NATIONAL TRANSPORTATION SAFETY BOARD
Office of Research and Engineering
Washington, D.C. 20594

September 7, 1999

Solid State Flight Data Recorder Factual

Specialist's Report of Investigation
by Sarah McComb

A. ACCIDENT

Location:	Little Rock, Arkansas
Date:	June 1, 1999
Time:	2351 Central Daylight Time
Aircraft:	American Airlines, flight 1420, MD-82, N215AA
NTSB Number:	DCA99MA060

B. GROUP

Chairman:	Sarah McComb
	National Transportation Safety Board
Member:	Garry Chesnutt
	Allied Pilot Association
Member:	Jim Kaiser
	American Airlines
Member:	Lyle Streeter
	Federal Aviation Administration
Member:	David Yingling
	Boeing

C. SUMMARY

On June 1, 1999, a McDonnell Douglas MD-82 crashed after landing on runway 4R at Little Rock, Arkansas. Flight 1420 was being conducted under the provisions of Title 14 CFR

Part 121. There were thunderstorms and heavy rain in the area at the time of the accident. The airplane departed the end of runway, went down an embankment, and impacted approach light structures. There was a crew of 6 and 139 passengers on board the airplane. Eleven persons were killed in the accident.

The Solid State Flight Data Recorder (SSFDR), a L3 Model FA2100 (s/n 00718), was removed from the accident aircraft and brought to the National Transportation Safety Board's (NTSB) Flight Recorder Laboratory in Washington, D.C. for readout and evaluation.

The SSFDR data indicate the following:

- At 11:50:13, while on a heading of approximately 42° and descending through a radio altitude of 70.5 feet, the GPWS warning was activated. Given the values of other parameters at this time, this warning would be consistent with a "sink rate" audible warning. Also at this time, the roll angle reached a maximum of 8.4° (right wing down) at 11:50:12 before decreasing to 0.7° (right wing down) at 11:50:19. The glideslope deviation value was approximately 3 dots (indicating fly down) during the approach for landing at 11:50:13.
- Fluctuations in vertical acceleration began at 11:50:19. At that time, vertical acceleration decreased to a value of 0.8623 G's. The following second, it increased to 1.2286 G's and then to a maximum value of 1.7002 G's. It subsequently decreased to a minimum value of 0.7295 G's at 11:50:21, before increasing to 1.1943 G's.
- At time 11:50:19, radio altitude was -0.2 feet and airspeed was 157 knots. The following second, the values decreased to -3.4 feet and 140 knots, respectively. Radio altitude continued to decrease the following second to -4.0 feet. However, airspeed increased to 145 knots. At 11:50:22, both parameters increased to -2.9 feet and 149 knots, respectively. Airspeed remained constant the next second while radio altitude decreased to -4.5 feet. At 11:50:24, airspeed decreased to 146 knots.
- The first indication of thrust reverser activity occurred at 11:50:22 when the left thrust reverser indicates an unlocked status. During the following 3 seconds both thrust reversers transitioned to deployed status. The right thrust reverser returned to the unlocked state at 11:50:27 and the left thrust reverser returned to the unlocked state the following second. Both reversers were then deployed for three seconds each before returning to the unlocked

state. At 11:50:39, the right thrust reverser was deployed before returning to the stowed position throughout the remainder of the recording. At 11:50:40, the left thrust reverser was deployed and remained in that position throughout the remainder of the recording.

- The rudder position reached 21.7° (aircraft nose-left (ANL)) at 11:50:19 before decreasing to –8.3° (aircraft nose-right (ANR)) two seconds later. Fluctuations in the rudder position values occurred until reaching a maximum of 24.3° (ANL) at 11:50:34. Fluctuations continued until reaching the final recorded values of –20.7° (ANR) and -20.5° (ANR) at 11:50:47.
- Left and Right elevator positions reached -17.2° (aircraft nose-down (AND)) and -14.1° (AND) at 11:50:23. Fluctuations occurred before reaching -2.1° (AND) and 1.8° (aircraft nose-up (ANU)), respectively, at 11:50:35. At 11:50:44, the left elevator position reached a value of 11.4° (ANU). The following second the right elevator position reached -18° (AND). At 11:50:47 the final recorded value of the left elevator was 9.6° (ANU) and that of the right elevator was 0.0°.
- At 11:50:19, magnetic heading was 40.9° during approach to runway 4R. Magnetic heading then decreased to the left over the next 10 seconds before reaching a heading of 29.7°. At 11:50:36, magnetic heading reached its lowest value of 23.6° to the left. The value then increased to the right until the end of the recorded data. The last recorded value was 71.0° at 11:50:47.
- Longitudinal acceleration decreased from a value of -0.0885 G's at 11:50:21 to a minimum of -0.2777 G's. The following second the longitudinal acceleration increased to -0.0539 G's. Longitudinal acceleration values then fluctuated before reaching -0.2553 G's at 11:50:34 and then increasing again to -0.0335 G's at 11:50:35.
- Fluctuations in vertical, lateral, and longitudinal accelerations occurred at 11:50:41. At that time, vertical acceleration was 0.8898 G's, lateral acceleration was 0.1578 G's, and longitudinal acceleration was -0.1332 G's. The following second vertical acceleration increased to 1.2721 G's and then decreased to 0.8829 G's. Lateral acceleration increased to 0.2188 G's and longitudinal acceleration decreased to -0.3265 G's. Acceleration values continued to fluctuate and dampen out over the next several seconds.
- At 11:50:19, the pitch angle was -0.7° and then decreased to -2.5° three seconds later. The pitch angle then remained constant at approximately 1° until 11:50:45 when it decreased to -2.5°. The final recorded value for the pitch angle was -5.3° at 11:50:47.

- The left spoiler remained at approximately 0° while in flight and on the ground with the exception of minor fluctuations that resulted in increases to approximately 10°. This was also true of the right spoiler except when the right spoiler position increased to 58.9° at 11:50:36 before decreasing to 0.4° at 11:50:39. Left aileron position reached -14.5° (right wing down) at 11:50:35 and then finally increased to 11.2° (left wing down) at 11:50:43.
- The left brake pedal position was approximately 3.4° during the airplane's approach, while the right brake pedal position was approximately -0.4° during approach. At 11:50:30, the left pedal position reached 19.2° and then decreased to 7.1° at 11:50:34. The value then increased to 17.3° two seconds later. The right brake pedal position reached 18.6° at 11:50:33 and then reached a maximum of 18.9° at 11:50:41. The final recorded values for the left and right brake pedal positions were 17.3° and 13.9°, respectively.
- At 11:50:26, the left and right engine pressure ratios (EPRs) reached values of 1.89 (reverse (REV)) and 1.67 (REV), respectively. The left EPR then fluctuated before reaching a maximum of 1.98 (REV) at 11:50:34. The right EPR reached 1.74 (REV) at 11:50:35. Both EPRs then decreased until reaching approximately 1.00 at the end of the recorded data.
- Throughout the recorded period of the accident, the pitch trim position remained at a constant value of approximately -5°. The left and right slats remained in the extended position. The flap position remained constant at approximately 40°.

D. DETAILS OF INVESTIGATION

1. Description of Recorded Data

This model SSFDR accepts serial bit stream data in an ARINC 573/717[1] format at a rate of 64 12-bit words per second. The SSFDR uses solid-state Flash Memory technology as the recording medium. The recording is stored in a Crash Survivable Storage Unit. A minimum of the last 25 hours of operational data is retained on the recording medium.

Prior to recording, the serial data stream is compressed using a modified Hoffman encoding scheme. The data can be decompressed and restored to the original ARINC

[1] Flight Data Acquisition and Recording System Characteristic, Published by Aeronautical Radio, Inc. (ARINC), 2551 Riva Road, Annapolis, Maryland

575/717 format without any data loss. This requires the use of specialized manufacturers or equivalent software.

The Digital Flight Data Acquisition Unit (DFDAU) provides a means of gathering, conditioning, and converting flight data parameters to digital data. In this aircraft, the DFDAU function is performed by the SSFDR. The DFDAU provides a serial binary digital data stream to the SSFDR at a rate of 768 bits/sec. A binary, or logical one, is represented by a voltage transition between clock transitions.

The DFDAU input signals are time division multiplexed, with parameter identification established by means of position or time slot addresses in the serial data stream output. This output is a continuous sequence of four-second data frames. Each frame consists of four subframes of 64 separate 12-bit words, with the first word containing a unique 12-bit synchronization (sync) word identifying it as subframe 1,2,3, or 4. The data stream is "in sync" when successive sync words appear at the proper 64-word intervals. If the data stream is interrupted, sync words will not appear at the proper interval or sequence, and the time reference will be lost until the subframe pattern can be reestablished

2. Examination and Readout

The SSFDR was examined upon receipt. The exterior of the recorder displayed evidence of fire and smoke damage as shown in Figure 1. However, there was no mechanical damage and the memory module inside exhibited no visible signs of damage.

Figure 1: SSFDR (L3 Model FA2100, s/n 00718)

The SSFDR data were transcribed to hard disk for further analysis. The transcribed data were reduced from the recorded binary values (0's and 1's) to engineering units (for example feet, knots, degrees, etc.) using conversion formulas obtained from American Airlines for this airplane. Attachment I contains the parameter listing for this airplane. The transcribed data were processed by the National Transportation Safety Board's Recovery Analysis and Presentation System (RAPS), which converted the raw data to engineering units and presented it in tabular and graphic form. An examination of the recovered data indicated that the recorder operated normally. The SSFDR contained over 62 hours of data.

1. Time Correlation with Cockpit Voice Recorder

The cockpit voice recorder (CVR) was separately correlated with the air traffic control (ATC) transcript beginning with the last transmission from the cockpit to ATC and then moving back in time. The SSFDR data was then correlated to the CVR using the time of the last transmission from the cockpit to ATC (CVR local time = 11:48:42.33 CDT) with the last time that the parameter VHF 1 Keying indicated a state of "Keyed" (FDR subframe reference number = 18743.13 seconds). The time shift necessary to correlate the SSFDR subframe reference number with CVR local time was 23779.2 seconds.

2. Data Printout and Graphs

a. Accident Data

Tabular printouts of accident data are included in Attachments II-1 to II-38. Attachments II-1 to II-26 include data from the accident timeframe of 11:49:50 p.m. to 11:50:50 p.m. Attachments II-27 to II-38 include data from the airplane's previous landing in Dallas, TX. Attachment II-39 includes engine data from the airplane's push back from the gate in Dallas, TX.

b. Accident Data Plots

Attachments III-1 to III-6 contain six plots of selected parameters. The first four plots cover the time period of the accident, from 11:49:50 p.m. to 11:50:50 p.m. The following parameters are included in the first plot: pressure altitude, radio altitude, airspeed, magnetic heading, vertical acceleration, longitudinal acceleration, lateral acceleration, right main landing

heading, vertical acceleration, longitudinal acceleration, lateral acceleration, right main landing gear. The second plot contains the following parameters: roll angle, pitch angle, left thrust reverser, right thrust reverser, GPWS warning, left elevator position, rudder position, left aileron position, left outboard spoiler position, right inboard spoiler position, glideslope deviation 1, localizer deviation 1. The third plot contains all relevant engine data. The fourth plot contains all relevant flight control data. The next two plots contain the same parameters as the first two plots, but cover the time period of the airplane's previous landing. The final plot contains engine data from the airplane's push back from the gate in Dallas, TX.

[redacted]
Sarah L. McComb
Mechanical Engineer

Attachments:

Attachment I:	MD-82 Parameter Listing
Attachments II-1 to II-39:	Tabular Printouts of SSFDR Data
Attachments III-1 to III-7:	Plots of SSFDR Data