NATIONAL TRANSPORTATION SAFETY BOARD
OFFICE OF RESEARCH AND ENGINEERING

Washington, D.C.

October 24, 1995

FLIGHT DATA RECORDER FACTUAL REPORT OF INVESTIGATION

DCA-95-MA-054

A. ACCIDENT

Location : Carrollton, Georgia
Date : August 21, 1995
Aircraft : Atlantic Southeast Airlines (ASA) Flt. 529, Embraer EMB-120 RT, N256AS

B. GROUP

Dennis R. Grossi, Group Chairman, N.T.S.B.
Francis Rock, Federal Aviation Administration
Joseph M. Bracken, Air Line Pilots Association, Int'l.
Steve Josephson, Hamilton Standard
Mark Feeney, Pratt and Whitney Canada
Sergio Horta, Embraer Aircraft Co.

C. SUMMARY

On August 21, 1995, at about 1253 eastern daylight time (EDT), an Embraer EMB-120RT, N256AS, airplane operated by Atlantic Southeast Airlines (ASA) crashed after departing the Atlanta Hartsfield International Airport (ATL), Atlanta, Georgia. The flight was a scheduled passenger flight carrying 26 passengers and a crew of three operated under the provisions of Title 14 Code of Federal Regulations (CFR) Part 135. The flight was operating in accordance with instrument flight rules (IFR). While climbing through 18,000 feet, the flight crew declared an emergency and initially attempted to return to Atlanta. The pilots advised they were unable to maintain altitude and were vectored toward West Georgia Regional Airport, Carrollton, Georgia for an emergency landing. The airplane continued descent until ground impact. The airplane was destroyed by impact forces and postcrash fire. The captain and seven passengers received fatal injuries.

Following the accident, the digital flight data recorder (DFDR), a Loral Model F800 (p/n 17M800-261, s/n 4856) fitted to N256AS was removed from the wreckage and brought to the Safety Board's laboratory in Washington, D.C. for readout and evaluation. The data recorded during the accident flight was successfully recovered along with data from 3 previous flights.

The parameters of control wheel position and rudder pedal position displayed values that were inconsistent with other related parameters. The engineering unit conversion algorithms for control wheel position was recalculated from data recorded during pre flight control checks. However, the parameter rudder pedal position, only recorded small changes that did not approach full travel and therefore, could not be calibrated. In addition, the post accident examination of the wreckage revealed that the rudder pedal sensor was not securely connected to the rudder pedal system.

The following is a brief chronology of the accident flight data. All time are referenced to the local times unless otherwise noted (see *Airplane Performance Study* for correlation of DFDR and local time):

- At approximately 12:23:00, the data are consistent with the start of a normal takeoff from Atlanta Hartsfield International Airport.

- Following the initial takeoff climb, the engine torque values remained nearly constant at between 79% and 86%, dropping below 79% for 12 second as the altitude values passed through 12,400'. The engine torque values remained generally symmetrical during the climb.

- The data indicated a steady climb to 18,000 feet at an airspeed of 160 knots while on a westerly heading. At 12:43:27, the parameters for the left engine indicated a sudden and complete lost of power.

- During the next 4 minutes, the data indicates a continuous left turn and descent down to 8,200 feet. The bank angle and airspeed values varied from 0° to 30° (left wing down), and 200 to 150 knots, respectively.

- As the airplane passed through 8,200 feet, the data indicated the airplane entered a right turn. The right turn was maintained for the next two minutes as the altitude decreased to 5,000 feet and the airspeed decreased from 174 to approximately 160 knots. Upon reaching 5,000 feet, the right bank was decreased and an easterly heading was maintained for the next minute and a half as the altitude values decreased to 2,500 feet. The airplane then entered a second right turn for approximately 30 seconds until reaching 1,800 feet.

- From 12:51:50 to 12:52:18, the pressure altitude values decreased to 1,200 feet at a steady rate of approximately 850 feet per minute (fpm). The airspeed values decreased 15 knots, from 155 to 140 knots while the torque values for engine no. 2 ranged between 78% and 93%. The bank angles fluctuated between 15° and 30 ° left wing down (lwd), while right wing down (rwd) control wheel inputs were maintained. The control wheel values increased as the airspeed decreased reaching 50° rwd near the end of the period. The heading values indicated a steady turn to the left that reached 37° by the end of the period.

- From 12:52:18 to 1252:36, the rate of descent decreased to approximately 275 fpm as the airplane descended to 1,100 feet. The torque values for engine no. 2 decreased to 38% for approximately 4 seconds and then increased to 73% for the remainder of the period. The airspeed values continued to decrease reaching 125 knots by the end of the period. The roll values approached wings level while the control wheel values fluctuated between 40° and 50° rwd. The heading values indicated a continuos left turn. The pitch attitude values, which had been between 0° and 2°, began to increase (nose up) reaching better than 9° near the end of the period.

- During the final 8 seconds of recorded data the pitch attitude oscillated between 4 and 8 degrees (nose up) as the rate of descent increased to better than 1,300 fpm. The torque values for the left engine decreased to between 37% and 40%, as the airplane roll to approximately 30° lwd, and then in response to right control wheel inputs, rolled to nearly wings level at the end of the data. The final airspeed and altitude values were 120 knots and 1,088 feet (MSL), respectively.

D. DETAILS OF INVESTIGATION

1. Description of Data

This model DFDR accepts input signals from a remote Flight Data Acquisition Unit (FDAU), and stores the data in a crash survivable memory unit. The data are recorded digitally on ¼ inch magnetic tape. The tape contains 6 tracks that sequentially record 25 of data. This recorder incorporates a unique recording technique, whereby the data are reformatted from the standard 12-bit word, to a 15-bit word. This technique, known as Group Code Recording (GCR), replaces 4-bit input nibbles with 5-bit groups. These 5-bit groups are arranged so that, within each group, no more than two zeros ever occur in a row.

The FDAU provides a means of gathering, conditioning, and converting flight data parameters to digital data. The FDAU 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 FDAU 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 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 sustained only minor thermal damaged to the dust cover and face plate. The interior of the recorder and tape recording medium were not damaged.

3. Readout and Evaluation

a. Readout

The original magnetic tape recording medium was removed from the recorder and mounted on an instrumentation tape deck for playback. The tape was searched for the data recorded during the accident flight, which was located on tracks 4 and 5. The transition from track 4 to 5 occurred at 12:27:26.

The conversion of the DFDR recorded elapsed time to local time was established by correlating the microphone keying data recorded by the DFDR and the corresponding VHF transmission recorded by Air Traffic Control and the Cockpit Voice Recorder. The correlation was established for the data recorded on track 5 only. Therefore, the local time reference prior to 12:27:27 should be considered approximate (an undetermined amount of data *(time)* was lost during the transition from track 4 to 5).

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

b. Evaluation of DFDR data

With the exception of some random periods of anomalous data, the recorder operated normally. In addition, the parameters Control Wheel Position and Rudder Pedal Position contained values that were inconsistent with other related DFDR parameters.

The random data anomalies generally involved very short periods and affected all the parameters. As a result, anomalous periods were easily identified and corrected. The correction process involved an examination of a digitized version of the raw analog waveform generated during playback. When suspect data were identified the digitized waveform was evaluated to detect any distortions that might be miss interpreted by the playback hardware and software. Corrections were applied as necessary and the resulting engineering units and discrete values were validated.

The extensive impact and fire damage prevented a calibration of the DFDR flight control system position sensors. The flight control position sensors were removed for further evaluation. The position sensors for the control column and control wheel were securely attached to the respective aileron and elevator systems. However, the shaft of the rudder pedal position sensor was not attached to the flexible shaft assembly. The flexible shaft was free to move and fell off during removal, and was not recovered. All three sensors were determined serviceable during a post accident bench check. See *Systems Group Chairman's Factual Report Of Investigation* for more details.

The flight control position parameters were further evaluated in an attempt to establish new calibration data that would produced engineering units that were more representative of the actual control inputs. This was accomplished by an evaluation of the data recorded during the accident and the three prior flights.

The data were plotted and evaluated to obtain baseline values that could be used to calibrate the flight control parameters. The data recorded during the takeoff and landing ground runs were examined along with wings level cruise data. The flight control checks performed prior to takeoff provided significant reference data. The examined data contained 4 instances of data excursions consistent with flight control checks prior to takeoff. In all 4 instances, minimum and maximum values were recovered for "Control Wheel Position" and "Control Column Position". However, "Rudder Pedal Position" excursions consistent with a flight control check were barely discernible and provided no useful calibration points.

The sampling rate for the flight control parameters (4 per seconds) was insufficient to guarantee the recording of the maximum travel of the control inputs during a normal preflight control check. This was born out by the data which contained peak values that varied from check to check. Therefore, the data were further scanned for peak values.

In the case of the control wheel position, peak values of -40.77° and 47.9° were observed. The value -40.77°, recorded while the airplane was on the ground and not moving, was consistent with the control wheel being moved to the control stops. The 47.9° value was recorded during the final 44 seconds of the accident flight. In addition, the control wheel values recorded during wings level steady heading conditions generally ranged from 3.5° to 4° (right wing down).

The peak values (-6.74° and 9.2°) recorded for control column position during the preflight control checks were the primary source of calibration reference data. A June 11, 1994, maintenance check of the flight recorder system also provided reference values.

c. <u>Calibration of flight control sensors.</u>

On June 11,1994, a check of the flight recorder parameters was conducted by ASA maintenance. The data generated during this test contains values that approximate full travel and null or neutral for rudder pedals and control column inputs. There was only one value recorded for control wheel position (raw octal - 5137, converted - 16.7°).

3. <u>Recalculated Engineering Unit Conversion Algorithms for Flight Control Parameters</u>

The peak values recorded during the last 4 flights and the June 11, 1994, maintenance check, were examined in an effort to determine engineering unit conversion algorithms that best represented the DFDR signal characteristics at the time of the accident. The following table contains a listing of peak values and standard calibration values for the parameters of Rudder Pedal Position, Control Wheel Position and Control Column Position:

PARAMETER	POSITION	RAW OCTAL VALUES (engineering units) STANDARD	CALIBRATION JUNE 11,1994	PREFLIGHT CONTROL CHECK
Rudder Pedal Position.	Neutral (0.0°)	3777	4033	N/A
	Full Right (15.7°)	7715	7147 (12.9°)	N/A
	Full Left (-15.7°)	0062	767 (-12.1°)	N/A
Control Wheel Position	Full Left (-51.4°)	260	N/A	1160 (-40.5°)
	Neutral (0.0°)	3777	N/A	(3.6° to 4.0°)
	Full Right (51.4°)	7516	N/A	6464 (39.2°)
Control Column Position.	Full Forward (-7.8°)	1431	1615 (-7.1°)	1604 (-6.7°)
	Neutral (0.0°)	3777	4032 (0.2°)	N/A
	Full Aft (11.8°)	7750	7145 (9.5°)	7053 (9.2°)

a. Control Column Position

The values obtained from the maintenance check, and the preflight control checks for Control Column Position were in general agreement with standard values. The maintenance check and preflight control check values for the full forward were nearly 3° less than the standard value, while the values for the full aft position were within the minimum sensor accuracy (±2°) of standard. The general agreement with standard values validated the standard conversion algorithm, therefore, a new conversion algorithm was not computed.

b. Control Wheel Position

The standard conversion algorithm for Control Wheel Position produced values of approximately 3.5° to 4° (right wing down) during wings level flight, and ground operations when a 0° value would be expected. A conversion algorithm based on the assumption that the recorded peak values represented full travel of the control wheel, produced values that placed the control wheel at approximately 0.0° during wings level flight. The resultant values are listed in the attached data printout as "CTRL WHEEL (corr)".

c. Rudder Pedal Position

The lack of DFDR rudder pedal values that could be correlated to full travel of the rudder pedals, and the fact that the rudder pedal position sensor was not secured to the mating portion of the rudder system following the accident, obviated the calibration of the rudder pedal position sensor.

E. DATA PRINTOUT

A printout of all recorded parameters, starting at local time 12:43:00 (DFDR lapse 13,844) to 12:52:45 (DFDR lapse time 14,429) was compiled. The printout starts 26 seconds before the parameters for engine number 1 recorded values consistent with an engine failure. The printout contains two derived parameters, "PRESSURE ALT COMB" which was produced by combining the Course and Fine altitudes, "MSL ALTITUDE" which was derived from PRESSURE ALT COMB corrected to a barometric pressure of 30.08 Hg. However, due to the volume of data, the printout will be retained in the Docket under separate cover.

F. DATA PLOTS

Attachment II contains plots of selected parameters. Individual plots were prepared for the takeoff from Atlanta Hartsfield (Plot 1), the loss of the left engine (Plot 2), the forced landing (Plot 3) and selected engine parameters from engine loss to end of data (Plot 4).

[redacted]

Dennis R. Grossi
Flight Data Recorder Specialist

Attachments: