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

March 27, 1997

Flight Data Recorder - 10

by Dennis R. Grossi

A. ACCIDENT

Location:	Near Monroe, Michigan
Date:	January 9, 1997
Time:	15:50 local standard time
Aircraft:	Embraer EMB-120; N265CA
NTSB Number:	DCA97MA017

B. GROUP

Group Chairman:	Dennis R Grossi National Resource Specialist Flight Data Recorders National Transportation Safety Board
Member:	Joseph Bracken Staff Engineer Airline Pilots Association
Member:	Matt Jacobs EMB-120 Check Airman Comair
Member:	Decio Coelho Pullin Aerodynamics Group Manager Embraer
Member:	Steve Wade Pilot, Flight Operations. Pratt and Whitney Canada
Member:	Francis Rock Aircraft Engineering Federal Aviation Administration
Member:	Stephen W. Josephson System/Advanced Controls Propulsion Engineering Hamilton Standard

C. SUMMARY

COMAIR flight 3272, operated as a 14 CFR Part 135 commuter passenger flight form Cincinnati, Ohio to Detroit, Michigan, crashed while on approach to runway 3R. There were 26 passengers and 3 crew onboard, none survived and the airplane was destroyed.

The Solid State Flight Data Recorder (SSFDR), a Loral Fairchild Model F1000 (s/n997, Part No. S800-2000-00), was removed from the aircraft wreckage and brought to the Safety Board's laboratory in Washington, D.C. for readout and evaluation.

The following is a brief summary of the FDR information recovered during the final minutes of the accident flight. All times reference local time[1] unless otherwise noted:

- At 1553:25, the FDR data indicated that the aircraft was descending in a wings level attitude through 4,800 feet at an airspeed of 164 knots, while established on a 140° magnetic heading. The engine values indicated that power was set at approximately flight idle (15% left, 12% right engine torque) and the propeller speed for both engines was approximately 85%. A pitch attitude of 1 ° nose-down was maintained and the auto pilot was engaged in the altitude pre-select "ARM" mode.

- At 1553:27, the control wheel (CW) position values indicated the start of right CW inputs. The roll attitude indicated the start of a right roll approximately 1 second later, the heading values change less than a degree until 4.4 seconds later when a 2.3° change to the right was recorded. The heading values continued to increase indicating a continuous right turn until a heading of 180° was established 21 seconds later. The roll angle increased steadily to 26° right wing down (RWD) over the next 10 seconds, and was maintained for approximately 3 seconds. The maximum right CW input recorded during this period was 5.3°.

- At 1553:42, the roll attitude values indicate the start of a roll back to wings level flight, and the pitch attitude began to increase from -1.6° nose-down (ND). A wings level attitude, and a 0.23° pitch attitude were reached 8 seconds later. The maximum left CW input recorded during the roll back to wings level was 1.1°.

- At 1553:55, the airplane began to level off while maintaining a heading of 180° and an airspeed of 169 knots with power set near flight idle.

- At 1554:03, the aircraft started a left bank as the pitch attitude, which had been increasing steadily since 1553:42, reached approximately 3° nose-up and the airspeed decreased to 164 knots while power remained at approximately flight idle. One second later the airplane leveled at 4,000 ft. as the heading data indicates the start of a left turn. Three seconds after leveling at 4,000 ft., the auto pilot modes changed from "Altitude Pre Select - ARM" to "Altitude - HOLD.

[1] The local time reference is based on a correlation of the FDR and Cockpit Voice Recorder(CVR)/Air Traffic Control (ATC) radar.

- From 1554:08 to 1554:09, the values for CW and roll attitude began to diverge, with CW changing from -2.04° left wing down (LWD) to -0.14° LWD, as roll attitude increased from -18.22° to -22.01° LWD", and the pitch trim and control column values start to move in the nose-up direction. Two seconds later, the data for the left and right angle of attack (AOA) vanes started to diverge, and the lateral acceleration values start to increase from near zero.

- At 1554:12, the bank angle values stopped increasing in the LWD down direction and remained constant at approximately 27° (the auto pilot roll command limit) for approximately 2 seconds. The CW position values, which had been indicating increasing RWD control inputs, fluctuated between 5.1° and 6.3° RWD. At the end of this period, the roll attitude resumed increasing to the left, and the CW began to record increasing RWD control inputs.

- At 1554:14, the roll angle increased beyond -28 ° LWD, although control wheel and rudder inputs moved in a RWD direction as the airspeed decreased to 149 knots. A continuous left turn was maintained as the heading values passed through 153°.

- At 1554:15, the torque values began to increase on both engines as the airspeed decreased to 148 knots. One second later the bank angle reached 30° LWD and the torque values reach 33.3% (lt.) and 39.3% (rt.)

- At 1554:17, the pitch attitude, which had been increasing steadily since 1553:42, started to decrease after reaching the peak nose-up value of approximately 5 °. However, the parameters "Control Column Position" and "Pitch Trim Position" continued to move in a nose-up direction; a trend started 9 seconds earlier.

- At 1554:22, the bank angle had increased to 38° LWD, while the control wheel and rudder inputs continue to move in a RWD direction. The left and right angle of attack (AOA) values indicated a difference of approximately 7°, with AOA #2 (rt.) the larger. The engine torque values increased to 85.2% (lt.) and 94.7% (rt.) and the airplane continued to decelerate reaching an airspeed of 147 knots.

- At 1554:22.67, the "auto pilot fail mode" discrete transitions to the "fail mode", and the trend of RWD CW values continued with the control inputs reaching 19.5°[2]. The torque values increased abruptly to 103.5% (lt.) and 96.1% (rt.) as the airspeed continued to decrease reaching 146 knots. The pitch attitude decreased to 3.3° nose-up and the bank angle increased to -38.04° LWD.

- At 1554:23.59, the status of the parameter "auto pilot disconnect" indicated "normal" operation, and 0.03 seconds later the status of parameter "master warning" indicated that a "warning" was issued. At 1554:23.67, the parameter "control wheel position" changed 25.8° from 19.5° RWD, recorded one second earlier, to -6.3° LWD, ending a 14 second trend of RWD values.

- At 1554:23.7, the roll attitude changed 11° (- 40° to -51°) in 0.5 seconds and the

[2] Auto pilot fail mode and control wheel position (rt.) are both recorded in the same 12 bit word.

pitch attitude decreased 3° (3° to 0.0°) in 0.25 seconds. The pitch attitude continued the nose-down trend, decreasing to -50° nose-down within five seconds. The abrupt left roll also continued reaching 146° LWD within two seconds. The next time auto pilot status was sampled (1554:24.125) the status had changed to "disengaged". The altitude data also indicated the start of the descent from 4,000 feet MSL.

- During the increase in power starting at 1554:15, a torque split commences until 1554:22, when the peak recorded torque values of 108% (left engine) and 138% (right engine) occurred. These peak values were present for one sample, or less than one second. Over the next 4 seconds, the engine parameters indicated a power reduction on both engines to values near flight idle.

- The aircraft continued to descend with oscillations in pitch attitude between -80 ° and -20 ° nose-down until the recording ends at 1554:40.

- The airplane was configured with flaps and gear up for the entire flight from just after takeoff.

D. DETAILS OF INVESTIGATION

1. Description of Data

This model SSFDR accepts serial bit stream data in an ARINC 573/717[3] 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.

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 573/717 format without any data loss. This requires the use of specialized manufacturers or equivalent software.

The use of data compression will vary the duration of a SSFDR recording. Dynamic phases of flight such as takeoff and landing require more memory than steady or static conditions. Therefore, the duration of the SSFDR recording will depend on flight dynamics. The minimum requirement for this Part 135 airplane is 25 hours of data.

The Digital Flight Data Acquisition Unit (DFDAU) provides a means of gathering, conditioning, and converting flight data parameters to digital data. The DFDAU provides a serial binary digital data stream to the DFDR 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

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

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 of Recorder

The flight recorder was destroyed by the impact forces and post crash fire. Although burned, the crash survivable memory module remained intact, and the nonvolatile memory was not damaged. It was necessary to replace the damaged memory module ribbon cable external connector before conducting the readout.

3. Readout and Evaluation

a. Readout

A transcription was accomplished using a standard Loral Fairchild Ground Station/2, Read Out Center (ROC). The memory module was connected to the serviceable Model F1000 SSFDR maintained by Safety Board, using standard connectors. All data were recovered using normal recovery procedures.

The data were reduced from the recorded decimal values (0 to 4095) to engineering units (e.g., feet, degrees, knots, etc.) by conversion algorithms obtained from the airplane manufacturer. Attachment I contains a parameter listing.

The transcribed data were process by the 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.

b. Evaluation

An examination of the recovered data indicated that the recorder operated normally. However, the following parameters displayed anomalous, spurious, or out of calibration values:

Parameter [4]	Remarks
Elevator Control Column Position (Lt.)	Noisy and not consistent with roll & heading values.
Control Wheel Position (Lt.)	Noisy and not consistent with roll & heading values.
Pitch Trim Position	Random spurious data points
Prop Imbalance (Lt.)	Not Active
Static Air Temperature	Noisy
Heading	Random spurious data points
Rudder Pedal Position	Random periods of noisy data; values exhibit a bias of ≈ 7° to 8° (left), as established during simulation.

[4] The parameters "Elevator Control Column Position (Rt.)" and "Control Wheel Position (Rt.) " recorded valid values.

The Safety Board has observed similar problems with the flight control parameters on earlier Embraer accidents and incidents. As a result, on July 27, 1996, the Safety Board issued Safety Recommendations A-96-33 and -34, to the Federal Aviation Administration (FAA) calling for a design review and appropriate changes to ensure the proper recording of the flight control parameters, and a maintenance check every 6 months, until the improvements are incorporated. The FAA's September 5,1996, response agreed with the recommendations. Embraer is currently conducting a design review, and the FAA is in the process of developing revised flight recorder maintenance procedures.

In addition to the data anomalies previously listed, a number of discrete parameters indicated simultaneous change of status for one sample, which amounted to one second in most cases. The affected parameters all involved auto pilot functions. The airplane manufacturer is currently evaluating these events. In addition, a review of the auto pilot manufacturer's installation manual is in progress.

During the final 2 seconds of recorded data the parameters of pitch and roll displayed anomalous values.

E. Tabular Data

The tabular listing is included in the addendum to this report.

F. Data Plots

Attachment II contains 3 data plots of selected parameters. Plots 1 and 2 cover the same 100 second period from 1553:05 to 1553:45; the last data for the accident flight was recorded at 1554:40. Plot 1 contains the parameters that retained values for flight path, airplane attitude, accelerations, flight control inputs, selected auto pilot modes, and engine torque. Plot 2 contains all of the engine parameters, plus roll attitude, airspeed, static air temperature and selected auto pilot parameters. Plot 3 covers a 50 second period from 1553:55 to 1554:45, and contains the same parameters as Plot I except that AOA vane angle # 1 and #2 have been substituted for vertical and longitudinal acceleration.

[redacted]

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Attachments: