 feet overcast; visibility 10 miles, light rain; temperature 62 degrees F; dew point 57 degrees F; winds 160 degrees at 26 knots gusts to 35 knots; altimeter setting 29.51 inches Hg.; peak wind 160 degrees at 35 knots; pressure falling rapidly.
>
> Time 0030 - Weather Data as of 12/0001:
> Altimeter setting 29.42 msl.
> Pressure Altitude 645 feet ABV.
> Conversion 29.23 Inches Hg.
> Temperature 61 degrees F.
>
> Time 0031 - Attention [captain's name] - Have information from BDL Tower that aircraft have been making landings but have advised of turbulence and low level windshear on final. Winds are more aligned with runway at BOS if that becomes necessary.

1.8 Aids to Navigation

The FAA Maintenance Management System Log Incident Summary Listing stated that the postaccident BDL VOR flight check was satisfactory. The Summary Listing also stated that an evaluation of technical performance of ground equipment was completed for the BDL VORTAC, BDL VASI, and BDL ATIS, and no problems were noted.

1.9 Communications

There were no known communications difficulties associated with flight 1572.

1.10 Airport Information

Bradley International Airport is served by three paved runways. The field elevation is 174 feet msl. Runway 6/24 is 9,502 feet long and 200 feet wide. There is an ILS CAT I and a VOR or global positioning system (GPS) approach to runway 24 and an ILS CAT II and III, VOR, a nondirectional beacon (NDB) or GPS to runway 6. Runway 1/19 is 5,145 feet long and 100 feet wide. There are no instrument approach procedures published for this runway.

Runway 15/33 (the accident runway) is 6,846 feet long and 150 feet wide, with a 998 foot unpaved safety overrun area for runway 33. There is an ILS CAT I approach to runway 33 and a VOR (GPS) approach to runway 15. The BDL runway 15 VOR approach is used most often when the speed and direction of the winds preclude the use of the primary runway 06/24. The runway 15 threshold elevation is 170 feet msl and the touchdown zone elevation is 172 feet msl. Runway 15 is equipped with high intensity runway lights (HIRL), runway end identifier lights (REIL), and a visual approach slope indicator (VASI)-L (angle 3.5 degrees.). The runway is grooved.

The BDL VOR is located just north of the intersection of runways 6/24 and 15/33. The control tower and airline terminal buildings are located south of the intersection of runway 6/24 and 15/33.

The airport has an FAA-approved emergency plan, and it is certificated as Aircraft Rescue and Fire Fighting (ARFF) Index D, in accordance with 14 CFR 139.[17]

1.11 Flight Recorders

The airplane was equipped with a Sundstrand Model UFDR (S/N 7605) digital flight data recorder (DFDR). It recorded 78 parameters.

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[17]Index D is the FAA ARFF index for air carrier aircraft of at least 126 feet but less than 159 feet in length. 14 CFR 139 requires that a minimum of three ARFF vehicles be available that carry an amount of water and commensurate quantity of fire-fighting foam so that the total quantity of water for foam production carried by all three vehicles is at least 4,000 gallons.

The flight recorder tape was found undamaged with no evidence of excessive wear. The airplane was also equipped with a Fairchild model A-100A cockpit voice recorder (CVR) (S/N 53395). See Appendix B for a transcript of the CVR recording that lasts 31 minutes and 29 seconds. Figures 3a and 3b contain pertinent FDR parameters overlaid with pertinent flightcrew comments recorded on the CVR.

1.12 Wreckage and Impact Information

1.12.1 Altimeter Setting Documentation

Following the accident, the barometric pressure settings in the altimeters were observed to be as follows:

Captain's:	29.23 inches Hg.
First officer's:	29.23 inches Hg.
Standby:	29.47 inches Hg.

1.12.2 Wreckage Distribution

1.12.2.1 Impact with Trees

The initial impact mark from the airplane was with a tree located on the top of Peak Mountain Ridge, approximately 2.54 nautical miles northwest of the approach end of runway 15. Numerous additional trees also had indications of being impacted. The ground elevation at the bottom of the first impacted tree was 728 feet msl; the tree was determined to have broken at 770.5 feet. The approximate location of this tree was identified by GPS equipment as 41^{o} 58.22' N and 72^{o} 44.38' W. A survey of tree heights on and around the ridge performed shortly after the accident indicated that the trees in the area of initial impact were approximately 60 feet tall.

Debris from the airplane and small broken tree branches were found along the wreckage path in the wooded area on the ridge. The airplane pieces found were leading edge skin, trailing edge flap skin, belly and flap fairing fittings, and a clear wing tip lens cover. The right main landing gear outboard door was also located in the wreckage path. The total length of the wreckage path on the ridge was 290 feet. The bearing from the first to the last impacted tree on the ridge was approximately 137^{o} magnetic.

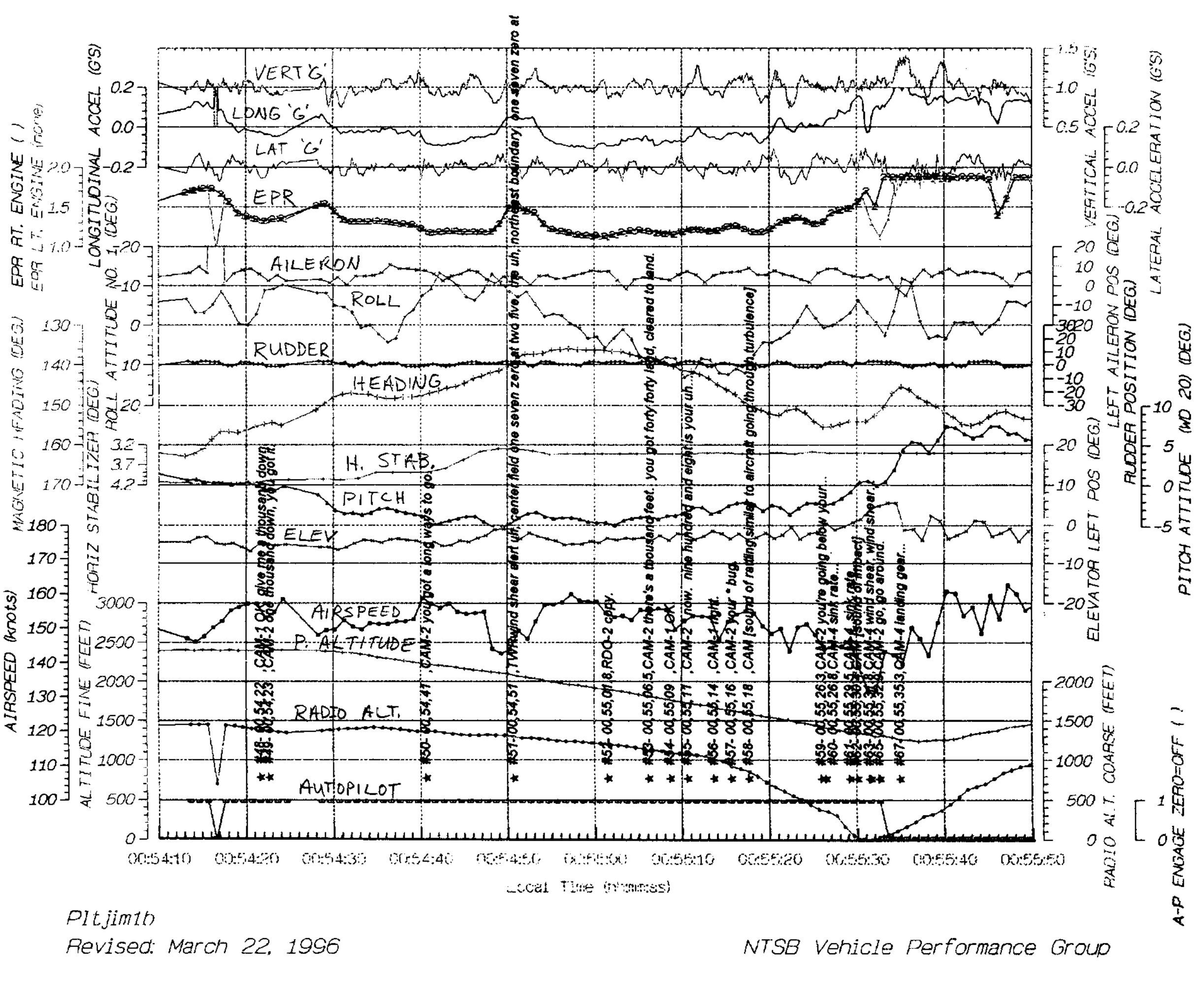

Figure 3a.--FDR plots and CVR comments.

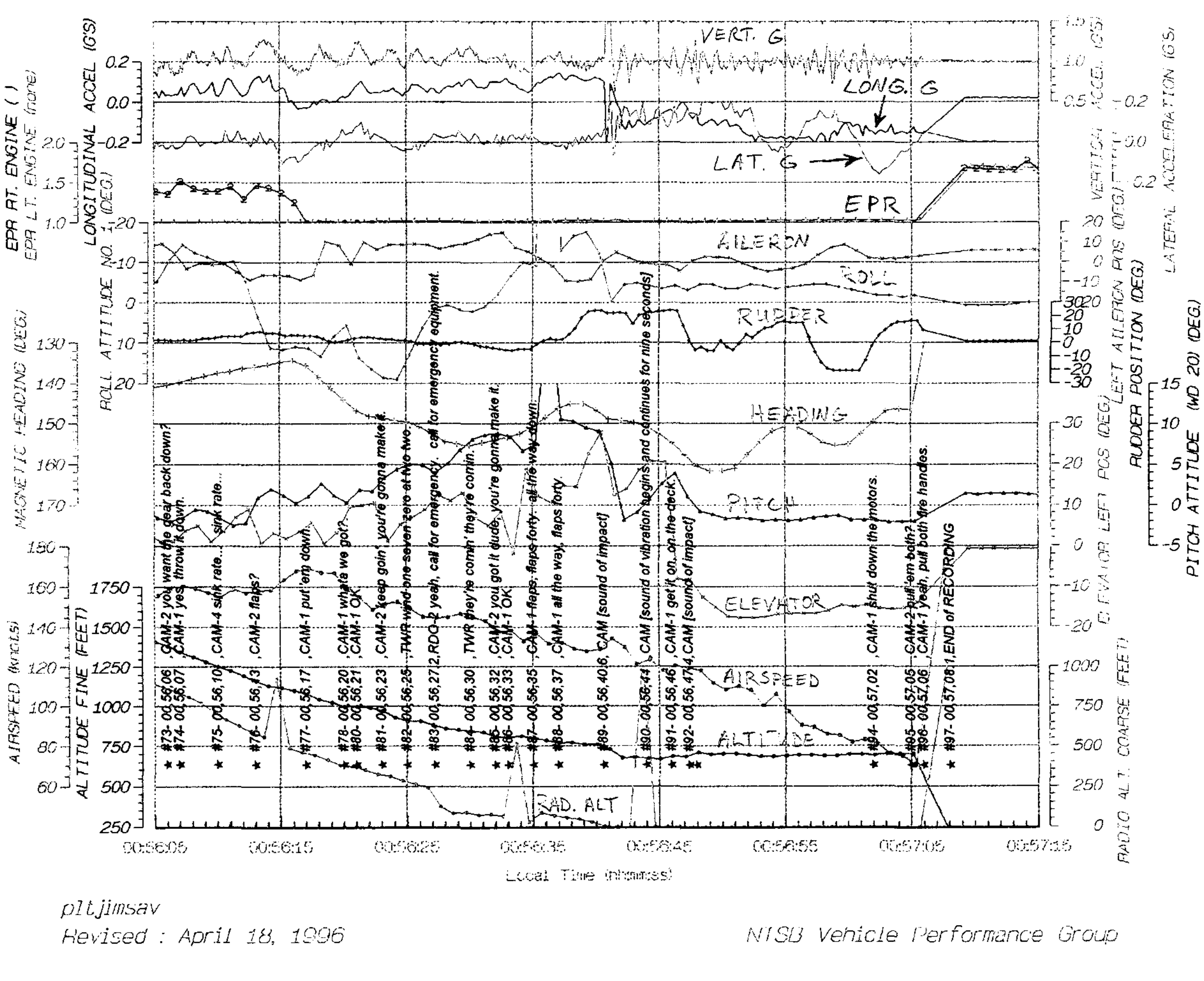

Figure 3b.--FDR plots and CVR comments.

About 1,100 feet prior to the initial ground impact mark, a tree, located in the flightpath of the airplane landing on runway 15, sustained a sharp metal strike mark 76 feet above the ground. This tree was at an elevation of about 170 feet msl.

1.12.2.2 Ground Impact Information

A total of 14 orange metal posts were fastened to 14 pairs of concrete pads to support the localizer antenna. Post No. 13 exhibited evidence of a black tire mark about 6 feet above the ground. Posts Nos. 3 to 12 were destroyed and were broken into numerous pieces. Three localizer antenna posts (Nos. 1, 2 and 14) exhibited no impact damage.

The first ground scar, consisting of a black tire mark, was located below post No. 10. This pad was approximately 18 feet to the right of stopway centerline. A ground scrape mark progressed from below post 10 and extended toward the runway overrun area, in the direction of flight.

The left and right main landing gear tire marks crossed the runway threshold mark on the left side. A runway threshold light (second from the left) sustained impact damage and was found on the left side of the runway. The left main landing gear tire marks departed the runway edge at the threshold mark and remained on the pavement. The right main landing gear tire mark remained inside the runway edge line. These tire marks curved back toward the runway centerline after crossing taxiway "J". The airplane came to rest on the runway approximately 3,137 feet from the runway threshold.

1.12.3 Structural Damage

1.12.3.1 Fuselage

The airplane was damaged from its impact with the trees and localizer antenna posts. There was no fire damage to the fuselage and no impact damage to the fuselage above the floor line. No impact damage or skin waviness[18] was noted in the areas around the pitot tubes or static ports. The fuselage section forward of the wing front spar had no impact damage. The fuselage belly honeycomb fairing, aft of the wing front spar, sustained impact damage with numerous punctures and some scrape marks from forward to aft.

The left main landing gear forward wheel well structure, which supports the honeycomb fairing, sustained impact damage and was bent aft. Orange paint transfer marks were found in the area of impact. The hydraulic lines in the wheel well just aft of the impact location were severed. The right main landing gear forward wheel well structure was damaged and bent slightly aft. Wood fibers were found embedded at the right main landing gear impact location, and there were no paint transfer marks.

The lower section of the aft pressure bulkhead was crushed radially inward. About 12 inches of structure on either side of the bulkhead centerline were bent upwards. The main vertical beam remained intact and was undamaged. The right side stringers were deformed slightly upwards.

1.12.3.2 Wings

1.12.3.2.1 Left Wing

The left wing remained attached to the fuselage with damage to the leading and trailing edge control surfaces. The damage consisted mainly of dents and tears, forming a semicircular shape, with wood fiber embedded at the impact locations. The leading edge of the three inboard slats exhibited impact damage at numerous locations. The trailing edge flaps remained attached to the wing and were found extended to 40 degrees. The inboard flap suffered damage at two locations.

1.12.3.2.2 Right Wing

The right wing remained attached to the fuselage with damage to the leading and trailing edge control surfaces. The leading edge slats

[18]Skin waviness is mild wrinkling of the fuselage skin because a skin panel does not always conform to the exact outer mold line of an airplane. Skin waviness in the vicinity of static ports could alter the local static pressure sensed by the ports.

remained attached to the wing and sustained severe impact damage. The trailing edge flaps remained attached to the wing and were found extended to 40 degrees. The inboard flap sustained one large area of impact damage at its inboard end, and two such areas on its outboard end.

1.12.3.3 Landing Gear

The nose landing gear was extended and remained attached to the airplane with minor impact damage. Both nose landing gear taxi lights were broken. Small pieces of nose landing gear taxi light glass and a retainer ring were found on the ridge. Small tree limbs, about 8 inches long and 1 inch in diameter were found wedged between the taxi light fixtures. Both tires remained inflated and there was no evidence of flat spots or lateral scrape marks on the tires.

The right main landing gear was extended and remained attached to the airplane with impact damage to the strut scissors assembly. The landing gear tires remained inflated. The outboard gear door was missing and was located on the ridge. The inboard gear door remained attached and was found in the open position.

The left main landing gear was extended and remained attached to the airplane with minor impact damage. The outboard tire of the left main landing gear had burst at some point in the accident sequence, and was replaced on the runway to facilitate towing the airplane to the hangar. Small twigs were found wedged between the tires.

1.12.3.4 Empennage

There was no evidence of any damage to the vertical stabilizer, rudder, and rudder trim tab. The right horizontal stabilizer leading edge contained a 3-inch-wide area of impact damage 5 feet inboard from the tip. The damage was about 3 inches wide, and the leading edge was crushed aft. Wood bark was found embedded in the impact location. There was no other damage to the right horizontal stabilizer.

1.12.3.5 Hydraulic System

Hydraulic lines in both main landing gear wells were damaged in the vicinity of other wheel well structural damage. On the forward wall of the left main landing gear well, the left system ground service and power transfer suction lines were broken. In addition, a brake return line near the control module was bent and leaking. In the right wheel well, several lines were broken between the brake control module and the landing gear.

1.12.3.6 Powerplants

Both engines had tree branches and sticks in the inlets. The fan blades on both engines had soft body impact damage and wood fibers were found on the underside of the mid-span shrouds. The left engine cases and fan ducts did not have any holes or penetrations, and the fourth stage turbine blades were intact. The right engine fan duct and intermediate case were burned in the plane of the seventh and eighth stage compressor stages; however, the cowling was not burned. The forward side of the mixer lobes and struts had metal spatter build up. The right engine did not have any other apparent damage.

Internal examination of the engines revealed that the left engine low pressure compressor (LPC) stages were damaged due to the impact of the rotors with the stators, particularly in the third stage area. The high pressure compressor (HPC), high pressure turbine (HPT), and low pressure turbine (LPT) were not damaged, but they had metal spatter on the airfoil surfaces. The right engine LPC stages were also damaged due to the impact of the rotor with stator airfoils. The HPC seventh, eighth, and ninth stage blades were burned, almost down to the airfoil platforms. Metal spatter was found on the HPT and LPT airfoils. The fuel controls and fuel pumps were bench tested and found to be working correctly.

The flight data recorder engine pressure ratio parameters indicated that the engines were operating at engine pressure ratios of about 1.5 at the time of the ridge line tree strike. No mention of engine problems prior to the ridge line tree strike were noted upon review of the cockpit voice recording.

1.13 Medical and Pathological Information

Shortly after the accident, both flight crewmembers underwent standard drug testing. The results of these tests were negative.

1.14 Fire

See Section 1.12.3.6 for description of fire damage to the right engine.

1.15 Survival Aspects

According to interviews with the flight and cabin crewmembers, after the airplane stopped, the captain ordered an evacuation. A flight attendant opened the aft emergency exit/galley door, but the slide did not inflate automatically, as intended. He pulled the manual inflation handle, and the slide then inflated. An unknown number of passengers and two flight attendants evacuated through this exit.

Because the evacuation slide failed to inflate automatically, it was examined by investigators from the Safety Board, American Airlines, and the FAA at the facilities of the manufacturer, Air Cruisers Company.

Three tests were conducted on the airplane's emergency evacuation slide assembly. The first two tests followed the Douglas maintenance manual instructions which did not call for the inflation cable to be routed through the grommet on the girt bar grommet tab. The instructions stated, "check that loop on firing lanyard is secured to girt tab with retaining ring on manual inflation handle; then secure lanyard cover flap over firing lanyard." In those two tests, the slide dropped down but did not unfold or inflate. In the first test, the manual inflation handle remained within view when the door was opened, and within reaching distance of the cabin door. In the second test, the handle dropped over the side of the fuselage, and it could not be seen from the cabin by someone standing at the door. In the third test, the inflation cable was routed through the grommet on the girt bar grommet tab. When it was tested, the slide inflated properly.

In July, 1996, McDonnell Douglas incorporated revised text and graphics on the installation of floor level emergency evacuation slides into the

FAA-approved MD-80 and DC-9 maintenance manuals. That revision instructs the installer to "[p]ass [the] inflation cable[19] loop through [the] grommet tab," and includes two diagrams illustrating the proper routing of the inflation cable through the grommet tab.

According to the flight attendants and questionnaires that passengers provided to the Safety Board, during the evacuation, flight attendants shouted commands to passengers to remove their shoes (regardless of shoe style) and to leave carry-on luggage on the airplane. About a third of the passengers who completed questionnaires stated that shoe removal either slowed their evacuation or that shoes in the aisle obstructed their exit. Passengers (including a woman carrying a 10-month old baby) reported that they stumbled or tripped over piles of shoes in the aisle and galley areas.

American Airlines is the only major air carrier that commands passengers to remove all shoes during an evacuation.

1.16 Tests and Research

1.16.1 Systems Tests

1.16.1.1 Pitot-Static System

The airplane was equipped with three pitot-static systems. The captain's system provides inputs to digital central air data computer (CADC) No. 1, which drives the captain's primary flight instruments (Mach/airspeed indicator, vertical speed indicator, and altimeter). The first officer's system provides inputs to CADC No. 2, which drives the first officer's primary flight displays. The third system, known as the auxiliary system, provides inputs directly to the standby altimeter and airspeed indicator. Each system has its own pitot probe and static ports.

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[19]In the revised text and graphics, the term "inflation cable" is sometimes used in place of the previously used term for the same part, "firing lanyard." However, the term "firing lanyard" is still used to designate that part in several diagrams and unchanged portions of the maintenance instructions for removal and installation of evacuation slides.

Following the accident, an atmospheric leak check was performed on all three systems in accordance with the AAL Maintenance Manual. According to the test procedure, the maximum allowable changes in altitude and airspeed during the test are 100 feet and 5 knots in 1 minute (i.e., leakage in the system may not result in more than 5 knots airspeed deviation or 100 feet difference in altitude). All three systems successfully passed this test.

An additional test was performed to determine the relative accuracy of the pitot static systems. All three systems were tested at simulated approach flight conditions, and the cockpit airspeed and altitude readings were recorded. Indications from all three sets of flight instruments were within 25 feet and 3 knots of each other at all flight conditions tested.

The CADCs have a self-test capability. Both computers successfully passed this test. In addition, it was noted that the magnetic fault indicators (fault balls) on the computers were not tripped.

The heater elements in the pitot probes and static ports were tested and found to be functioning properly.

1.16.1.2 Autopilot Systems

The airplane was equipped with two autopilot systems, each controlled by a digital flight guidance computer. In the vertical axis, the autopilots can fly the airplane through various flight maneuvers such as maintaining an existing altitude and climbing or descending to a preselected altitude and holding that altitude. Selection of modes is done through the flight guidance control panel.

Following the accident, the E-24 circuit breaker (DC Autopilot 1) was found tripped in the cockpit. It could not be determined when the circuit breaker tripped. During systems group testing, electrical power was applied to the airplane, and the E-24 circuit breaker was reset. It remained in for the duration of the testing without tripping.

An autoland preflight test, normally initiated during the autoflight portion of the daily preflight, was performed after the accident, and both autopilot systems successfully passed this test. Further, a return-to-service test, normally performed by maintenance personnel following replacement of an autoflight system component, was also accomplished, and both systems successfully passed this test.

Several additional tests were performed to evaluate the effect of the E-24 (DC Autopilot 1) circuit breaker on Autopilot 1 system operation. With the system engaged, tripping the circuit breaker caused the blue AP 1 engagement lights on the flight mode annunciators to go out and the red flashing AP DISCONNECT lights to illuminate. In another test, it was determined that if the circuit breaker was already tripped, Autopilot 1 would not engage.

Following the accident, the flight guidance system of an American Airlines MD-80 simulator was used to capture a VOR course on a VOR instrument approach and to establish rates of descent using the vertical speed mode of the autopilot. Prior to the final approach fix (FAF) for the VOR instrument approach, altitude capture was accomplished using the altitude select window. After passing the FAF, altitude capture was accomplished using the altitude hold button on the flight guidance panel.

With manual capture of altitude, using the altitude hold button, a vertical speed of 1,100 feet per minute, and the "rough air" feature of the simulator activated, the rate of descent was simulated. When the altitude hold button was engaged, the simulator continued to descend an additional 120 to 130 feet. The simulator then recovered, or climbed back up to, the selected altitude. In simulated smooth air, the simulator recovered with less total loss of altitude. For example, with rate of descent of 700 feet per minute, when altitude hold was engaged, the loss and recovery took about 50 feet. Similarly, with a rate of descent of 1,100 feet per minute, a recovery from about 80 feet below the desired altitude occurred.

1.16.1.3 Windshear Warning System

The airplane was equipped with a Honeywell Standard Windshear System, which is designed to provide warnings to the flightcrew in the event of a potentially hazardous windshear condition. The computer activates yellow caution lights if it detects an increasing performance windshear, and it activates red warning lights and an aural "WINDSHEAR, WINDSHEAR, WINDSHEAR" warning if it detects a decreasing performance windshear. A successful self-test of the windshear warning system was performed in accordance with the AAL Maintenance Manual.[20]

1.16.1.4 Ground Proximity Warning System

The airplane was equipped with an Allied-Signal Mark II Ground Proximity Warning System (GPWS) computer. This computer utilizes a radio altimeter[21] and barometric altitude rate information to determine proximity with the ground. The GPWS is designed to activate electronically produced word warnings and visual light warnings to warn the flightcrew when a hazard is detected.

The system operates in several modes to provide warnings for various unsafe flight conditions. These modes include: excessive descent rate, excessive terrain closure rate, descent after takeoff, descent in wrong configuration, and excessive deviation below the glideslope.

During a non-precision approach, with the airplane configured for landing (gear and flaps down), the only mode available is excessive rate of descent warning. In this mode, the computer monitors barometric sink rate beginning with the airplane descending below 2,450 feet (agl). If the sink rate exceeds a threshold value, a "SINK RATE" aural warning is issued. At approximately 200 feet (agl), the threshold value is approximately 1,200 feet per minute. According to the CVR transcript, the "SINK RATE" warning is heard 4 seconds before the sound of the first impact with the trees.

A ground proximity warning system (GPWS) ground test was performed according to the AAL Maintenance Manual. The test was successfully completed, and all annunciations and aural warnings operated normally.

According to Allied-Signal, development is underway on an upgraded GPWS system known as Enhanced GPWS. This system

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[20]During the accident sequence, the windshear warning system did not activate until just after the ridge line tree strike occurred.

[21]A radio altimeter, sometimes called a radar altimeter, does not require accurate barometric pressure settings, but rather gives readouts of height above the ground by time-varying frequency and by measuring differences in frequency of received waves, proportional to time and height.

incorporates aircraft position data (from the flight management system) with a self-contained terrain database to offer enhanced protection from descent into terrain. On a non-precision approach, the enhanced GPWS can anticipate the terrain features within a 25 mile radius of the airport and offer warnings to protect against premature descent into terrain, regardless of airplane configuration. This system is expected to be certified by the FAA for use in aircraft in 1996.

1.16.1.5 Other Systems

The follow-up rod that drives the left flap position sensor was bent and damaged. It was not possible to determine how this damage would have affected the flap position indication. During the initial on-scene investigation, the flap track indicators showed that the flaps were in the 40 degree position. No anomalies were seen during flight control cable tension tests. All six fuel boost pumps were tested and found to operate normally. A DME functional/accuracy test was performed, and no problems were noted.

1.17 Organizational and Management Information

1.17.1 American Airlines - General

1.17.1.1 Pilot Training

The American Airlines McDonnell Douglas MD-80 fleet is in applicant status for the Advanced Qualification Program (AQP).[22] Accordingly, pending development/completion of the AQP, pilot qualification, including training and certification, is conducted under the terms of Exemption Number 5950, which grants relief from some of the traditional pilot qualification requirements of 14 CFR Part 121. For example, the FAA grants permission to perform a single visit training (SVT) session, which is once per year training, to any carrier that applies to develop an AQP, while the AQP development is in progress (see Section 1.17.1.2). The AQP

[22]The Advanced Qualification Program is described in Special Federal Aviation Regulation (SFAR) 58. The purpose of the AQP is to “provide for approval of an alternate method for qualifying, training, certifying, and otherwise ensuring competency of crewmembers, aircraft dispatchers, other operations personnel, instructors, and evaluators who are required to be trained or qualified under Parts 121 and 135 of the FAR....”

development process may take 2 or more years to complete for each airplane type. American Airlines applied for approval of an AQP in April 1994 for SVT on all its airplanes, beginning with the Fokker F-100. Once the AQP has been approved by the FAA, pilot qualification will be conducted in accordance with the AQP requirements of SFAR Number 58. At that time, Exemption Number 5950 will no longer be applicable.

1.17.1.2 American Airlines Single Visit Training

Single Visit Training differs from traditional FAR Part 121 training and checking requirements in that it is conducted annually for captains and first officers rather than bi-annually. A training session every 6 months, as opposed to every 12 months under SVT, is conducted only for initial upgrade captains, captains who fail a SVT proficiency check, or captains who require additional training. Single visit training consists of on-site ground and flight training/checking for a 4- or 5-day period. Two days of the recurrent ground training cover security, crew resource management, aircraft systems, performance and emergency equipment review. Two 4-hour simulator sessions are scheduled with specified briefing and debriefing periods. The first simulator is a practice session overseen by a simulator pilot to review and practice required maneuvers. The second 4-hour simulator session, overseen by a check airman, includes a recurrent line operated simulation (LOS)[23] period followed by an annual proficiency check for both flight crewmembers.

The FAA approved Exemption 5950 for AAL based upon a SVT training plan with certain conditions and limitations. One of the limitations imposed upon AAL is that the airline must include a pretraining "first-look" evaluation that addresses at least a core set of Part 121, Appendix F,[24] material prior to the repeated execution of any such core set items in a simulator or training device. The maneuvers, tasks, or procedures are those most likely to be sensitive to loss of proficiency because of infrequency of

[23]Line operational simulation (LOS) is the FAA’s revised terminology for training that was formerly known as line oriented flight training (LOFT), and includes special purpose orientation training and line operational evaluation. The revised definition (FAR Part 142.3) was adopted on May 23, 1996, and became effective on August 1, 1996.

[24]Appendix F sets forth maneuvers and procedures required to be demonstrated in pilot proficiency checks.

practice. Data on the first look maneuvers is provided to the FAA on a de-identified basis.

The MD-80 Worksheet, dated February 1995, included four items designated as "first-look" maneuvers. One of the first-look maneuvers is the non-precision approach. Further, AAL requires this non-precision approach to be included in the first-look evaluation in all the fleet training programs that AAL operates. The captain completed American Airlines 4-day SVT on August 21, 1995. The first officer completed SVT training on August 19, 1995. Both flight crewmembers received satisfactory performance reports during their training.

1.17.1.3 Company Altimeter Procedures

AAL is the only United States airline that uses the QFE (height above field elevation) altimeter setting system during the takeoff, departure, approach, and landing phases of flight.[25] American Airlines procedures require flightcrews to set their primary altimeters so that they read altitudes above the elevation of the airport they are departing from or at which they are arriving, while the standby altimeter continues to show altitude above sea level. Other U.S. airlines use the QNH (height above sea level) altimeter setting system during all flight phases. These airlines set all their altimeters to show altitudes above sea level at the departure and arrival airports. During the cruise phase of flight, all airlines use the QNH altimeter setting method. The details of American Airlines QFE altimeter setting methodology follow.

During a descent, AAL procedures call for the flightcrew to set the proper QNH altimeter settings in both the primary altimeters (the captain’s and the first officer’s) and the standby altimeter located on the center instrument panel. This is to be accomplished when passing down through the flight level 180 (in the United States). After reaching the AAL "changeover altitude" (10,000 feet), the flightcrew is to set the captain's and first officer's altimeters to a QFE setting so that they read height above

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[25]The former Eastern Airlines also used the system in its operations. Currently, several foreign carriers use the system in international operations. There are certain airports within the AAL system with very high field elevations that require the pilot to use only QNH (height above sea level) altimeter settings during approaches. Mechanical limitations within the altimeters preclude the adjustment of the altimeters to satisfy QFE requirements.

destination field elevation. As a cross-check to ensure that the company-provided QFE setting is accurate, a comparison should then be made between the altitude shown on the flightcrew’s altimeters and that shown on the third standby altimeter containing the QNH (height above sea level) setting. The difference, in feet, between the flightcrew's altimeters and the standby altimeter should equal the published elevation of the airport of intended landing.

During descent and prior to arrival at the final approach fix (FAF), AAL procedures require the flightcrew to use the standby altimeter with the QNH setting for intermediate air traffic control or approach plate directed level-offs. According to AAL procedures, upon arrival at the FAF, the flightcrew should begin using their primary altimeters which are set QFE. If a missed approach is commenced, the flightcrew should revert to the standby altimeter (QNH) for altimeter information.

After landing, AAL flightcrews’ primary altimeters should read zero feet. Flightcrews of airlines that use the QNH system, on the other hand, should see altimeters that read the field elevation of the airport after landing.

According to many AAL flightcrews, one advantage of the QFE system over the QNH system is the standardization of approaches with regard to altitudes seen by flightcrews from the FAF until landing. This is especially true, they said, during ILS approaches that usually have minimum altitudes of 200 feet above the ground. Most approaches flown by AAL flightcrews are ILS approaches. Regardless of the field elevation above sea level, flightcrews become accustomed to using 200 feet above the ground as a minimum altitude. Each approach, no matter what the airport elevation, will appear the same to flightcrews, concerning minimum altitude.

According to the AAL DC-9 Operating Manual, the following mandatory altitude callouts are to be made by the pilot not flying during an approach to land:

1. 1,000 feet above field level
2. 100 feet above minimum descent altitude (MDA)
3. MDA

The first officer, who was the pilot not landing, called out: "There's a thousand feet" at 0055:06 The flight recorders revealed that this one thousand foot callout was made when the primary altimeters indicated that the aircraft was about 1,140 feet above the field elevation, based upon the altimeter setting of 29.23 (QFE). The CVR does not reflect a callout at 100 feet above MDA.

1.17.1.4 Actions of American Airlines Since the Accident

On December 20, 1995, 38 days after the accident involving AAL flight 1572, AAL flight 965, a regularly scheduled passenger flight from Miami, Florida, to Cali, Colombia, struck terrain near Buga, Columbia, 33 miles northeast of the Cali (CLO) VOR navigation aid, in night visual meteorological conditions, during a descent for a landing at Cali. The airplane was destroyed, and 159 of 163 passengers and crewmembers aboard lost their lives. The Colombian civil aviation authority determined that the probable causes of that accident were:

1. The flightcrew's failure to adequately plan and execute the approach to runway 19 at [the airport] and their inadequate use of automation.

2. Failure of the flightcrew to discontinue the approach into Cali, despite numerous cues alerting them of the inadvisability of continuing the approach.

3. The lack of situational awareness of the flightcrew regarding vertical navigation, proximity to terrain, and the relative location of critical radio aids.

4. Failure of the flightcrew to revert to basic radio navigation at the time when the FMS-assisted navigation became confusing and demanded an excessive workload in a critical phase of flight.

Contributing to the cause of the accident were:

1. The flightcrew's ongoing efforts to expedite their approach and landing in order to avoid potential delays.

2. The flightcrew's execution of the GPWS escape maneuver while the speedbrakes remained deployed.

3. FMS logic that dropped all intermediate fixes from the display(s) in the event of execution of a direct routing.

4. FMS-generated navigational information that used a different naming convention from that published in navigational charts.[26]

Discussions between FAA and AAL officials in early January 1996 led to AAL's formation of a Safety Assessment Program to examine seven critical phases of American's operations. AAL plans to have quarterly progress meetings and issue a final report in January 1997. AAL also implemented immediate actions after the accident that included raising the:

1. minimum descent altitude and visibility requirements for all non-precision approaches by 100 feet and 1/2 mile, respectively,[27]

2. visibility minima on all NDB approaches by 1 statute mile, and

3. the ceiling of the "sterile cockpit" from above 10,000 feet to above 25,000 feet in Latin American airspace.

On January 19, 1996, AAL distributed to all of its DC-9 captains and first officers DC-9 Operating Manual Bulletin No. DC-9-2 (in the form of additional checklist pages) entitled "Non-Precision Approach Crew Coordination Procedures." The bulletin states, in part:

> Despite its name a non-precision approach must be executed with exacting precision.

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[26]Aircraft Accident Report, "Controlled Flight Into Terrain, American Airlines Flight 965, Boeing 757-223, N651AA, Near Cali, Colombia, December 20, 1995." Aeronautica Civil of the Republic of Colombia.

[27]These restrictions have since been eliminated following the completion of other phases of the Safety Assessment Program.

> MDAs and step-down altitudes are limits. Any altitude level-off variation must be *above* the MDA or step-down altitude rather than *below* [italics in original bulletin].
>
> The primary attention of both pilots will be directed to the level-off at the step-down altitude or MDA.
>
> After level-off at the MDA, the pilot-not-flying will direct primary attention outside the airplane and call out visual references in the sequence required.

AAL's examination of its operations was to be carried out through seven assessment teams, each with representatives of the airline, the pilot's union and the FAA. The seven areas addressed by these teams are:

> 1. Human factors issues pertaining to the recent accidents, including approach charts, procedures, and training;
>
> 2. Division-specific items, dealing with issues relevant to unique geographic features;
>
> 3. Advanced technology relating to flight management system (FMS) and GPWS modifications;
>
> 4. Operations structures and procedures, including corporate culture or organizational influences on flight operations;
>
> 5. Flight Operations Quality Assurance (FOQA), and evaluation of its implementation in conjunction with AAL's "Airline Safety Action Partnership" (ASAP) program to improve training in general for feedback into the Advanced Qualification Program (AQP);
>
> 6. Confidential reporting system data analyses; specifically, examination of all available information, and assess any new and useful techniques from other operators for accident prevention; and

7. Pilot communications, including visits by the Senior Vice President, Flight Operations, and the President, APA, to meet all pilots and flight managers at all crew bases.

In addition, AAL established a Controlled Flight Into Terrain (CFIT) Task Force and a Non-Precision Approach Working Group. It also inserted specific guidance on flightcrew response to CFIT scenarios in the Advanced Aircraft Maneuvering Program. All AAL simulators now have specific terrain profiles in which flightcrews will receive GPWS terrain warnings and are expected to extract maximum aircraft performance in recovery. The airline briefed the Safety Board at the 6 month or midpoint of its Safety Assessment Program and has reported that the assessment program's report is expected to be completed on schedule in January 1997.

1.17.2 FAA Surveillance of AAL Flight Operations

The FAA conducted a National Aviation Safety Inspection Program (NASIP) inspection of AAL from August 21 through September 1, 1995. Both airworthiness and operations were inspected. One area of potential deficiency noted involved operations training. Specifically, it was found that AAL broke up crew pairs in the SVT training program, contrary to the terms of Exemption 5950 and the AAL Approved Training Manual. A crew pair consists of a captain and a first officer. Both documents state that pairs of crewmembers should remain together as much as possible through all phases of training and checking. During the NASIP inspection, 35 cockpit en route inspections were performed. Those en route inspections resulted in no findings concerning flight operations.

The captain had been observed by FAA flight inspectors during four en route inspections. FAA records indicated that the captain does not have an accident/incident or violation history.

There is no record of FAA en route inspections for the first officer. FAA records indicated that the first officer does not have an accident/incident or violation history.

1.17.3 FAA Instrument Approach Design Procedures

In the past, the FAA instrument procedures development personnel were collocated with Flight Inspection Area Office (FIAO) personnel, and, in fact, served as copilots on FIAO flight inspection missions. Following the loss of a Beech Super King Air 300/F flight inspection airplane near Front Royal, Virginia, on October 26, 1993, the Safety Board issued Safety Recommendation A-93-165 to the FAA on November 24, 1993. Subsequently, the procedures development program was separated from the flight operations inspection program. Safety Recommendation A-93-165 asked the FAA to:

> Direct the Office of Aviation System Standards to evaluate the recommendations in the 1989 System Safety Survey relating to the second-in-command responsibilities and flying proficiency and to establish duties as appropriate.

> The Administrator responded to this recommendation by stating:

> On February 5, 1995, all procedures development duties were removed from the second-in-command (SIC) position description, and SIC duties are restricted to flying responsibilities.

FAA Terminal Instrument Procedures (TERPS) Handbook, FAA Order 8260.3B, contains standardized methods for designing instrument flight procedures for non-precision approaches. The development and final approval of a non-precision instrument approach is accomplished in several steps. First, the basic procedure is developed by the National Flight Procedures Office in Washington, D.C. (AVN-100) in coordination with the nearest regional Flight Procedures Office (FPO) to the airport where the approach is to be used. Once developed, the procedure is sent to the Technical Support Branch, AVN-160, for a quality control review. After the review, the procedure is sent to the Flight Inspection Operations Division, AVN-200, through the FIAOs, to ensure that the descents and turns on the approach are within realistic flight inspection tolerances. AVN-200 is also responsible for ensuring that obstacles marked on the chart are actually where they are depicted, and that the obstacles are as high as the chart depicts.

According to the FAA, the FIAO is responsible for final approval of instrument flight procedures by ensuring that:

> (1) Data used to develop the instrument approach procedure was correct.
>
> (2) The instrument approach procedure was developed in accordance with FAA Order 8260.3B TERPS and Order 8260.19 [C], Flight Procedures and Airspace, and other appropriate directives.…

In reference to obstacle data accuracy, paragraph 270 of FAA Order 8260.19 states:

> The evaluations can provide accurate, consistent, and meaningful results and determinations only if FIAO and regional flight procedures specialists apply the same rules, criteria, and processes during development, review, and revision phases.

The National Flight Procedures Office (AVN-100) uses maps, charts, surveys and mathematical data to develop the basic approach procedure. The FIAOs under AVN-200 use airplanes, theodolites (optical devices to measure angles and thus heights), and other direct measuring equipment for obstacle height verification.

The Atlantic City, New Jersey, Flight Inspection Area Office (FIAO), initially verified the height of the obstacles on the BDL VOR runway 15 approach as it was being developed. This office also rechecked the obstacles after this accident. On both occasions, the FIAO determined that the approach was "obstacle free."

1.17.3.1 Terminal Instrument Procedures (TERPS) and the VOR Approach to Runway 15

The instrument approach to runway 15 was first published and became effective on February 9, 1989. The controlling obstacle in the final segment (the highest obstacle that could affect the approach) was 739 feet of terrain and an additional 80[28] feet tree height, for a total height of 819 feet msl. This is the ridge line and trees that the flight 1572 initially struck.

Amendment 1 to the procedure was effective on the same date, February 9, 1989. The amendment revised the missed approach point (MAP) from a point defined by time and distance to one based upon the BDL VOR.

Amendment 2, effective on July 20, 1995, included several changes to the procedure. One change included the addition of a visual descent point (VDP) to the approach. A VDP is defined as a point on the final approach from which normal descent from the MDA to the runway touchdown point may be commenced, provided that visual reference is established. The VDP was 3.1 nautical miles from the BDL VOR, which is 2.86 nautical miles from the threshold of the runway.

On April 8, 1994, the Air Line Pilots Association (ALPA) sent a letter to the Manager of the Flight Procedures Review Branch in the FAA's New England Region. In part, the letter stated that several pilots had experienced GPWS warnings while descending from the 5 nautical mile FAF to the 3.1 nautical mile VDP. ALPA stated that the steep nose-down attitude might have been exacerbated by the close proximity in that segment of the ridge line struck by flight 1572.

In the summer of 1994, as a result of ALPA's concerns, an analysis of the VDP was undertaken by the FAA. The FAA procedures analyst indicated that a "no-VASI" standard (3 degree descent angle) had been used in the VDP placement, thereby placing the VDP at 3.1 nautical miles from the VOR. This is 0.6 nautical mile farther away than the VDP would have been located using a "with-VASI" standard (3.5 degree descent angle). Because a 3.5 degree VASI was already on runway 15 at BDL, it was determined that the VDP located according to a no-VASI 3 degree descent standard should not have been published, and it was removed by Amendment

[28]Although FAA standards specify 60 feet as an acceptable tree allowance in the Connecticut area, the procedures specialist stated that he retained the original 80 foot value (used when the approach was first designed) to provide an added safety measure. It could not be determined why the 80 foot value was used when the approach was first designed. The exact height of the trees struck by the airplane could not be determined because the tops were torn into many small pieces.

2A. Amendment 2A was the latest amendment to the procedure, and it was the chart used by the accident flightcrew.

1.17.3.2 Visual Descent Point Clearances

According to the TERPS Handbook 8260.3B, paragraph 251a, 1) where a VASI is installed, the VDP shall be located at the point where the lowest VASI glideslope intersects the lowest MDA. The Handbook also states, “Do not establish a VDP if penetrations of the VDP surface exist....” Based on the downwind bar of the runway 15 VASI at 3.0 degrees, a VDP would be placed at around 2.5 DME. TERPS criteria also require a 2 degree obstacle clearance surface for the installation of the VDP.

On June 26, 1996, as a result of this accident, the Safety Board made the following recommendations to the FAA:

> A-96-31
> Publish a visual descent point (VDP) for runway 15 in the appropriate location, and ensure that the VDP is present on all VOR runway 15 instrument approach charts used by pilots flying into Bradley International Airport (BDL).
>
> A-96-32
> If the inclusion of a VDP on approach charts to runway 15 is not possible due to obstacles, because charting methodology rather than empirical measurement was used to determine obstacle clearance, then ensure that a warning about the 3.5-degree glideslope and the high terrain along the approach path is placed on VOR runway 15 instrument approach charts for BDL, or make such a warning a permanent Notice to Airmen (NOTAM) for BDL, or use some other means to disseminate such a warning on a permanent basis.

On September 4, 1996, the FAA responded favorably to Safety Recommendation A-96-31 by stating that:

> The Federal Aviation Administration (FAA) agrees with this safety recommendation and on August 15, 1996, published a visual descent point (VDP) at 2.3 nautical miles (BDL 2.4

> DME) on the VOR RWY 15 instrument approach procedure for Windsor Locks/Bradley International Airport, Connecticut.

Because of this response, Safety Recommendation A-96-31 is being classified "Closed--Acceptable Action," and A-96-32 is being classified "Closed--No Longer Applicable."

1.17.3.3 Required Obstacle Clearance for VOR Runway 15

According to TERPS Handbook, FAA Order 8260.3B, the required obstacle clearance (ROC) for VOR approaches with final approach fixes is 250 feet rounded to the next higher 20-foot increment. Using this criteria, the 819 foot msl ridge line results in 1,080 feet msl ROC (908 feet agl). Because no adjustments were deemed necessary by the FAA for the VOR runway 15 approach, this number is also used as the MDA.

1.17.3.4 Precipitous Terrain Approach Adjustments

The forward of TERPS Handbook, FAA Order 8260.3B, states:

> This publication prescribes standardized methods for use in designing instrument flight procedures….These criteria do not relieve procedures specialists and supervisory personnel from exercising initiative or taking appropriate action in recognizing both the capabilities and limitations of aircraft and navigational aid performance.

Paragraph 323 of that handbook pertains to minimums' adjustments. Paragraph 323 (a) states that consideration should be given to induced altimeter errors and pilot control problems in precipitous terrain that may result when winds are 20 knots or more over such terrain. TERPS Handbook, FAA Order 8260.3B does not, however, define precipitous terrain.

According to the FAA, the flight procedures specialists do not automatically add adjustments to ROCs for precipitous terrain. Rather, they rely on flight inspection reports and user inputs. According to the BDL air traffic control tower personnel, there have never been any complaints or comments regarding the effect of the ridge line on altimeters or its effect upon airplane control on the approach course to runway 15. The FAA did not adjust the BDL VOR runway 15 approach MDA for precipitous terrain.

1.17.3.5 VASI Obstacle Clearances

BDL has a VASI-4 system for runway 15. The upwind bar is aimed at 3.5 degrees and the downwind bar is aimed at 3.0 degrees. FAA Order 6850.2A, paragraph 301b, states that the VASI should have a clear 2 degree obstacle clearance surface originating at the VASI downwind bar and extending to 4 nautical miles.

In 1987, the FAA's New England Region, Airways Facilities Branch, had the obstacle clearance surface checked by survey and it was validated "clear" of obstacles. On November 13, 1995, the day after the accident, a flight inspection of the approach was conducted by the Atlantic City Flight Inspection Area Office. The flight inspection form reports that the VASI was checked satisfactory for obstacle clearances.

During the initial development of the BDL VOR runway 15 approach, the procedures specialist that designed the approach determined, based upon charts, that a 55-foot obstruction existed within the required obstacle clearance plane of the VASI. In June, 1996, the FAA responded to Safety Board requests about obstacle clearance relative to the VASI, indicating that the 819-foot obstruction on the ridge line penetrated the required 2 degree clearance surface by 55 feet.

1.18 Additional Information

1.18.1 Air Traffic Control Aspects

The BDL TRACON provides separation and sequencing to arriving and departing airplanes at Bradley International Airport. The BDL tower controls takeoffs and landings at BDL. The accident occurred during a late evening shift. The normal staffing at that time (and the actual staffing at the time of the accident) for BDL TRACON is one area supervisor and one full performance level (FPL) radar controller. The control tower cab is normally staffed with one FPL controller on late evening shifts.

1.18.1.1 The TRACON Supervisor in the Tower Cab

Because of high winds on the night of the accident, one of the windows in the BDL air traffic control tower began to flex and water began to leak inside the tower cab. A decision was made to temporarily close the tower and the TRACON Area Supervisor in Charge made notifications of tower closure to the New England Communications Center and airport management. He then asked the Bridgeport automated flight service station (AFSS) to issue a NOTAM [Notice to Airmen] concerning tower closure. He then ensured that local and ground control frequencies, normally handled by local and ground controllers in the tower, were being monitored in the TRACON.

The TRACON supervisor then escorted the airport carpenters to the tower cab to inspect the windows, and he saw that the window closest to the local control position appeared to be bowing more than the others. He noted water at the bottom seal. The carpenters determined that the window could be fixed and then departed the tower. The TRACON supervisor remained in the tower cab, and then told the approach controller, located in the radar room beneath the tower cab, that if he wanted to put flight 1572 on the tower frequency it would be fine because "I'm up here and this way if I need to tell him anything, I can."

The TRACON controller and the TRACON supervisor in the tower were not providing air traffic control services to other airplanes at the time. The approach controller then told American Airlines flight 1572 that there was “someone in the tower,” that while it was “not really officially open,” the flight could change to tower frequency. Flight 1572 proceeded to do so.

At 0053:27, flight 1572 transmitted, "Hey, tower American Airlines flight 1572 we're on a six-mile final for runway one five." The TRACON supervisor in the tower cab transmitted to flight 1572, "landing is at your discretion, sir. The winds 170 at 25, peak gusts 40, and ah the runway does appear clear, you can land and taxi to the gate at your discretion." At 0054:51, the TRACON supervisor transmitted:

> Windshear alert. Uh, centerfield one seven zero at two five. The uh, northeast boundary, one seven zero at two four, one niner zero at twelve at the southeast boundary.

Flight 1572 responded with, “Copy.” About 1 minute later, at 0056:02, flight 1572 transmitted, “Tower, call for emergency equipment..., we’re going down on the runway.” At 0056:25, the TRACON supervisor issued the wind as 170 degrees at 22 knots. Flight 1572 then transmitted again to call for emergency equipment, and the supervisor stated that the equipment was inbound. About 10 seconds later the airplane touched down.

The TRACON supervisor had been a full performance level tower controller 3 years previously, and he also possessed a current multiengine commercial pilot's license with an instrument rating, and a flight instructor's certificate. His total flying time was about 670 hours.

1.18.1.2 TRACON Altimeter Setting Transmissions

The controllers in the tower and the TRACON obtain current altimeter information from the DASI (Digital Altimeter Setting Indicator). The DASI system is a self-contained instrument located in the tower’s equipment room, and it transmits the current altimeter to readouts located in both the tower and TRACON. In turn, the reading on the DASI is used to update the automated radar terminal system (ARTS) so that the altitude readouts on the controllers’ radar displays are correct. The ARTS system always reads in msl. According to air traffic control procedures in the ATC Handbook, FAA Order 7110.65, the altimeter setting should be transmitted to the flight upon initial radio contact.

The ARTS record of keyboard entries shows that at 0021:14, the approach controller entered 29.38 inches Hg. in the ARTS systems area of the computer. The record of entries further shows that at 0044:34 he entered 29.34 inches Hg., and at 0048:07, he entered 29.36 inches Hg. The atmospheric pressure continued to drop and was calculated to be 29.24 inches Hg. at the time of the accident.

Boston ARTCC issued flight 1572 an altimeter setting of 29.40 inches Hg. at 0033:30, about 21 minutes prior to the tree strike, and approximately 11 minutes before handing the flight off to the BDL TRACON.

This was the last altimeter setting issued to the flight from an air traffic controller. The TRACON approach controller did not issue a current altimeter setting to flight 1572 upon initial radio contact with the flight at 0043:49. At that time, the DASI readout indicated a setting of 29.38 inches Hg.

A review of the BDL Facility Status Logs from October 1, 1995, through November 11, 1995, revealed no reports of outages or complaints concerning the tower's DASI.

1.18.1.3 Minimum Safe Altitude Warning (MSAW)

MSAW is a computer program to warn a controller when an airplane descends or will descend below a predetermined altitude. The MSAW at BDL was programmed to provide an alarm if the aircraft's Mode C transponder transmitted two signals when the airplane was at or below 1,050 feet msl. However, if the radar does not pick up the aircraft's mode C transponder signal, the program cannot function. The BDL approach control radar system produced an MSAW alarm for flight 1572 at 0055:39. The radar tracking data showed that when this alarm was produced, the aircraft was at 800 feet msl and the aircraft had already struck the trees. FAA personnel stated that under normal circumstances, the MSAW should have produced an audible alarm at that time in the tower cab, and a visual alarm should have occurred on the radar display and on the DBRITE [bright radar indicator tower equipment] in the radar room and tower cab.

Radar tracking data showed no radar "hits" from flight 1572's mode C transponder between 0055:23 and 0055:32, and also none between 0055:05 and 0055:23. The radar antenna produces returns about every 4.5 seconds. FAA personnel reported that the reason for the absence of these hits was the shielding of the airplane from the radar by the ridge line. FAA technicians later explained that if the radar could not "paint" the airplane, the MSAW computer program could not warn the controller that the airplane was at an unsafe altitude.

According to FAA equipment design personnel, if a steady stream of Mode C information had been available to the computer, the MSAW alarm would have sounded as soon as the aircraft descended past 1,100 feet msl. They indicated that on final approach, a standardized set of

MSAW parameters is used, not taking into account obstacles such as the ridge. BDL FAA personnel said that in an attempt to improve radar coverage prior to the accident, they had changed or optimized the tilt on the radar antenna, but that the ridge still obstructed radar coverage.

1.18.2 Industry Actions to Improve the Safety of Non-precision Approaches

1.18.2.1 Approach Plate Terrain Depictions

The Safety Board reviewed several other airlines' BDL VOR runway 15 approach plate terrain depictions. This review revealed that the information provided to the flightcrews varied among the carriers. The British Airways approach chart for the BDL VOR to runway 15 (published by Aerad) had terrain contours depicted in color. The ridge line and the associated 819 foot obstruction was depicted on the approach chart.

The Delta Air Lines approach plate for runway 15 included an additional information sheet depicting terrain along the approach from MISTR to DILLN and the airport. The 819 foot obstruction and the ridge line were depicted on the supplement.

The other approach charts reviewed by the Safety Board were similar to the one used by AAL in that they contained only a notation of the 819 foot obstacle, but they did not depict the ridge line.

1.18.2.2 Non-precision Approach Flight Procedures

To reduce the glidepath variability that may occur in non-precision approaches (as opposed to precision approaches with constant glidepaths) some airlines are devising methods to fly non-precision approaches in ways that more closely resemble precision approaches.

In airplanes that have modern flight management system suites, some airlines are recommending that their flightcrews fly a stabilized approach with a constant glidepath to a point near the MDA. In other words, flightcrews are to overfly intermediate level-off points at higher altitudes, while maintaining a stable rate of descent, rather than fly down to intermediate level-off points, level off, then descend again to reach the next lowest altitude authorized by the approach procedure. To ensure that flightcrews do not descend below the MDA using the new stabilized approach technique, one airline adds an additional 50 foot safety buffer to the MDA to allow the airplane to "round out" its descent above the actual MDA before a missed approach climb is established.

1.18.2.3 Controlled Flight Into Terrain (CFIT) Training Aids

The Boeing Commercial Airplane Group, as part of a larger aviation industry effort to prevent CFIT accidents, has produced a five-part CFIT Education and Training Aid for use by all operators. Section One of the aid gives top managers of airlines a broad overview of the CFIT problem and possible solutions. Section Two, a Decision Maker's Guide, describes areas of line airline operations, whereby those who regulate and lead the aviation industry can aim their efforts toward CFIT elimination. Section Three is an Operator's Guide describing specific causal factors of CFIT accidents, traps in which flightcrews can find themselves, and specific in-flight escape maneuvers. Section Four describes a model CFIT education program for an airline, and Section Five provides further background information on the CFIT problem via selected readings and topical accident and incident information.

The Flight Safety Foundation (FSF)-sponsored CFIT Task Force has developed a CFIT checklist to aid in the avoidance of CFIT accidents. This checklist was created to identify the degree of potential for a CFIT accident prior to each flight. The checklist user evaluates risk factors associated with a particular flight by assessing the relative danger of each risk factor and the safety-enhancing aspects of the proposed flight in a numerical fashion. The checklist is divided into two diagnostic parts:

> CFIT Risk Assessment (includes negative destination CFIT risk factors such as VOR/DME approaches, airports near mountainous terrain, and radar coverage limited by terrain masking, and risk multipliers such as IMC [instrument meteorological conditions] weather and long crew duty days).
>
> CFIT Risk Reduction Factors (includes positive company management traits and the availability of CFIT training programs).

Within the highest set of CFIT risk factors, according to the FSF, are flying at night in IMC conditions, and using the autopilot in the vertical speed mode close to the ground.

1.18.2.4 Previous Recommendations on CFIT

The Safety Board has made many safety recommendations to the FAA concerning CFIT accidents and GPWS during the last 25 years. The first recommendation, A-71-053, concerned a Southern Airways DC-9 that struck power lines on approach to the Gulfport, Mississippi Municipal Airport. The FAA responded that existing instrumentation and procedures were safe and adequate to prevent these accidents provided cockpit disciplines were maintained. However, CFIT accidents continued to occur, and in 1975 the FAA made GPWS mandatory on Part 121 airplanes. In 1986 the Safety Board asked FAA to extend GPWS coverage to Part 135 operations. FAA studied the issue, and made GPWS mandatory on Part 135 turbine-powered airplanes with 10 or more passenger seats in 1994. The Board has also issued numerous recommendations on improving GPWS equipment and flightcrew training over the years.

The catastrophic losses of life and property from CFIT accidents have not been restricted to Parts 121 and 135. In 1995, the Board recommended that coverage be extended to all turbojet aircraft with 6 or more passenger seats, including Part 91 operations. The Department of Transportation (DOT) recently released a study[29] for the FAA on Part 91 turbine-powered aircraft that shows a "significant potential for CFIT accident prevention in the aircraft fleet studied." FAA staff have informed Safety Board staff that the FAA is preparing a notice of proposed rulemaking (NPRM) that would require enhanced GPWS on all Part 91, 121, and 135 aircraft that are turbine powered with 6 or more passenger seats.

[29]DOT report, "Investigation of Controlled Flight Into Terrain, Aircraft Accidents Involving Turbine-Powered Aircraft with Six or More Passenger Seats Flying Under FAR Part 91 Flight Rules and the Potential for Their Prevention by Ground Proximity Warning Systems," Project Memorandum #DOT-TSC-FA6D1-91-01, by Robert O. Phillips, March, 1996.

After the investigation of the AAL Cali, Columbia, accident, the Aeronautica Civil of the Republic of Colombia made the following recommendations to the FAA:

> Require that all approach and navigation charts used in aviation graphically portray the presence of terrain that is located near airports or flightpaths.
>
> Encourage manufacturers to develop and validate methods to present accurate terrain information on flight displays as part of a system of early ground proximity warning. (Enhanced GPWS)
>
> Develop a mandatory CFIT training program that includes realistic simulator exercises that are comparable to the successful windshear and rejected takeoff training programs.
>
> Evaluate the CFIT escape procedures of air carriers operating transport category aircraft to ensure that the procedures provide for the extraction of maximum escape performance, and ensure that those procedures are placed in operating sections of the approved operations manuals.

The Aeronautica Civil of the Republic of Colombia made the following CFIT recommendation to the International Civil Aviation Organization:

> Evaluate and consider the adoption of the recommendations produced by the CFIT Task Force that have been created under the initiative of the Flight Safety Foundation.

Following the investigation of the AAL Cali, Columbia, accident, the Safety Board made the following recommendations to the FAA on October 16, 1996:

A-96-93
Evaluate the terrain avoidance procedures of air carriers operating transport-category aircraft to ensure that the procedures provide for the extraction of maximum escape performance and ensure that those procedures are placed in procedural sections of the approved operations manuals.

A-96-94
Require that all transport-category aircraft present pilots with angle-of-attack information in a visual format, and that all air carriers train their pilots to use the information to obtain maximum possible airplane climb performance.

A-96-95
Develop a controlled flight into terrain training program that includes realistic simulator exercises comparable to the successful windshear and rejected takeoff training programs and make training in such a program mandatory for all pilots operating under 14 CFR Part 121.

A-96-98
Develop and implement standards to portray instrument approach criteria, including terminal environment information and navigational aids on FMS-generated displays, that match, as closely as possible, the corresponding information on instrument approach charts.

A-96-101
Examine the effectiveness of the enhanced ground proximity warning equipment and, if found effective, require all transport-category aircraft to be equipped with enhanced ground proximity warning equipment that provides pilots with an early warning of terrain.

A-96-102
Require that all approach and navigation charts graphically present terrain information.

A-96-106
Revise Advisory Circular 120-51B to include specific guidance on methods to effectively train pilots to recognize cues that indicate that they have not obtained situational awareness, and provide effective measures to obtain that awareness.

2. ANALYSIS

2.1 General

The flightcrew had the proper FAA airmen certifications and were qualified in accordance with applicable regulations and company requirements. They received the proper amount of crew rest before the accident flight and did not appear to be under unusual psychological pressure. The airplane was properly fueled; passengers and cargo were loaded in accordance with AAL weight and balance requirements. The flight was released in accordance with AAL dispatch procedures.

The weather at BDL was at or above the required minimums for landing, and included overcast clouds, visibility restricted by moderate rain, and strong, gusty wind conditions. All components of the VOR runway 15 instrument approach were operating normally. No malfunctions of the visual approach slope indicator (VASI) for runway 15 were reported by the airport.

There was no evidence of a malfunction of the pitot-static system, the autopilot system, the ground proximity warning system, the windshear warning system, or any flight control system, that could have contributed to this accident. In addition, no structural failures occurred prior to the airplane striking trees. According to the FDR and postaccident examination, the left engine rolled back to a low power level shortly after the ridge line tree impact due to low pressure compressor damage. The right engine continued to operate at a high power setting until a fire burned away the high pressure compressor airfoils. Both engines were operating normally prior to the tree strike.

2.2. Adequacy of Weather Information

2.2.1 NWS SIGMETs

There were a number of NWS SIGMETs in effect pertinent to the route of flight 1572. These SIGMETs were not included in the flight release or provided to the flightcrew while en route to BDL by American Airlines dispatch. However, the flight release of flight 1572 included an American Airlines Terminal SIGMEC for moderate turbulence, moderate icing, and low level windshear for the BDL area. Severe icing or turbulence was not forecast by American Airlines' meteorological staff, although the NWS meteorologists were forecasting occasional severe turbulence and icing in a larger area that included the route of flight for flight 1572.

The Safety Board concludes that, regarding the operation of flight 1572, AAL weather forecasts, as documented in the SIGMECs, were substantially correct. NWS SIGMETs covered broader geographic areas than the more focused AAL SIGMEC reports, and contained, in this case, information on occasional severe icing and turbulence that did not apply to flight 1572. The Safety Board also concludes that AAL's FAA-approved system of providing flightcrews with more focused forecasts, in the form of SIGMECs, is a valid method of weather dissemination. Should a flightcrew be forced to divert to an area not covered by a SIGMEC forecast, ample opportunity exists, via ACARS or air-to-ground radio, to obtain current weather in the divert area. In addition, providing flightcrews with both SIGMECs and SIGMETs might prove confusing to flightcrews when the reports are inconsistent, as they were in this case.

2.2.2 Weather Conditions at BDL

The National Center for Atmospheric Research (NCAR) study conducted for this investigation stated that the predicted pressure decrease of 1 millibar could be underestimated by a factor of 2 or 3. The Safety Board concludes that such an underestimation did not occur at the time of the accident because the FDR altitude trace did not contain an altitude spike that would have resulted from a significant atmospheric pressure change.

The flightcrew was given the BDL weather conditions prior to departure that forecast strong winds, moderate turbulence and possible low level windshear during their time of expected arrival. After takeoff, the first officer stated that they received a normal ACARS message that included a 2300 BDL weather observation. The message also stated that the pressure was falling rapidly (PRESFR).

During the descent, the flightcrew received two messages over the ACARS relating to the BDL weather. The first message was sent at 0030 and provided the flightcrew with the altimeter setting for conversion to an above field elevation (QFE) setting and the altimeter setting for mean sea level (QNH) at BDL. At 0031, another message was sent to the flightcrew advising them of turbulence and windshear on final approach.

At 0034, the first officer received the ATIS information for BDL, and he recognized that it was "over an hour and a half old." However, the flightcrew did not request more current information about the conditions at BDL. Interviews revealed that both flight crewmembers were aware of the turbulence and windshear advisories at the field. They were also aware of the possibility of a low but legal ceiling and visibility. The CVR revealed that they made appropriate preparations with the lead flight attendant regarding the passengers and cabin service in preparation for approach and landing in turbulent conditions. They were also aware that the tower was closed due to wind damage.

Although it would have been prudent to request a weather update from the BDL final approach controller, the Safety Board concludes that with the exception of a current altimeter setting (discussed below), the flightcrew had adequate information concerning the weather at BDL as they began their descent to the airport.

2.3 Altimeter Settings

The altimeter settings (29.42 inches Hg. (QNH) and 29.23 inches Hg. (QFE)) received by the flightcrew in the 0030 ACARS message were based upon a 2352 weather report. Thus, these altimeter settings were 29 minutes old when the flightcrew received them and 54 minutes old when the airplane struck the trees on the ridge line. The altimeter setting they received from Boston Center at 0033:27 (29.40 inches Hg.) was 22 minutes old when they struck the trees. The altimeter setting they received in the ATIS message at 0034 (29.50 inches Hg.) was based on a 2251 recording of the weather, and was 1 hour and 46 minutes old when the tree strike occurred.

About the time of the accident the correct QFE altimeter setting for the airport was about 29.15 inches Hg. Using this value, the Safety Board concludes that the indicated altitude (height above airport elevation) that the airplane's QFE altimeter was indicating was about 76 feet too high (based on the altimeter setting received at 0030), resulting in the airplane being 76 feet lower than indicated on the primary altimeters.

The Safety Board concludes that because they knew that the atmospheric pressure was falling rapidly, the flightcrew should have requested a current altimeter setting from the BDL approach controller when one was not given by the controller, as required, upon initial radio contact. If they had done so, they would have received a current altimeter setting of 29.38 inches Hg. (QNH) which would most likely have resulted in the aircraft being 40 feet higher[30] than it was when it struck the trees, or approximately 71 feet above the terrain. The survey of tree heights that was performed shortly after the accident indicated that trees in the area of initial impact were approximately 60 feet tall. Therefore, an additional 40 feet might have given the aircraft enough clearance to miss the trees on the downslope of the ridge. Accordingly, the Safety Board concludes that the flightcrew's failure to request a current altimeter setting from the approach controller was a contributing factor in this accident.

AAL procedures require that the flightcrew change the primary altimeters from QNH (height above sea level) to QFE (height above the ground) during the descent at 10,000 feet. To accomplish this, flightcrews use either the QNH and QFE settings obtained from AAL ground station personnel at the airport of intended landing or they use both settings from company meteorologists obtained over ACARS. In this case, the flightcrew received an ACARS message at 0030 that contained a QFE setting of 29.23 inches Hg. and a QNH setting of 29.42 inches Hg. According to AAL procedures, the flightcrew should have then set their individual altimeters to QFE and compared them to the third (standby) altimeter that would still be set to QNH. The difference between the two settings should be equal to the published field elevation of the airport of intended landing.

After the accident, the primary altimeters were found set at 29.23 inches Hg., which is consistent with the setting given in the ACARS message. However, the standby altimeter was set at 29.47 inches Hg., which does not match the setting found in the ACARS message, or with any of the other altimeter settings given to the flightcrew. During the descent, the first officer stated to the captain that 29.47 inches Hg. (QNH) was what had been given to them when they started to descend. In fact, the Boston ARTCC had given, and the first officer acknowledged, a setting of 29.40 inches Hg. (QNH).

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[30] 9.25 feet for each 0.01 inch of Hg. between 29.38 and 29.42.

If the flightcrew had set the altimeters to 29.23 (QFE) and 29.42 (QNH) the settings would have produced the proper difference in indicated altitudes, which would have been equal to the field elevation (174 feet msl). Although the flightcrew used an incorrect standby altimeter setting during the initial descent below 18,000 feet, the mistake could have been detected if the proper procedures[31] had been used at the changeover altitude of 10,000 feet. First, when the pilots switched from using the standby altimeter to determine their altitude, set in error at 29.47 (QNH), to their primary altimeters, set at 29.23 (QFE), their altimeters displayed an indicated altitude that was about 240 feet lower than the standby altimeter. Second, using the QFE setting of 29.23 inches Hg. given the flightcrew by the 0030 ACARS message, the field elevation would have been inconsistent with any altimeter setting on the third altimeter, except the setting of 29.42 inches Hg. (QNH).

Following the accident, neither crewmember stated that they remembered the ACARS message or the associated altimeter settings that the company provided to them. However, documents retrieved from the accident airplane revealed that the ATIS information was handwritten on the ACARS message received from the company. The Safety Board could not determine who wrote this information on the message. However, the Safety Board concludes that, although the flightcrew did not use the most current QNH setting they had available in the standby altimeter (29.40 inches Hg.), this error did not affect the accident sequence of events because the flightcrew had the correct, but outdated, QFE setting (29.23 inches Hg.) in the altimeters they were using when the accident occurred.

2.3.1 Other Altimeter Errors

Safety Board investigators determined that there were two potential sources of altimeter errors in addition to the incorrect altimeter setting already discussed. They are (1) the error resulting from differences between the true mean temperature of the column of air below the airplane and the mean temperature assumed for the air column in the standard atmosphere; and (2) the error associated with departure of the distribution of

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[31]AAL procedures require flightcrews to compare the differences between the primary and standby settings to the field elevation. If there is a discrepancy, they would be expected to read the ACARS message again for the correct settings, or, most effectively, to ask the approach controller for a current setting.

pressure from hydrostatic equilibrium.[32] The effect of errors resulting from these two sources was found to be insignificant in this case.

2.4 The Descent Below MDA

According to the AAL DC-9 Operating Manual the pilot not landing is responsible for calling out 1,000 feet above field level, 100 feet above minimum descent altitude (MDA), and MDA.

The first officer, who was the pilot not landing, called out: "There's a thousand feet" at 0055:06. A correlation of the CVR with the FDR revealed that this 1,000-foot callout was made at around 1,140 feet agl, based upon the flightcrew's altimeter setting of 29.23 inches Hg. (QFE). Although this mandatory callout was made, the first officer did not follow additional company procedures by also calling out 100 feet above MDA (1,008 feet above the field elevation). However, 5 seconds later, at 0055:11, the first officer stated to the captain, "now nine hundred and eight is your uh...," which indicated that he was aware of the close proximity of the MDA (908 feet agl) to the 1,000 above field level callout. At that time, the airplane was about 1,050 feet agl. The captain replied, "right."

The first officer stated that he then looked out the airplane windshield to locate the airport. When he looked back at the instrument panel, he saw that the airplane had descended below MDA. At 0055:25, the first officer said, "You're going below your…." At that time the airplane was about 350 feet above the ground and 5 seconds away from contact with the trees. Information from the DFDR indicates that a constant rate of descent of 1,100 feet per minute was maintained until the first officer uttered his "you're going below your…." statement. The Safety Board concludes that if the first officer had monitored the approach on instruments until reaching MDA and delayed his search for the airport until after reaching MDA, he would have been better able to notice and immediately call the captain's attention to the altitude deviation below the MDA.

[32]Hydrostatic equilibrium is a balance between gravity and pressure gradient force. Strong winds flowing over high terrain can result in nonhydrostatic equilibrium.

Further, if the flightcrew had computed a visual descent point (VDP) for their approach to runway 15, as described in the AAL flight manual, the DME associated with a VDP would have provided the flightcrew with a specific point in space to leave the MDA for landing. There would be no reason for the first officer or the captain to be looking away from the instruments and out the windscreen for the airport until just before or at the VDP. Both of them could have been concentrating upon the level off at the MDA. However, in this case, no VDP was calculated, the first officer began looking for the airport prior to reaching the MDA in the critical stages of the descent to MDA, and he was not adequately monitoring the flight instruments to serve as an additional backup to the captain.

If the captain had planned for a VDP, he could have set up a more shallow rate of descent commensurate with reaching the target altitude at or just prior to the VDP. The reduced rate of descent would have allowed the captain to better monitor his descent progress toward the MDA. Also, a reduced rate of descent would have enabled the airplane to capture the MDA with less of a roundout (altitude loss) when the autopilot altitude hold button was depressed. A reduced rate of descent would also have given the captain a greater opportunity to arrest the descent at the MDA if he had manually taken control of the airplane.

The captain stated that he attempted to “level off” the airplane at MDA, using the altitude hold button of the autopilot. However, that feature of the autopilot was not engaged until after the first officer uttered his “you’re going below your....” statement. The captain never took manual control of the airplane to either arrest his descent at the MDA or to initiate a more positive and immediate recovery to the MDA once he flew below this altitude.

In summary, regardless of the outdated altimeter setting that affected the indicated altitude that the flightcrew observed, they allowed the airplane to descend about 309 feet below the indicated MDA for the instrument approach. The captain initially did not recognize the descent below MDA, and he failed to react immediately when he was alerted to the altitude deviation by the first officer. The Safety Board concludes that the flightcrew’s failure to maintain the required MDA until the required visual references identified with the runway were in sight directly caused this accident.

2.5 Actions After Tree Strike

Regardless of the fact that the flightcrew descended below the MDA, their actions after the initial tree strike were noteworthy. The leading edge and trailing edge flaps of the airplane were severely damaged, power from one engine failed almost immediately after the tree strike, and power from the other engine failed shortly thereafter. Any mistakes in glidepath management, ground track management, or airplane configuration timing by the captain and first officer would probably have caused the airplane to land in unsuitable terrain prior to the clear area at the end of the runway and undoubtedly would have resulted in more severe injuries to crew and passengers. The Safety Board concludes that the excellent crew resource management and flight skills that the flightcrew used, as reflected on the CVR recording following their encounter with the trees, were directly responsible for limiting the number of injured passengers to one individual.

2.6 Terminal Instrument Procedures (TERPS)

As discussed below, the manner in which AVN-100 procedures specialists evaluated the obstacles on the instrument approach in question is markedly different from that of the flight procedures inspectors in the FIAO, making it possible to come to a different conclusion concerning the height of obstacles along the flightpath. In spite of the procedures that required the FAA FIAO to coordinate with the flight procedures specialists in the event of data or charting errors, such coordination apparently was never effectively accomplished.

The instrument procedures development program was separated from the flight operations inspection program in 1994. The procedures specialists, who design the instrument approaches, are now part of the FAA's Office of Aviation System Standards (AVN) and design an approach based upon charting methodology, rather than actual physical surveys to determine obstacle clearance surfaces. The specialists never directly measure obstacle heights, glidepath angles, and other variables, when they design an approach, but rather they rely upon graphs, charts, maps, and tables of information to do so. During the initial development of the BDL VOR runway 15 approach, the procedures specialist that designed the approach determined, based upon charts, that a 55 foot obstruction existed within the required obstacle clearance plane of the VASI. Further, if a VDP were to be established at the intersection of the VASI with the MDA, the same obstruction would penetrate the required obstacle clearance plane by 55 feet. This was inconsistent with the FIAO determination, both during the approach development and after the accident by means of flight inspection, that the obstacle clearance plane was not penetrated by the ridge line and trees.

Order 8260.19C, paragraph 430, states, in part:

> Establish a VDP on a non-precision approach, providing the [standard instrument approach procedure] SIAP meets the requirements of TERPS....

But, paragraph 432, further states, in part:

> If a VDP is not established, give the reason; e. g., obstacles....

An examination of FAA records revealed no reason for the absence of a VDP for the approach to runway 15 at BDL.

If the VASI geometry designed by the procedures specialist indicated an encroachment by obstacles of 55 feet, then FAA procedures should have required re-examination of the approach to determine the adequacy of clearance, and the VASI should have been moved or decommissioned until the required obstacles were removed. If, on the other hand, the VASI obstruction clearance plane was "clear," then in the Safety Board's opinion, an appropriately located VDP should have been placed on the approach plate to provide flightcrews with an appropriate DME fix from which a visual descent for landing could be made more safely. Based upon TERPS criteria for VDP location, the DME fix for the VDP should have been located on the flightpath past the ridge line and trees. This would provide flightcrews with adequate required obstacle clearance and a defined point from which a visual descent could be made, past the ridge line. It would also tend to keep approaching airplanes at a safer altitude until after passing the ridge line where they would begin their descents to the MDA.

The flight procedures unit used maps, charts, surveys and mathematical data to support their conclusions, whereas the flight inspection unit used airplanes and a theodolite (an optical device to measure angles and heights) for obstacle height verification. In this case their results were different with regard to the height of the trees on the ridge line and whether they constituted an obstruction within the VASI-required obstacle clearance plane. The different methods of verification can be a good check and balance to ensure accuracy of measurements; however, when the two branches differed in conclusions, there should have been, but was not, a mechanism in place to resolve the differences. The Safety Board concludes that quality control was inadequate within the FAA for accurately resolving the height of the trees on the ridge line. Therefore, the Safety Board believes that the FAA should examine and make more effective the coordinating efforts of the flight inspection program and the procedures development program, with emphasis placed on ensuring quality control during the development, amendment, and flight inspection process for instrument approaches.

The Safety Board also concludes that there is great value in flying non-precision approaches with a constant rate or angle of descent until the airport environment can be visually acquired, if the avionics aboard the airplane can safely support such a procedure. Therefore, the Safety Board believes that the FAA should evaluate TERPS design criteria for non-precision approaches to consider the incorporation of a constant rate or constant angle of descent to MDA in lieu of step-down criteria.

2.6.1 Precipitous Terrain

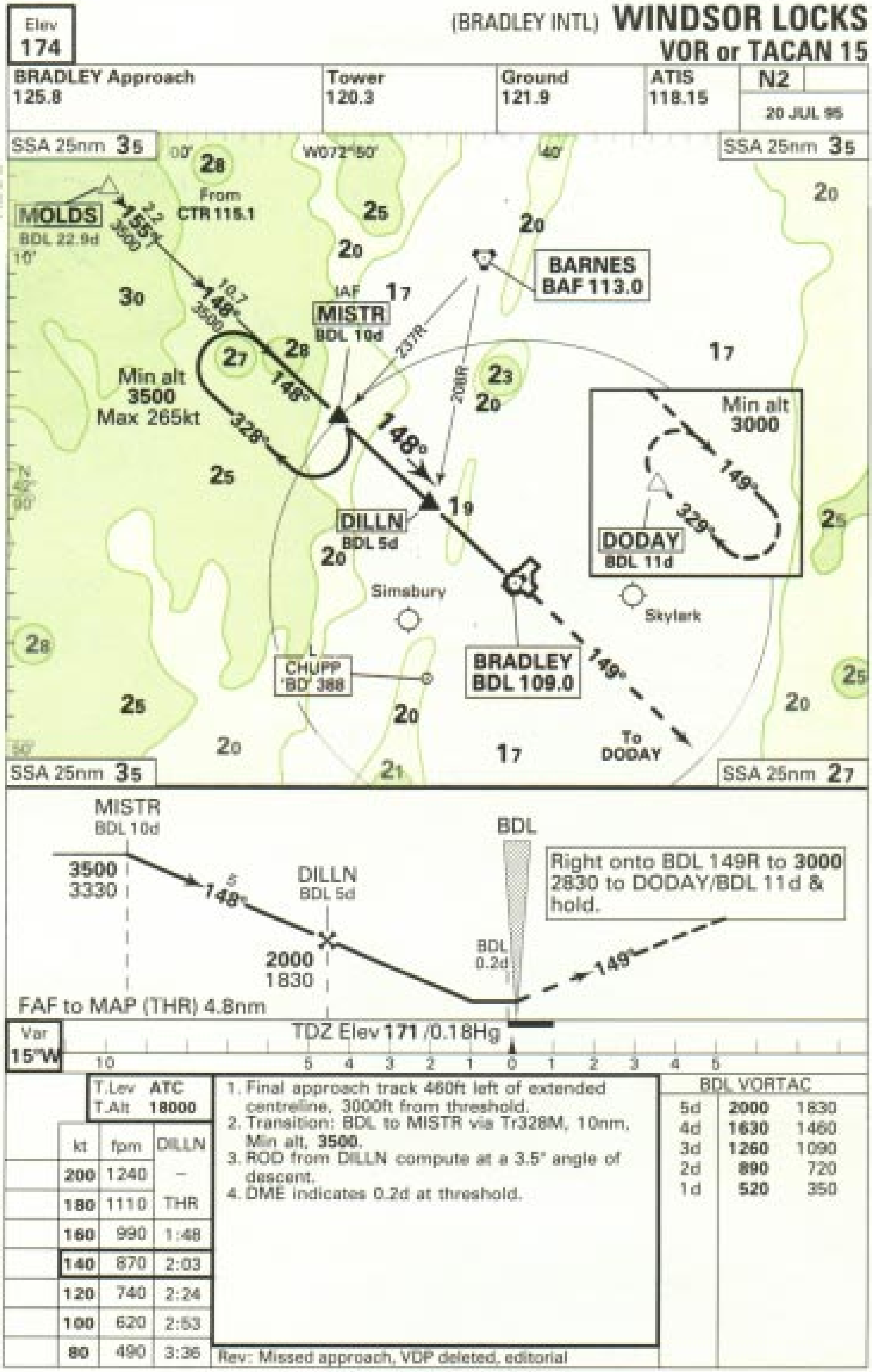
The TERPS Handbook states that consideration should be given to induced altimeter errors and pilot control problems in precipitous terrain that may result when winds are 20 knots or more over such terrain. No changes to the instrument approach procedure for runway 15 at BDL were made to account for precipitous terrain. Precipitous terrain is not defined in the TERPS Handbook. However, the BDL runway 15 approach is used primarily when the winds are such that their speed and direction preclude the use of the primary runway 06/24. Such conditions are likely to result in wind velocities in excess of 20 knots over the ridge line, which occurred the night of the accident. Such winds adversely affect airplane altimetry, and although it does not appear to have been a factor in this accident, the Safety Board concludes that the FAA should have, but did not, consider the issue of precipitous terrain when developing and modifying the approach to runway 15.

The Safety Board believes that the FAA should incorporate precipitous terrain adjustments in the runway 15 approach. In addition, the Safety Board believes the FAA should include a more comprehensive set of guidelines concerning precipitous terrain adjustments in the TERPS (FAA Order 8260.3B) Handbook, clarifying the definition of precipitous terrain, and establishing defined criteria for addressing the potential effects of such terrain.

FAA flight inspections of instrument approaches are not normally flown during adverse wind and turbulence conditions, such as those on the night of the accident, because the flight inspection pilots must fly under visual flight rules (VFR) to observe man-made obstacles and high terrain. Therefore, the flight inspectors may not be fully aware of how such adverse conditions affect the safety of a particular instrument approach. Because the Safety Board is concerned that non-precision approaches at airports other than BDL may be adversely affected by wind and turbulence associated with precipitous terrain, the Safety Board believes that the FAA should review and evaluate the appropriateness of the let-down altitudes for all non-precision approaches that have significant terrain features along the approach course between the initial approach fix and the runway. Airline safety departments and pilot labor organizations, such as the Allied Pilots Association and the Air Line Pilots Association, should be consulted as part of this review. In addition, the Safety Board believes that the FAA should solicit and record user comments about difficulties encountered in flying a particular approach to evaluate approach design more accurately.

2.6.2 Approach Plate Terrain Depictions

The single 819-foot obstacle depicted on the final approach course of most BDL runway 15 VOR approach plates could lead flightcrews to believe that there was one discrete obstacle, and that it was the only dangerous point on the final approach (see Figure 1). However, the Safety Board concludes that the entire ridge line is an obstacle, and that it and similar terrain close to other airports should be fully depicted on the appropriate approach charts. As an example, see Figure 4, the BDL approach plate used by British Airways. The Safety Board continues to believe, as reflected in Safety Recommendation A-96-102, following the accident near Buga, Colombia, that the FAA should require that all approach and navigation charts graphically present terrain information.



kt	fpm	DILLN
200	1240	–
180	1110	THR
160	990	1:48
140	870	2:03
120	740	2:24
100	620	2:53
80	490	3:36

BDL VORTAC		
5d	2000	1830
4d	1630	1460
3d	1260	1090
2d	890	720
1d	520	350

Figure 4.--BDL approach plate used by British Airways.

2.7 Air Traffic Control Factors

2.7.1 ATC Altimeter Setting Distribution Procedures

The approach controller is required to issue the QNH (above sea level) altimeter setting on initial contact with an arriving flight, in accordance with the Air Traffic Control Handbook, FAA Order 7110.65. AAL flight 1572 first contacted the approach controller at 0043:41. The controller should have issued the current altimeter setting of 29.38 inches Hg. at that time. The controller said that the omission was inadvertent. If the controller had issued the current altimeter setting on initial contact, the aircraft would most likely have been 40 feet higher than it actually was when it struck the trees.[33] The survey of tree heights that was performed shortly after the accident indicated that the trees in the area of initial impact were approximately 60 feet tall. Therefore, an additional 40 feet might have given the aircraft enough clearance to miss the trees on the downslope of the ridge. Accordingly, the Safety Board concludes that this omission by the controller was a contributing factor in this accident.

There is no requirement for an approach controller to issue an altimeter change to an aircraft after the initial contact. However, considering the fact that the pressure changes were described by the weather observer as "pressure falling rapidly," and especially in light of the controller’s failure to issue the current altimeter setting (29.38 inches Hg.) upon initial radio contact and his 0044:34 entry of 29.34 inches Hg. in the ARTS system while the accident aircraft was on his frequency,[34] the Safety Board concludes that it would have been prudent for the approach controller to have issued the altimeter setting changes as the airplane neared the airport. The latest altimeter setting available to the approach controller while the accident flight was on his frequency was 29.36 inches of Hg. If the flightcrew had received and correctly entered this setting, it would have resulted in the aircraft being

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[33]The altimeter setting of 29.42 inches Hg. (the QNH equivalent of the 29.23 inches Hg. QFE setting the flightcrew was using on final approach) minus 29.38 inches Hg. equals .04, or 40 feet of indicated altitude.

[34]When he entered 29.34 inches Hg., the controller should have recognized that this was a substantially lower barometer reading than existed when the accident airplane initially reported on the frequency (29.38), and it should have reminded him that he had not provided the flightcrew with a current altimeter setting.

approximately 60 feet higher, thus likely enabling it to clear the trees on the ridge line.

This accident illustrates the safety hazards that may result when flightcrews of landing aircraft are not informed of current altimeter settings in circumstances of rapidly falling atmospheric pressure. Therefore, the Safety Board believes that for arriving aircraft executing instrument approaches at all airports, during periods in which the weather observer has included in the weather report the remark, "pressure falling rapidly," controllers should be required to issue, as frequently as practical, altimeter setting changes to flightcrews in addition to the altimeter setting issued on initial contact.

2.7.2. Tower Closure and Assistance Provided by the TRACON Supervisor

The winds on the evening of the accident were strong enough to bow tower windows and allow water to enter the tower cab, posing an electrical hazard to the tower controller. The Safety Board therefore concludes that the closure of the tower was a good managerial decision because the safety of people in the tower was compromised by the adverse wind and rain. The TRACON supervisor's presence in the tower to monitor repairs, and his provision of wind and runway information to the aircraft was beneficial to the flight. He informed the flight that the runway was clear, provided landing winds, and he also provided a windshear alert. This information would not otherwise have been provided to the flightcrew.

Although additional information regarding the current altimeter setting would have been even more helpful to the flightcrew, the TRACON supervisor was not required to provide that, or any, information. He was voluntarily assisting the flight by providing advisory information, and he was not officially serving as an air traffic controller. Further, the flightcrew had been told by the approach controller that the tower was not “officially” open, and therefore, the flightcrew could reasonably assume that there was no “official” ATC service in the tower. The Safety Board notes that the supervisor was very careful in his wording and did not give flight 1572 clearance to land. His exact words were, “Bradley tower, uh, landing is at your discretion, sir....runway does appear clear, you can land and taxi to the gate at your discretion.”

The first officer on two occasions (0054:04 and 0055:06) used the words "cleared to land," in conversation with the captain. However, because the tower was closed, the captain of flight 1572 could land the airplane only on his own authority. The Safety Board concludes that the TRACON supervisor's communications with the flight were appropriate and aided the flightcrew. He acted in a professional manner, and should be commended for his willingness to assist the flight under the circumstances.

As further discussed in Section 2.7.4, the ATIS report broadcast at the time of the accident was based on weather observations almost 2 hours old, information that would be of little use to flightcrews in the area. Therefore, the Safety Board concludes that as part of the tower closure procedure, the ATIS broadcast should have been updated to reflect the temporary tower closure, and it should have advised flightcrews to obtain local weather and airport information from another source.

2.7.3 MSAW (Minimum Safe Altitude Warning)

MSAW is a computer program to warn a controller when an airplane descends or will descend below a predetermined altitude. If the radar does not receive a signal from a target, the program cannot function. The MSAW at BDL was set to alarm if the aircraft transmitted two mode C returns at or below 1,050 feet msl (30 feet below the MDA for the runway 15 VOR approach). There was no alarm as flight 1572 descended below the MDA because the aircraft was not in radar contact at that point because of shielding by the ridge line. There was a radar return recorded at 1,300 feet (above the MSAW envelope) but because of shielding from the ridge, the aircraft was out of radar contact for three radar sweeps and was therefore not visible to the controllers. Then, a single radar return was recorded at 900 feet, followed by another radar sweep with no recording of the flight, and then two radar returns were recorded at 800 feet. The MSAW then sounded an alarm, as it should have under those conditions.[35] However, this alarm sounded about 4 seconds after the airplane had struck the trees.

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[35]Two consecutive sweeps with radar contact with an airplane are required to set off the MSAW alarm. This is the reason that the MSAW did not alarm following the single radar contact at 900 feet.

According to the FAA, because of the lack of radar coverage close to the ridge, the minimums for the VOR 15 approach would have to be raised to give MSAW protection for this approach. It is not desirable for an MSAW alarm to occur above the MDA. This would result in an MSAW false alarm sounding on every approach, making the occasional valid alarm likely to be ineffective. Because the last radar return before the airplane struck the trees was recorded at 1,300 feet, the lowest altitude at which the MSAW could be programmed to activate and be effective is 1,300 feet. Therefore, to have full MSAW coverage, the approach minimums for this approach would have to be raised from 1,080 feet msl to somewhat above 1,300 feet msl, to keep the MDA above the alarm point for the MSAW. However, an MDA this high would defeat the purpose of the instrument approach. The descent from a 1,350-foot MDA to the runway would have to start far back along the final approach course, and the ceiling and visibility minimums would be unrealistically high. The Safety Board therefore concludes that despite the lack of full MSAW coverage along the approach, the MSAW operated properly, and that because of topographical limitations of the BDL local area, it is not practical to provide full MSAW coverage.

2.7.4 The Outdated ATIS Broadcast

The ATIS report information Victor, based on 2251 EST weather (from a weather observation taken almost 2 hours before the accident) was broadcast continually through the time of the accident. Because of the age of the observation, ATIS Victor was of little use to flights in the area of BDL. The relieving tower controller, who "entered the tower a couple of minutes before midnight" said that he listened to the ATIS but did not notice the time on it, nor did he notice if the SAIDS incoming information warning light was blinking. This would have indicated that new weather information was available. He said that the environment was very noisy (because of wind noise) and that he did not hear SAIDS incoming information warning tones. The weather sequence, taken at 2252, was time stamped at 2249:21. However, the clock making the time stamp was about 4.5 minutes slow. Therefore, the Safety Board believes that it was actually received at around 2253. The 2351 weather sequence would have actually been received at around 2358. The Safety Board believes that the weather information would have been on the display prior to the closing of the tower. However, the time stamps and readout of the SAIDS indicated that the information was sent at 2358 and would probably have been displayed when he began his shift. The information would also have been on the display at the time the tower closed.

If the ATIS had been updated, the altimeter setting would have been 29.42 inches Hg., (based on the 2352 local observation) a less current altimeter setting than the one that the flightcrew received from Boston ARTCC (29.40 inches Hg., based on the 2333 observation). The flightcrew had actually received an earlier ACARS setting of 29.42 inches Hg. (erroneously entered in the standby altimeter as 29.47 inches Hg.), the same setting that would have been provided on the unbroadcast ATIS.[36] The Safety Board concludes that the tower controller being relieved should have advised the relieving controller that the ATIS needed to be updated, even if it meant that they had to use the airport police to tell the weather observer to call the tower with more current weather. Although the failure to update the ATIS was not a factor in this accident, this failure raises concerns because of the potential hazards of not having current weather information available for flights inbound to BDL. Therefore, the Safety Board believes that the FAA should revise Facility Operation and Administration handbook 7210.3, or other appropriate orders, to require that when a tower shuts down for any reason, and if the tower controllers have time to record a new ATIS indicating that the tower is closed, they should do so.

2.8 Weather Conditions at the Time of the Accident

Possible downdrafts of about 400 feet per minute may have existed near the lee (northwest) side of the ridge where the tree strike occurred, according to the NCAR simulation. Douglas estimated a maximum updraft of about 600 feet per minute in this same geographical area. However, updrafts are not common on the lee side of ridge lines (downdrafts usually occur on the lee side of an obstacle). On the other hand, the NCAR simulation is dependent on an initial steady wind direction of 160 degrees, which probably does not accurately represent the accident conditions, as the winds were variable, not steady. Variation of the wind direction would result in a change in the location of updrafts and downdrafts in relation to the ridge. In addition, the presence of a horizontal axis vortex

[36]The unbroadcast ATIS wind direction, velocity and gust factor would have been similar to that of the earlier ATIS broadcast.

on the lee side of the ridge could have produced a localized updraft along the flightpath of the airplane. The Safety Board concludes that, although the variable wind conditions at the time of the accident may have caused localized updrafts and downdrafts in the area, the DFDR data indicates that there were no large-scale updrafts or downdrafts that would have affected the accident aircraft.

During the approach to runway 15, to the point at which flight 1572 struck the trees, the airplane would have encountered moderate turbulence and localized updrafts and downdrafts due to the interaction between strong low altitude winds and rough terrain along the flightpath. Windshear due to strong gusty low altitude winds also occurred following the tree strike, as the airplane was on approach to the runway. An estimated mean wind profile indicated a decreasing headwind as the airplane descended to the runway.

Although windshear was occurring as the airplane approached and passed over the ridge line, it was the gustiness of the low altitude winds, rather than a small-scale weather feature, that significantly affected airplane performance. Airspeed excursions amounted to only about 10 knots. Further, a descent rate of about 1,100 feet per minute was initiated by the flightcrew from about 1,840 feet msl and was maintained until tree contact. The linear nature of the pressure altitude trace indicates that the airplane's flightpath was probably not significantly affected by updrafts, downdrafts, or windshear. Such an effect would be seen as a deviation from the near linear pressure altitude trace. Therefore, the Safety Board concludes that the decreasing headwind shear seen in the estimated mean wind profile data was not severe enough to cause the flightcrew to deviate below the MDA.

Along the approach to runway 15, cloud bases were near 2,000 feet with multiple cloud layers above, and the tops of the clouds were above 15,000 feet. Flight visibility was near 0 miles in the clouds and 2 to 3 statute miles below the lowest cloud base. The first officer reported "there's the runway straight ahead " at 0055:57. The airplane was about 2.1 miles from the end of the runway at this time. Moderate rain probably occurred along the approach to the runway with more intense rain near the runway.

Given the above described conditions, the Safety Board concludes that the weather at the time of the accident was not severe enough to cause the aircraft to deviate below the MDA, and did not contribute to the accident.

2.8.1 LLWAS Equipment

The northwest LLWAS sensor was physically out of alignment by 38 degrees and was corrected subsequent to the accident. Analysis of the LLWAS data, according to the FAA, indicated that this sensor did not appear to degrade the entire LLWAS system to any significant degree during the analyzed period.

The Safety Board could not determine whether the LLWAS system would have provided another windshear alert if the sensor had not been misaligned. Nevertheless, the Safety Board considered the possibility that if the northwest sensor had been correctly aligned, it might have alerted due to erratic wind conditions; and an LLWAS alert from this sensor in the area of flight 1572 might have prompted the flightcrew to perform a missed approach. The Safety Board could not rule out this possibility. However, the Safety Board believes that it is more likely that if the flightcrew had received a northwest LLWAS alert from the tower controller, they would have continued the approach because under the known turbulence and erratic wind conditions, LLWAS alerts are to be expected. Thus, under these conditions, it would not be unreasonable for a flightcrew to react to such a warning by more closely monitoring their airspeed, rather than immediately initiating a missed approach. Therefore, the Safety Board concludes that the misaligned LLWAS sensor did not contribute to this accident.

According to the FAA, procedures are in place to check and correct the alignment of sensors based on the SPES analysis, which is run on a regular basis. However, the FAA also indicated that because of manpower shortages, it can take 3 to 6 months after discrepancies are noted for the alignment of the sensors to be examined and adjusted by airport personnel. The Safety Board concludes that 3 to 6 months after discrepancies are noted is an unacceptable period of time to verify the accuracy of sensor alignment, since wind direction can have a direct bearing on the windshear detection capability of the system. Therefore, the Safety Board believes that the FAA should develop a plan to physically check and correct wind sensor alignment in a more timely manner.

The Safety Board is also concerned that the FAA's process of "recertifying" the LLWAS--despite the implication that "recertification" signifies that the system has been found to comply with all original certification requirements--does not include checking that the sensors are properly aligned. Although the FAA indicated that the misalignment did not appear to degrade the system during the analyzed period (October 31, 1995 to November 12, 1995), this result is relevant only to the wind conditions experienced during that period. A misalignment of 38 degrees could clearly compromise the effectiveness of the system under some wind conditions. Accordingly, the Safety Board believes that the FAA should evaluate its LLWAS recertification process, and ensure that the process addresses the total functional capability of the system.

2.9 Survival Factors

2.9.1 The Malfunctioning Escape Slide

Instructions for rigging the inflation cable, contained in the Douglas DC-9/MD-80 Maintenance Manual 25-62-00-2-2, page 204, paragraph 11, were ambiguous. At the time of the accident, they stated: "Check that loop on firing lanyard is secured to girt tab with retaining ring on manual inflation handle; then, secure lanyard cover flap over firing lanyard." The instructions did not specifically call for the inflation cable to pass through a grommet on a tab near the girt bar before the cable is connected to the retaining ring on the manual inflation handle. In addition, the diagram in the rigging instructions did not display the grommet or the tab, or the inflation cable passing through the grommet on the tab near the girt bar before the cable is connected to the manual inflation handle (see Figure 5). This is required for the slide to inflate properly. The Safety Board concludes that because of the ambiguous instructions that appeared in the Douglas Maintenance Manual, operators of MD-80 and DC-9 series airplanes could be misrigging emergency evacuation slides. Therefore, the Safety Board believes that the FAA should require all operators to inspect immediately all MD-80 and DC-9 floor level exits to ensure that evacuation slides have been properly rigged.

As a result of this accident, American Airlines took immediate action to clarify instructions in its maintenance manual and is conducting a fleet-wide inspection of all emergency evacuation slides on its MD-80 airplanes. Douglas also took action and revised its maintenance manual instructions for installation of evacuation slides to include improved diagrams showing proper routing of the inflation cable through the grommet tab, and to include instructions to “[p]ass [the] inflation cable loop through [the]grommet tab.” (See Figure 6.) (The “inflation cable” had previously been referred to in the manual as the “firing lanyard.”) Although these revisions clearly and accurately depict the proper routing of the inflation cable, the Safety Board is concerned that the change in terminology from “firing lanyard” to “inflation cable” was not reflected in all the maintenance manual diagrams and instructions dealing with the installation and removal of evacuation slides. In several places, the cable is still referred to as a “firing lanyard.” The Safety Board concludes that because Douglas uses two different terms (“firing lanyard” and “inflation cable”) for the same part in its MD-80 and DC-9 maintenance manuals, the manual remains potentially confusing. Therefore, the Safety Board believes that the FAA should require Douglas Aircraft Company to review and amend its MD-80 and DC-9 maintenance manuals so that terminology used in graphics and instructions pertaining to the installation and removal of evacuation slides are clear and consistent.

2.9.2 Evacuation Route Difficulties

The aisle and areas in front of the escape doors that constituted the escape routes were partially blocked by passenger shoes during the evacuation. This could have caused injuries or loss of life in the case of an interior fire or other critical situation. The practice of commanding all passengers to remove shoes during evacuations was originally targeted primarily at high heeled shoes, and was intended to prevent slide punctures. But modern slide design and strengthened fabric material now used in slide manufacturing make the policy outdated. In addition, (with the exception of high heeled shoes) safety is served by passengers wearing shoes because they can exit an airplane and move away from an evacuated airplane more readily.

It may still be appropriate for crewmembers to instruct female passengers to remove high-heeled shoes that could cause injuries during an evacuation. Experience has shown that ankle and leg injuries are more likely to result from passengers wearing high heels. In addition, other injuries could also occur to rescue personnel and passengers, as the passenger wearing high heels slides down to waiting individuals at the bottom of the slide.

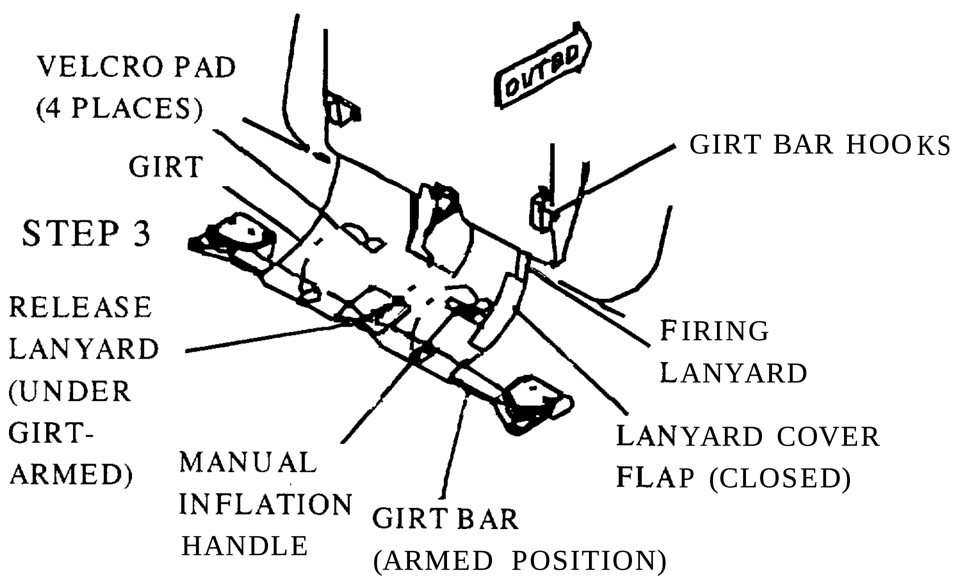

Figure 5.--Instruction diagram for rigging the firing lanyard (inflation cable).

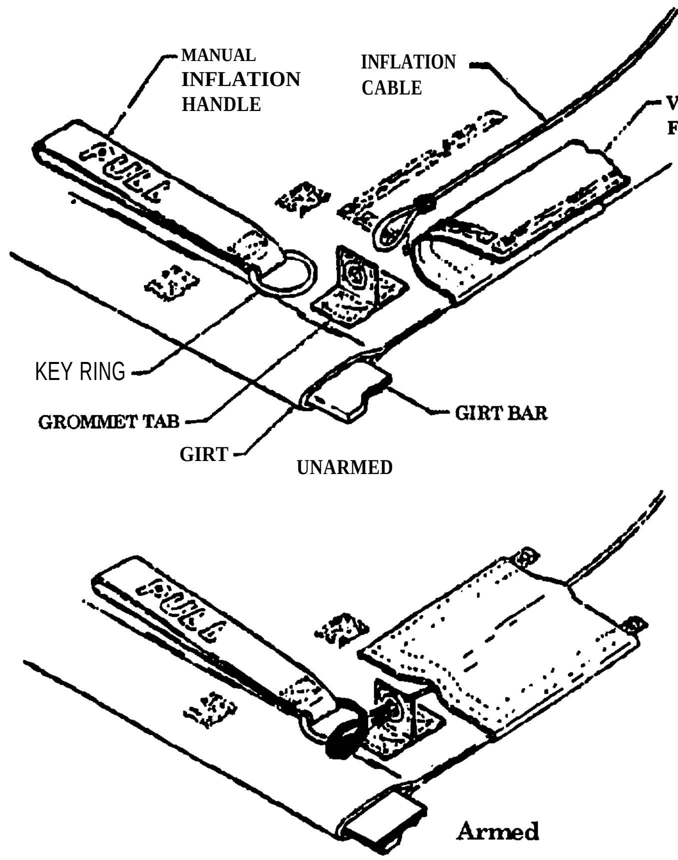

Figure 6.--Revised instruction diagram for rigging the inflation cable,

However, the Safety Board concludes that directing all passengers to remove shoes during evacuations may not be in the best interests of safety. There is no FAA policy regarding issuing commands for shoe removal during an evacuation. Although American Airlines is the only major carrier the Safety Board is aware of that instructs passengers to remove shoes during an evacuation, the Safety Board is concerned that there is no uniform policy or standard to which all operators (large and small) must adhere. The Safety Board therefore believes that the FAA should develop a uniform policy on shoe removal during evacuations, and require that all operators train their flight attendants to issue commands during an emergency evacuation consistent with that policy.

3. CONCLUSIONS

3.1 Findings

1. The flightcrew had the proper FAA airmen certifications and were qualified in accordance with applicable regulations and company requirements. They received the proper amount of crew rest before the accident flight and did not appear to be under unusual psychological pressure.

2. The airplane was properly fueled; passengers and cargo were loaded in accordance with AAL weight and balance requirements.

3. The flight was released in accordance with AAL dispatch procedures.

4. The weather at BDL was at or above the required minimums for landing, and included overcast clouds, visibility restricted by moderate rain, and strong, gusty wind conditions.

5. There was no evidence of a malfunction of the pitot-static system, the autopilot system, the ground proximity warning system, the windshear warning system, or any flight control system that could have contributed to this accident.

6. With regard to the operation of flight 1572, AAL weather forecasts, as documented in the SIGMEC, were substantially correct.

7. AAL's FAA-approved system of providing flightcrews with more focused forecasts, in the form of SIGMECs, is a valid method of weather dissemination.

8. The pressure decrease of about 1 millibar shown by the National Center for Atmospheric Research simulation for

the time and place of the accident was not underestimated by a factor of 2 to 3 because the flight data recorder's altitude trace did not contain an altitude spike that would have resulted from a significant atmospheric pressure change.

9. With the exception of a current altimeter setting, the flightcrew had adequate information concerning the weather at BDL as they began their descent to the airport.

10. Because the flightcrew knew that the atmospheric pressure was falling rapidly, they should have requested a current altimeter setting from the BDL approach controller when one was not given, as required, upon initial radio contact.

11. If the flightcrew had received a current altimeter setting from the BDL approach controller when the flight first contacted the approach controller at 0043, it most likely would have resulted in the aircraft being 40 feet higher than it was when it struck the trees, and it might have given the aircraft enough clearance to miss the trees.

12. At the time of the accident, the indicated altitude (height above airport elevation) that the airplane's QFE altimeter was indicating was about 76 feet too high (based on the altimeter setting received at 0030), resulting in the airplane being 76 feet lower than indicated on the primary altimeters.

13. Although the flightcrew did not use the most current QNH setting they had available (29.40 inches of Hg.) in the standby altimeter, this error did not affect the accident sequence of events because the flightcrew had the correct, but outdated, QFE setting (29.23 inches Hg.) in the altimeters they were using when the accident occurred.

14. If the first officer had monitored the approach on instruments until reaching minimum descent altitude (MDA) and delayed his search for the airport until after reaching the MDA, he would have been better able to notice and immediately call the captain's attention to the altitude deviation below the MDA.

15. The excellent crew resource management and flight skills that the flightcrew used, as reflected on the CVR recording following their encounter with the trees, were directly responsible for limiting the number of injured passengers to one individual.

16. FAA quality control was inadequate for accurately resolving the height of the trees on the ridge line.

17. There is great value in flying non-precision approaches with a constant rate or angle of descent until the airport environment can be visually acquired, if the avionics aboard the airplane can safely support such a procedure.

18. The FAA should have, but did not, consider the issue of precipitous terrain when developing and modifying the approach to runway 15.

19. The entire ridge line on the final approach course to runway 15 at BDL is an obstacle and it, and similar terrain close to other airports, should be fully depicted upon the appropriate approach charts.

20. Considering the fact that the pressure changes were described by the weather observer as "pressure falling rapidly," and especially in light of the controller's failure to issue the current altimeter setting (29.38 inches Hg.) upon initial radio contact, and his 0044:34 entry of 29.34 inches Hg. in the ARTS system while the accident aircraft was on his frequency, it would have been prudent for the approach controller to have issued the

altimeter setting changes as the airplane neared the airport.

21. Closure of the tower was a good managerial decision because the safety of people in the tower was compromised by the adverse wind and rain.

22. The TRACON supervisor's communications with the flight were appropriate and aided the flightcrew. He acted in a professional manner and should be commended for his willingness to assist the flight under the circumstances.

23. As part of the tower closure procedure, the ATIS broadcast should have been updated to reflect the temporarily closed tower, and it should have advised flightcrews to obtain local weather and airport information from another source.

24. Despite the lack of full minimum safe altitude warning (MSAW) coverage along the approach, the MSAW operated properly, and because of topographical limitations of the BDL local area, it is not practical to provide full MSAW coverage.

25. The tower controller being relieved should have advised the relieving controller that the ATIS needed to be updated, even if it meant that they had to use the airport police to tell the contract weather observer to call the tower with more current weather information.

26. Although the variable wind conditions at the time of the accident may have caused localized updrafts and downdrafts in the area, the DFDR data indicates that there were no large-scale updrafts or downdrafts that would have affected the accident aircraft.

27. The decreasing headwind shear seen in the estimated mean wind profile data was not significant.

28. The weather at the time of the accident was not severe enough to cause the aircraft to deviate below the MDA.

29. Three to 6 months after discrepancies are noted is an unacceptable period of time to verify the accuracy of low level windshear alert system (LLWAS) sensor alignment, since wind direction can have a direct bearing on the windshear detection capability of the system.

30. The misaligned LLWAS wind sensor did not contribute to this accident.

31. Because of the ambiguous instructions that appeared in the Douglas Maintenance Manual, operators of MD-80 and DC-9 series airplanes could be misrigging emergency evacuation slides.

32. Because Douglas uses two different terms ("firing lanyard" and "inflation cable") for the same part in its MD-80 and DC-9 maintenance manuals, the manual remains potentially confusing.

33. Directing all passengers to remove shoes during evacuations may not be in the best interests of safety.

3.2 Probable Cause

The National Transportation Safety Board determines that the probable cause of this accident was the flightcrew's failure to maintain the required minimum descent altitude until the required visual references identifiable with the runway were in sight. Contributing factors were the failure of the BDL approach controller to furnish the flightcrew with a current altimeter setting, and the flightcrew's failure to ask for a more current setting.

4. RECOMMENDATIONS

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

--to the Federal Aviation Administration:

Evaluate Terminal Instrument Procedures (TERPS) design criteria for non-precision approaches to consider the incorporation of a constant rate or constant angle of descent to minimum descent altitude in lieu of step-down criteria. (A-96-128)

Examine and make more effective the coordinating efforts of the flight inspection program and the procedures development program, with emphasis on ensuring quality control during the development, amendment, and flight inspection process for instrument approaches. (A-96-129)

Incorporate precipitous terrain adjustments in the BDL runway 15 approach. (A-96-130)

Include a more comprehensive set of guidelines concerning precipitous terrain adjustments in the Terminal Instrument Procedures (TERPS) (FAA Order 8260.3B) Handbook, clarifying the definition of precipitous terrain, and establishing defined criteria for addressing the potential effects of such terrain. (A-96-131)

Review and evaluate the appropriateness of the let-down altitudes for all non-precision approaches that have significant terrain features along the approach course between the initial approach fix and the runway. Airline safety departments and pilot labor organizations, such as the Allied Pilots Association and the Air Line Pilots Association, should be consulted as part of this review. (A-96-132)

Solicit and record user comments about difficulties encountered in flying a particular approach to evaluate approach design more accurately. (A-96-133)

For arriving aircraft executing non-precision instrument approaches at all airports, during periods in which the official weather report includes the remarks, "pressure falling rapidly," controllers should be required to issue as frequently as practical altimeter setting changes to flightcrews in addition to the altimeter setting issued on initial contact. (A-96-134)

Revise Facility Operation and Administration handbook 7210.3, or other appropriate orders, to require that when a tower shuts down for any reason, and if the tower controllers have time to record a new automatic terminal information service (ATIS) indicating that the tower is closed, they should do so. (A-96-135)

Develop a plan to physically check and correct low level windshear alert system (LLWAS) wind sensor alignment in a timely manner. (A-96-136)

Evaluate the low level windshear alert system (LLWAS) recertification process, and ensure that the process addresses the total functional capability of the system. (A-96-137)

Require all operators to inspect immediately all MD-80 and DC-9 floor level exits to ensure that evacuation slides have been properly rigged. (A-96-138)

Require Douglas Aircraft Company to review and amend its MD-80 and DC-9 maintenance manuals so that terminology used in graphics and instructions pertaining to the installation and removal of evacuation slides are clear and consistent. (A-96-139)

Develop a uniform policy on shoe removal during evacuations, and require that all operators train their flight attendants to issue commands during an emergency evacuation consistent with that policy. (A-96-140)

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

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Vice Chairman

John Hammerschmidt
Member

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Member

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Member

November 13, 1996

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APPENDIXES

APPENDIX A

INVESTIGATION AND HEARING

1. Investigation

The National Transportation Safety Board was notified of the accident about 0600 on November 12, 1995. An investigative team was dispatched that morning and arrived at Bradley International Airport shortly thereafter. Investigative specialists for meteorology, air traffic control, operations, airplane performance, structures, systems, and powerplants gathered evidence on scene for about 1 week. Investigative groups for the cockpit voice recorder and the flight data recorder were also formed in Washington, D.C.

Parties to the investigation included the Federal Aviation Administration, Bradley International Airport, American Airlines, the Allied Pilots Association, United Technologies Pratt and Whitney, the National Air Traffic Controllers Association, Douglas Aircraft Company, and Jeppesen Sanderson, Inc.

2. Public Hearing

There was no public hearing conducted in conjunction with this investigation.

APPENDIX B

COCKPIT VOICE RECORDER TRANSCRIPT

LEGEND

RDO	Radio transmission from accident aircraft
CAM	Cockpit area microphone voice or sound source
INT	Transmissions over aircraft interphone system
CTR-1	Radio transmission from the first Boston center controller
CTR-2	Radio transmission from the second Boston center controller
FED5	Radio transmission from Federal Express flight #Five
UNK	Radio transmission received from unidentified aircraft
ATIS	Radio transmission received from Bradley ATIS
APR	Radio transmission from Bradley approach control
TWR	Radio transmission from Bradley control tower
PA	Transmission made over aircraft public address system
-1	Voice identified as Pilot-in-Command (PIC)
-2	Voice identified as Co-Pilot
-3	Voice identified as female flight attendant
-4	Aircraft mechanical voice
-?	Voice unidentified
*****	Unintelligible word
@	Non pertinent word
#	Expletive
%	Break in continuity
( )	Questionable insertion
[ ]	Editorial insertion
....	Pause

Note 1: Times are expressed in eastern standard time (EST).

Note 2: Non pertinent conversation where noted refers to conversation that does not directly concern the operation, control, or condition of the aircraft, the effect of which will be considered along with other facts during the analysis of flight crew performance.

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT

START of RECORDING

START of TRANSCRIPT

TIME & SOURCE	CONTENT
0025:39 **CAM**	[6:05 minutes of non-pertinent conversation between captain and first officer]
0031:51 **CAM**	[sound of several clicks similar to cockpit door release being o activated]
0031:54 **CAM-1**	hey Z.
0032:01 **CAM**	[sound similar to cockit door being operated]
0032:06 **CAM-2**	good luck on your landing there captain.
0032:07 **CAM-1**	[sound of laughter]
0032:10 **CAM**	[sound similar to cabin to cockpit chime]
0032:14 **INT-1**	hello.
0032:15 **INT-3**	were you looking for me?
0032:16 **INT-1**	yeah Z, we just got a message it's really, it's going to be real bumpy on the way down uh, to landing.

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	TIME & CONTENTSOURCE	CONTENT	
0032:22 **INT-3**	OK.		
0032:23 **INT-1**	so, put everything away or whatever as soon as we start down uh, mater of fact we're starting our descent now so you can lock it all up and prepare for landing.		
		0032:25 **CTR-1**	American fifteen seventy two descend * pilots discretion. maintain flight level one niner zero.
		0032:31 **RDO-2**	pilot's discretion to one nine oh, American fifteen seventy two.
0032:32 **INT-3**	OK, thank you.		
0032:35 **CAM-2**	pd to one nine oh, boss.		
0032:37 **CAM-1**	yeah, lets go down.		
		0032:39 **RDO-2**	out of three five oh for flight level one nine oh, American fifteen seventy two.
0032:42 **CAM-1**	you might want to cool it down too. it's gonna get bumpy or they'll be throwing up *.		
		0032:46 **CTR-1**	American fifteen seventy two roger, contact Boston center on one three four point three.

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE		TIME & CONTENTSOURCE	CONTENT
		0032:52 **RDO-2**	thirty four three, we'll see you American fifteen seventy two.
		0032:55 **CTR-2**	... four three.
		0032:56 **UNK**	two niner four three, roger.
		0032:59 **CTR-2**	FedEx five, how is your ride sir?
		0033:04 **FED5**	we were getting some uh, light to moderate rain and uh, I'll say that turbulence is uh, light occasional moderate.
		0033:12 **ATIS**	[heard through captain's audio panel] * tango restricts aircraft the wings to the left of *** seventy one feet. sig-met x-ray three is valid for severe turbulence below one zero thousand. pre departure clearances are available. advise on initial contact you have Victor. Bradley airport information Victor, zero three five one........ temperature six two, dew point five seven, wind one six zero at two eight, gust three niner. altimeter two niner five zero. ap-proach in use, ILS runway two four or VOR runway one five. notice to airman, runway two four and one five.......
		0033:15 **CTR-2**	FedEx five roger, sounds like it's getting better out there.
0033:19 **CAM-2**	##.		
		0033:21 **FED5**	hasn't been too bad so far.

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**TIME & CONTENTSOURCE**	**CONTENT**	
		0033:23 **RDO-2**	Boston, American fifteen seventy two, out of three four oh for one nine oh.
		0033:27 **CTR-2**	American fifteen seventy two Boston center roger, descend and maintain one one thousand, the Bradley altimeter two niner four zero.
		0033:35 **RDO-2**	twenty nine forty, out of three four oh for one one thousand American fifteen seventy two.
0033:44 **CAM-2**	boss, I'm goin to get the ATIS real quick before, turbulence occurs. ** you know what I mean, I'm off. you got it?		
0033:52 **CAM-1**	I'm sorry, what?		
0033:53 **CAM-2**	I'm gonna get the ATIS real quick.		
0033:56 **CAM-1**	obviously I'm gonna want one five for ***.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**TIME & CONTENTSOURCE**	**CONTENT**	
		0034:00 **ATIS**	[heard through the first officer's audio panel] Bradley airport informatin Victor, zero three five one zulu weather. two thousand two hundred scattered, measured ceiling two thousand seven hundred overcast. visibility one zero miles, light rain. temperature six two. dew point five seven. wind one six zero two eight gusts three niner. altimeter two niner five zero. approach in use ILS runway two four or VOR runway one five. notice to airman, runway two four and one five open and wet. low level wind shear advisories are in effect. taxiway tango restricted to aircraft with a wing span less than one hundred and seventy one feet. SIGMET x-ray three is valid for severe turbulence below one zero thousand. pre-departure clearances are available. advise on initial contact you have Victor.
0034:47 **CAM-2**	I'm back. both runways are wet. ILS two four, VOR one five.		
0034:52 **CAM-1**	alright. ** this is like three fifty one so it's like an hour and a half old.		
0034:56 **CAM-2**	low level wind shear advisories, severe turbulence and all of that.		
0035:03 **CAM-1**	OK I'm off.		
0035:04 **CAM**	[sound of click similar to PA button being pressed]		
0035:05 **CAM-2**	I'm back.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
0035:06 **PA-1**	ah, we started our descent. now we're about a hundred miles away from uh Bradley's Field right now. be touching down in about twenty five minutes or so. ....and latest temperature's sixty two degrees and just calling it uh, light rain however the winds uh, pretty uh, pretty high. they're saying the winds are up to thirty miles an hour or so. so it might get a little choppy. right now they're reported some uh, moderate turbulence on the de-scent. might just get a little choppy on the way down.		
0035:46 **CAM-1**	Ok, uh,		
0036:00 **CAM-1**	just watch me the whole way, alright?		
0036:03 **CAM-2**	yea man, you got it.		
0036:04 **CAM-1**	any comments scream out. **.		
0036:11 **CAM-2**	** you're gonna get a lot of turbulence ***.		
0036:16 **CAM-1**	*.		
0036:16 **CAM-2**	** you know how to land it.		
0036:17 **CAM-?**	*.		
0036:20 **CAM-1**	let's go to pumps on high.		

INTRA-COCKPIT COMMUNICATION | **AIR-GROUND COMMUNICATION**

TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
0036:23 **CAM-?**	****.		
0036:36 **CAM-2**	I'll tell you, when I was an engineer, new with the airlines I watched a guy he's uh, nobody likes him he's a seven two captain, I forgot his # name. all the Navy guys, man they hate his guts. he's still on the seven two. he thinks he's an IP at the RAG.		
0036:51 **CAM-1**	uh.		
0036:54 **CAM-2**	I watched him land in thirty knots of direct cross, up at Bradley, when I was a wrench, and it scared the # out of me. Actually it scared me bad. some of the flying we do here is much harder than...		
0037:05 **CAM-1**	yeah, yeah, I agree, I agree.		
0037:13 **CAM-2**	just fight'n it all the way down.		
CAM	[thirty four seconds of nonpertinent conversation between captain & first officer.]		
0038:03 **CAM-1**	OK, one five. what gate are we going to?		
0038:08 **CAM-2**	gate eight.		
0038:42 **CAM-1**	gettin' a lotta rain out there.		

INTRA-COCKPIT COMMUNICATION **AIR-GROUND COMMUNICATION**

TIME & SOURCE	TIME & CONTENTSOURCE	CONTENT
0038:45 **CAM-2**	altimeters?	
0038:51 **CAM-1**	I'll tell you, flying at night I don't like it worth a #. twenty nine fifty?	
0038:56 **CAM-2**	yea, we they called twenty nine forty seven when we started down *** what ever you want.	
0039:03 **CAM-1**	OK.	
0039:07 **CAM-2**	pumps are up. you want these lights?	
0039:09 **CAM-1**	* I think you can leave them off for now.	
0039:16 **PA-1**	flight attendants prepare for landing please.	
0039:18 **CAM-2**	reset and cross-checked. ***.	
0039:27 **CAM-1**	OK, reset and cross-checked ***.	
0039:31 **CAM**	[several unintelligible comments between captain and first officer]	
0039:56 **CAM-1**	we'll be, we'll be out of icing now. *****.	
0040:01 **CAM**	[sound similar to stabilizer-in-motion horn]	

INTRA-COCKPIT COMMUNICATION AIR-GROUND COMMUNICATION

TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
0040:13 **CAM**	[sound of yawn]		
0040:33 **CAM-1**	what's the overcast?		
0040:35 **CAM-2**	twenty seven hundred.		
0040:44 **CAM-2**	*** shootin' the # VOR man.		
0040:49 **CAM-1**	I've got uh, thirteen dash one plate. ** make that three February, ninety five.		
0041:02 **CAM-2**	that's right, three February ninety five, that's it.		
0041:04 **CAM-1**	OK, I'm showing VOR runway one five. frequency one oh nine zero. our inbound's one forty eight. MISTR at three, thirty five hundred. cleared down to two thousand at DILLN, five DME. we're cleared down all the way to uh, nine hundred and eight feet. missed is climb to three thousand out the uh		
0041:26 **CAM-2**	straight out Bradley VOR one forty nine ****.		
0041:38 **CAM-1**	plus eleven.		
0041:39 **CAM-2**	punch the tail?		
0041:40 **CAM-1**	tail on.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**TIME & CONTENTSOURCE**	**CONTENT**	
0042:25 **CAM-2**	happy hour, two for one *.		
0042:28 **CAM-B**	[sound of laughter]		
0042:31 **CAM-2**	twelve for eleven.		
0042:32 **CAM-1**	eleven *.		
0042:37 **CAM-2**	* raining out.		
0042:37 **CAM**	[sound of snap similar to chart holder being released]		
0042:48 **CAM-1**	one seventy four's the elevation so, twenty nine, twenty three.		
0042:59 **CAM-1**	reset and cross checked.		
0042:59 **CAM-2**	minus uh.		
0043:02 **CAM-1**	showing seventy *.		
0043:04 **CAM-2**	flight instruments and bugs.		
0043:05 **CAM-1**	check ** feet difference.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**TIME & CONTENTSOURCE**		**CONTENT**
0043:08 **CAM-?**	tell me what else you got.		
0043:11 **CAM-1**	flight instruments and bugs uh, two eighty uh, wings level pretty good on the horizon, heading checks. peeps are down, final bug's..		
0043:21 **CAM-2**	** goin' to be one twenty seven for forty flaps.		
0043:26 **CAM-1**	set and cross checked.		
0043:28 **CAM-2**	did you already seat the #? # been seated?		
0043:30 **CAM-1**	yeah I did.		
0043:32 **CAM-2**	I thought I heard you say # be seated.		
		0043:32 **CTR-2**	American fifteen seventy two contact Bradley approach one two five point eight. have a good night.
		0043:37 **RDO-2**	twenty five eight, we'll see ya, American fifteen seventy two.
		0043:41 **RDO-2**	Bradley approach, American fifteen seventy two, eleven thousand, information Victor.
		0043:49 **APR**	American fifteen seventy two, Bradley approach, roger. expect VOR runway one five approach.

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**TIME & CONTENTSOURCE**		**CONTENT**
0043:55 **CAM-1**	OK.		
		0043:56 **RDO-2**	Roger.
		0044:04 **APR**	American fifteen seventy two, fly heading of uh, one zero zero.
		0044:07 **RDO-2**	one zero zero, American fifteen seventy two.
0044:13 **CAM-1**	one zero zero, one oh nine, one forty eight.		
0044:20 **CAM-1**	I'll use uh, medium brakes *.		
0044:23 **CAM**	[sound of two clicks]		
0044:26 **CAM-2**	can't set it yet.		
0044:27 **CAM-1**	no, no ***.		
0044:28 **CAM-2**	I'm so stupid. I is stupid with a capital s. definitely known as mistah.		
0044:38 **CAM-1**	what?		
0044:41 **CAM-2**	MISTR, MISTR.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	TIME & CONTENTSOURCE		CONTENT
0044:43 **CAM-2**	ten miles out.		
0044:45 **CAM-1**	yeah, then DILLN.		
0044:47 **CAM-2**	at five.		
0045:10 **CAM-1**	lotta rain.		
0045:12 **CAM-2**	I can see that.		
		0045:54 **APR**	American fifteen seventy two, descend and maintain four thousand.
		0045:57 **RDO-2**	eleven for four thousand, American fifteen seventy two.
0045:59 **CAM-1**	set.		
0046:21 **CAM-1**	plus thirteen.		
0046:22 **CAM**	[sound of two thumps similar to switches being moved]		
		0047:01 **APR**	American fifteen seventy two the winds are one seven zero at two nine gusts three nine.
		0047:05 **RDO-2**	copy.

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
0047:13 **CAM**	[sound of laughter]		
0047:14 **CAM**	[sound similar to stabilizer in motion horn]		
0047:28 **CAM-1**	well you got enough gas to go back.		
0047:29 **CAM-2**	it's only forty five off the bug.		
0047:32 **CAM-1**	do you have any other choices?		
0047:44 **CAM-2**	well you have runway one five.		
0047:45 **CAM-1**	you bet, that's where we're going.		
0047:48 **CAM-2**	[sound of laughter]		
0048:03 **CAM-1**	how about slats extend, please.		
0048:04 **CAM**	[sound of click similar to flap/slat handle being moved]		
0048:09 **CAM-?**	*** #.		
0048:09 **CAM**	[sound of rattling similar to aircraft going through turbulence]		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**TIME & CONTENTSOURCE**		**CONTENT**
0048:33 **CAM-?**	moderate....		
0048:36 **CAM-?**	yes.		
		0048:39 **APR**	American fifteen seventy two, turn right heading one two zero and intercept the final.
		0048:43 **RDO-2**	American fifteen seventy two.
0048:49 **CAM-2**	VOR's alive.		
0048:59 **CAM-1**	**.		
0049:00 **CAM-2**	you want you want this one?		
0049:01 **CAM-2**	I got this ready.		
0049:02 **CAM-1**	let's hold out.		
0049:06 **CAM-2**	ten miles at thirty five hundred.		
0049:11 **CAM-1**	yeah, I just got that *		
0049:18 **CAM-?**	OK.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**TIME & CONTENTSOURCE**	**CONTENT**	
0049:19 **CAM-2**	approaching four thousand.		
0049:21 **CAM-1**	OK.		
0049:21 **CAM-1**	VOR capture.		
0049:25 **CAM-1**	slowing down.		
0049:31 **CAM-1**	*** five.		
0049:32 **CAM-2**	**.		
0049:39 **CAM-1**	* set the radar *.		
0049:40 **CAM-2**	alright.		
		0049:41 **APR**	American fifteen seventy two, you're five miles from MISTR. cross MISTR at or above three thousand five hundred, cleared for the VOR runway one five approach.
		0049:49 **RDO-2**	OK we'll uh, we're cleared for the approach. and we'll cross MISTR at or above uh, thirty five hundred. Ameri-can fifteen seventy two.
0049:55 **CAM-1**	set. comin' down.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
		0049:57 **APR**	American fifteen seventy two, roger and uh, be advised uh, the tower is closed at this time. it's a, temporary closure, due to uh, problem with uh one of the windows uh, so I'll need a uh, a down uh time on you but you can stay on this frequency uh, for that.
0049:59 **CAM**	[sound similar to stabilizer in motion horn]		
		0050:16 **RDO-2**	roger and, what happened on the window?
		0050:19 **APR**	it's just loose. they've got carpenters up there now boarding it up...
0050:23 **CAM-2**	it blew out.		
		0050:23 **APR**	... but once that's done the tower should be open.
		0050:25 **RDO-2**	copy.
0050:28 **CAM-1**	flaps eleven, please.		
0050:30 **CAM-2**	you got it.		
0050:34 **CAM**	[sound of rattling similar to aircraft going through turbulence]		
0050:51 **CAM-2**	OK, five hundred feet, looking good, you can go down to, step down to two thousand by five miles. but then it ...		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
0050:58 **CAM-1**	what's your **?		
0051:03 **CAM-2**	I think it's gonna be smoother once we get out of the weather.		
0051:05 **CAM-1**	yeah.		
0051:10 **CAM-2**	OK, you're at thirty five hundred *.		
0051:16 **CAM-1**	OK, we're cleared down to where?		
0051:17 **CAM-2**	you're cleared down to two thousand MSL at DILLN. by DILLN....		
0051:21 **CAM-1**	OK, two thousand set and armed.		
0051:22 **CAM-2**	...five miles * so it's good. two thousand is set and armed.		
0051:27 **CAM-1**	flaps fifteen.		
0051:28 **CAM-2**	down to flaps fifteen.		
0051:30 **CAM**	[sound similar to flap handle being moved and sound of rattling similar to aircraft going through turbulence]		
0051:44 **CAM-1**	OK, comin' down.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**TIME & CONTENTSOURCE**	**CONTENT**	
0051:44 **CAM-2**	ten miles.		
0051:48 **CAM-1**	comin' back to idle.		
0051:49 **CAM-2**	roger.		
		0051:56 **APR**	American fifteen seventy two uh, you show yourself on the final? looks like you're uh, a bit to the left of it.
0052:01 **CAM-1**	yeah, looks like we're to the left of it.		
		0052:02 **RDO-2**	copy.
		0052:03 **APR**	American fifteen seventy two roger, and the wind's now one seven zero at two four, gusts three five.
		0052:07 **RDO-2**	roger.
0052:11 **CAM-1**	how 'bout gear down, please.		
0052:12 **CAM**	[sound similar to landing gear handle being operated followed sound similar to nose gear door opening]		
0052:24 **CAM-2**	* thousand and five.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**TIME & CONTENTSOURCE**	**CONTENT**	
		0052:24 **APR**	American fifteen seventy two uh, 'K, there is someone in the tower, it's not really officially open, but you can change to tower frequency one two zero point three.
		0052:34 **RDO-2**	OK, you're not gonna need that down time?
		0052:36 **APR**	negative.
		0052:38 **RDO-2**	see ya.
		0052:39 **APR**	good day.
0052:42 **CAM-1**	OK, it's two thousand feet until five miles.		
0052:43 **CAM**	[sound similar to stabilizer in motion horn]		
0052:45 **CAM-2**	that's it.		
0052:46 **CAM-1**	coming back. flaps twenty eight.		
0052:47 **CAM**	[sound similar to flap handle being moved]		
0052:50 **CAM-2**	OK, going down to nine oh eight, huh?		
0052:53 **CAM-1**	yeah.		

INTRA-COCKPIT COMMUNICATION **AIR-GROUND COMMUNICATION**

TIME & SOURCE	TIME & CONTENTSOURCE	CONTENT
0052:54 **CAM-2**	set and armed *.	
0052:56 **CAM-1**	naw you don't have to do *, three thousand **.	
0052:58 **CAM-2**	three thousand, missed.	
0053:04 **CAM**	[sound similar to stabilizer in motion horn]	
0053:11 **CAM-2**	* VOR, right on track.	
0053:13 **CAM-1**	OK.	
0053:16 **CAM-2**	gear's down and green spoiler lever?	
0053:18 **CAM**	[sound of click similar to spoiler lever being armed]	
0053:19 **CAM-1**	armed.	
0053:20 **CAM-2**	you got brakes are going to medium.	
0053:23 **CAM**	[unidentified high frequency sound of decreasing pitch for approximately one second duration]	
0053:26 **CAM-1**	**.	

INTRA-COCKPIT COMMUNICATION | **AIR-GROUND COMMUNICATION**

TIME & SOURCE	**TIME & CONTENTSOURCE**	**CONTENT**	
0053:27 **CAM**	[sound similar to stabilizer in motion horn]		
		0053:27 **RDO-2**	hey tower, American fifteen seventy two, we're on a six mile final for runway one five.
		0053:32 **TWR**	American fifteen seventy two, 's Bradley tower uh, landing is at your discretion sir. the wind is one seven zero at two five, peak gust to four zero. and uh, the runway does appear clear. you can land and taxi to the gate at your discretion.
0053:40 **CAM**	[unidentified high frequency sound of decreasing pitch for approximately one second duration]		
0053:43 **CAM-2**	showing you going through the course.		
		0053:46 **RDO-2**	are you uh and uh, what are you showing right now for winds?
		0053:50 **TWR**	one seven zero at two four.
		0053:53 **RDO-2**	copy.
0053:58 **CAM**	[sound of rattling similar to aircraft going through turbulence]		
0054:01 **CAM-1**	flaps forty.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**TIME & CONTENTSOURCE**	**CONTENT**	
0054:02 **CAM**	[sound of click similar to flap/slat handle being moved]		
0054:04 **CAM-2**	OK, annunciator lights checked, flaps and slats at forty forty and land, you're cleared to land dude.		
0054:22 **CAM-1**	OK, give me a thousand down.		
0054:23 **CAM-2**	one thousand down, you got it.		
0054:34 **CAM-2**	you're showin' **.		
0054:35 **CAM-1**	**.		
0054:41 **CAM-2**	you got a long ways to go.		
0054:47 **CAM**	[sound similar to stabilizer in motion horn]		
		0054:51 **TWR**	wind shear alert uh, centerfield one seven zero at two five. the uh, northeast boundary, one seven zero at two four, one niner zero at twelve at the southeast boundary.
		0055:01 **RDO-2**	copy.
0055:06 **CAM-2**	there's a thousand feet. you got forty forty land, cleared to land.		

INTRA-COCKPIT COMMUNICATION AIR-GROUND COMMUNICATION

TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
0055:09 **CAM-1**	OK.		
0055:11 **CAM-2**	* now. nine hundred and eight is your uh...		
0055:14 **CAM-1**	right.		
0055:16 **CAM-2**	your * bug.		
0055:18 **CAM**	[sound of rattling similar to aircraft going through turbulence]		
0055:25 **CAM-2**	you're going below your...		
0055:26 **CAM-4**	sink rate...		
0055:28 **CAM-2**	**.		
0055:29 **CAM-4**	..sink rate...		
0055:30 **CAM**	[sound of impact]		
0055:30 **CAM-4**	sink rate...		
0055:30 **CAM-4**	[sound of four beeps followed by]		
0055:31 **CAM-4**	wind shear, wind shear...		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**TIME & CONTENTSOURCE**		**CONTENT**
0055:32 **CAM-?**	go.		
0055:32 **CAM-4**	wind shear...		
0055:33 **CAM-2**	go, go around.		
0055:33 **CAM-1**	we're going. going, going around, going around.		
0055:35 **CAM**	[sound of horn]		
0055:35 **CAM-4**	landing gear...		
0055:36 **CAM**	[sound of horn]		
0055:37 **CAM-4**	[sound of four beeps followed by]		
0055:38 **CAM-4**	wind shear, wind shear, wind shear.		
0055:39 **CAM-1**	flaps fifteen, positive rate, gear up.		
0055:41 **CAM**	[sound of horn]		
0055:41 **CAM-4**	landing gear.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**TIME & CONTENTSOURCE**		**CONTENT**
0055:43 **CAM-2**	you want the gear up?		
0055:43 **CAM-1**	yep.		
0055:44 **CAM**	[sound of horn]		
0055:45 **CAM-4**	landing gear.		
0055:46 **CAM-?**	###.		
0055:46 **CAM**	[sound of horn]		
0055:47 **CAM-4**	landing gear.		
0055:48 **CAM**	[sound of horn]		
0055:50 **CAM-4**	landing gear.		
0055:51 **CAM**	[sound of horn]		
0055:52 **CAM-4**	landing gear.		
0055:53 **CAM-1**	left motor's failed.		
0055:56 **CAM-1**	**.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**TIME & CONTENTSOURCE**	**CONTENT**	
0055:57 **CAM-2**	there's the runway straight ahead.		
0055:58 **CAM-1**	OK.		
0056:00 **CAM-1**	tell 'em we're goin' down. tell 'im emergency.		
		0056:02 **RDO-2**	tower call for emergency equipment. we have, we're goin' down on the runway.
0056:06 **CAM-2**	you want the gear back down?		
0056:07 **CAM-1**	yes, throw it down.		
0056:10 **CAM-4**	sink rate...sink rate...		
0056:12 **CAM-1**	oh God.		
		0056:12 **TWR**	is that State on ground control?
0056:12 **CAM-2**	you're gonna make it.		
0056:12 **CAM-1**	OK.		
0056:13 **CAM-4**	...sink rate...		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**TIME & CONTENTSOURCE**		**CONTENT**
0056:13 **CAM-2**	flaps?		
0056:14 **CAM-4**	...sink rate...		
0056:17 **CAM-1**	put 'em down.		
0056:18 **CAM-2**	***.		
0056:20 **CAM-1**	whata we got?.		
0056:21 **CAM-2**	we're still flying.		
0056:21 **CAM-1**	OK.		
0056:22 **CAM-4**	...sink rate...sink rate.		
0056:23 **CAM-1**	God #.		
0056:23 **CAM-2**	keep goin', you're gonna make it.		
0056:24 **CAM-4**	...sink rate...		
0056:25 **CAM-2**	keep coming.		
		0056:25 **TWR**	wind one seven zero at two two.

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**TIME & CONTENTSOURCE**		**CONTENT**
0056:26 **CAM-4**	too low, flaps		
		0056:26 **RDO-2**	yeah, call for emergency. call for emergency equipment.
0056:27 **CAM-4**	terrain, terrain.		
		0056:30 **TWR**	they're comin' they're comin.
0056:30 **CAM-4**	terrain.		
0056:31 **CAM-4**	too low.		
0056:32 **CAM-2**	you got it dude, you're gonna make it.		
0056:33 **CAM-1**	OK.		
0056:34 **CAM-2**	you got a long *..		
0056:35 **CAM-1**	flaps, flaps forty. all the way down.		
0056:36 **CAM-4**	don't sink.		
0056:37 **CAM-1**	all the way, flaps forty.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
0056:38 **CAM-2**	they're all the way.		
0056:39 **CAM-1**	OK, hold on guy.		
0056:40 **CAM**	[sound of impact]		
0056:41 **CAM**	[sound of horn]		
0056:42 **CAM-4**	f-u-l-a-p-s.		
0056:44 **CAM**	[sound of vibration begins and continues for nine seconds]		
		0056:45 **TWR**	one seven zero at two two.
0056:46 **CAM-1**	get it on, on the deck.		
0056:47 **CAM**	[sound of impact]		
0056:48 **CAM-1**	hold it down buddy, hold it down, hold it down, hold it down, hold it down...		
0056:47 **CAM**	[sound of horn]		
0056:48 **CAM-1**	...hold it down.		

INTRA-COCKPIT COMMUNICATION | **AIR-GROUND COMMUNICATION**

TIME & SOURCE	TIME & CONTENTSOURCE	CONTENT
0056:53 **CAM-2**	God bless you, you made it.	
0056:55 **CAM**	[sound of horn]	
0056:56 **CAM-4**	landing gear. [continues to the end of the recording]	
0056:59 **CAM**	[sound similar to engine RPM decreasing]	
0057:02 **CAM-1**	shut down the motors.	
0057:04 **CAM-?**	throttles closed.	
0057:05 **CAM-2**	pull 'em both.	
0057:06 **CAM-1**	yeah, pull both fire handles.	

0057:06
END of RECORDING

END of TRANSCRIPT

APPENDIX C

AAL FLIGHT MANUAL EXCERPT ON ALTIMETER SETTING PROCEDURES

3.5 **Descent During Approach**

Radar vectors may provide course guidance to the final course or fix. When operating on an unpublished route or while being radar vectored, the pilot, when an approach clearance is received, shall maintain the last altitude assigned until the aircraft is established on a segment of a published route or instrument approach procedure unless a different altitude is assigned by ATC. After the aircraft is so established, published altitudes apply to descent within each succeeding route or approach segment unless a different altitude is assigned by ATC. Upon reaching the final approach course or fix, the pilot may complete the instrument approach in accordance with a procedure approved for the facility.

3.6 **Radar Vectors**

A. Comply with headings and altitudes assigned by the controller.

B. Question any assigned heading or altitude believed tobe incorrect.

C. If compliance with any radar vector or altitude would cause a violation of any FAR or create an unsafe situation, advise ATC and obtain a revised clearance or instruction.

3.7 **Altimeters**

A. Descent

1. At airports where Above Field Level (QFE) settings are not available, crews will convert Mean Sea Level (QNH) settings by application of the appropriate conversion charts contained in the Performance Section of the respective Operating Manual. (See Flight Manual Part II for procedures at BOG, LPB, and UIO.)
2. On descent, after each Pilot has set the individual altimeter to AFL(QFE) setting, a check will be made between the altitude shown on each instrument and that shown on the third altimeter. The difference should equal the published elevation of the airport of intended landing.
3. Throughout the approach, monitor barometric changes and correct the altimeters accordingly.
4. The Captain and FO should not reset altimeters simultaneously.

B. Approach

1. Altimeter callouts will be based on the Captain's or FOS barometric altimeter (AFL) during the approach from the Final Approach Fix on, except as follows:
   a) Callouts for Category II and Ill approaches will be based upon the radio altimeter from 300 feet on.
   b) On all approaches, callouts from 50 feet to touchdown will be based upon the radio altimeter.