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

April 18, 1996

Group Chairman's Airplane Performance Study
DCA95MA054

A. ACCIDENT

Operator:	Atlantic Southeast Airlines, Inc.
Location:	Carrollton, Georgia
Date:	August 21, 1995
Time:	1253 Eastern Daylight Time (EDT)
Aircraft:	Embraer EMB-120RT, N256AS

B. GROUP

Chairman:	Jim Ritter NTSB
Member:	Bruce Gillen Atlantic Southeast
Member:	Mike Huhn Air Line Pilots Association
Member:	Carla Worthey Federal Aviation Administration
Member:	Steve Josephson Hamilton Standard

C. SUMMARY

On August 21, 1995, at about 1253 eastern daylight time, 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 operating 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 flightcrew 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 to descend until ground impact. The airplane was destroyed by impact forces and postcrash fire. The captain and four passengers received fatal injuries.

D. DETAILS OF THE INVESTIGATION

Section I - Airplane Radar Data

National Track and Analysis Program (NTAP) radar data were obtained from the FAA, as tabulated in attachments I-1 and-2. Radar returns were usually available approximately every 10 seconds. The beacon code used by the accident flight was 2031.

ATL has an Automated Radar Terminal System (ARTS), operated by the FAA. The FAA supplied printouts of recorded radar data from the facility's computer, as tabulated in attachments I-3 through -6. Radar returns are normally available every 4 1/2 seconds. Attachment I-7 is a FAA plot that shows all of the ARTS target reports for the accident flight. Primary radar data (i.e. skin paint) were also provided by FAA, as tabulated in attachments I-8 and -9. Unlike primary radar data, NTAP and ARTS radar returns normally include airplane altitude. Latitude/longitudes and x-y data for pertinent ground sites are tabulated in attachment I-10.

NTAP radar data for the accident flight were converted from latitude/longitudes to an x-y format where x is true east and y true north, using the ATL radar antenna site as the origin (0,0). This data is tabulated in attachments I-11 and -12. For the ARTS data, a 0.45° westerly variation was used to convert the original range/azimuth coordinates into the x-y coordinate system. The 0.45° variation was necessary to bring the ARTS data into alignment with the NTAP data. The ARTS range/azimuth and x-y data are tabulated in attachments I-13 though -16.

Attachment I-17 is a graph of the NTAP and ARTS radar data that were available around the time of the accident. The plotted data begin around 1241, and end at 1251 local time. There is approximately a 2-minute gap in radar coverage, from 1248 to 1250. The final data shows the airplane at approximately 2800 ft-msl. The airplane crashed approximately 4.4 n.m. southwest of Carrollton, GA airport. The target and primary radar data are plotted in attachment I-18. The primary returns were plotted in an attempt to find missing propeller blade piece, however, the data did not reveal anything consistent with the trajectory of the missing piece.

Section II - Weather Data

The accident occurred at 1653 Universal Coordinated Time (UTC), or 1253 Eastern Daylight Time (EDT) in the local area. A printout of upper air wind data from Peachtree City, GA was provided by the Weather Group Chairman as shown in attachments II-1 and -2. Wind data was collected at 0800 and 2000 local time, or about 5 hours before and 7 hours after the loss of the propeller blade. Winds in attachment II-1 were used to generate wind vectors every thousand feet of altitude, as tabulated in attachment II-2. The wind data was used in trajectory calculations for the missing piece of propeller blade.

Section III - Propeller Trajectory Calculations

The airplane was over Pine Hill, Alabama, approximately 50 nautical miles west-southwest of ATL when the left engine lost part of one propeller blade at approximately 1243:25. The airplane was at approximately 18000 ft-msl and 160 knots. This point in the flightpath was used as the starting point for several estimated propeller trajectories. It was assumed that the blade piece could have been launched in four possible directions (up, down, left, right), and the initial velocity for each direction was calculated as shown in attachment III-1. The radar data plot in attachment III-2 shows the point where the propeller separated during the flight.

The Safety Board's WINDFALL program was used to calculate the trajectory of the missing blade piece. There was uncertainty about what C_DS term should be used in the calculations. The maximum flat plate area of the blade piece was estimated to be 3 ft^2. However, if the piece basically presented its minimum frontal area (0.12 ft^2) to the wind, then a dart-like trajectory would result. Dart-like and tumbling plate trajectories were both calculated, and the large variation in possible trajectories is shown in the graph in attachment III-3. The distance traveled ranged from about 0.4 n.m. for the tumbling plate to 1.6 n.m. for the dart trajectory.

Attachment III-4 gives a graph of the final trajectories that were calculated. The tumbling plate trajectory and both sets of upper atmosphere wind data were used. These trajectories were superimposed on a topographic map of the region, as shown in attachment III-5.

Because the blade was lost somewhere within a large area, the performance group investigators faced a difficult task to locate it. Attachment III-6 shows the primary and secondary areas that were searched by the performance group on September 11 and 12. Excellent assistance was provided to the group by the Randolph County Rescue Squad volunteers, and the Randolph County Alabama Sheriff's Office. Although the blade was not found during the search, a good effort was made, largely through the assistance of the volunteers and people living in the area. The propeller blade was found the following week by Mr. W.F. Stillwell, who found the blade while mowing. It was well hidden in some tall grass just outside the primary search area, as shown on attachment III-6.

The propeller was found at (33°28'30" N, 85°24"45.6"W).

To help determine the proper C_DS term to use in future trajectory studies, the WINDFALL program was re-run using the known location of the propeller blade piece. It was assumed that the blade exited left of the airplane (direction #3), and the 8 am wind data was used since it was closest in time to the accident flight. The C_DS term was then varied until the calculated trajectory ended close to where the blade landed. The C_DS term in this case was found to be 1.105 ft^2, which is less than the 1.8 ft^2 used to develop the search plan.

Section IV - Cockpit Voice Recorder (CVR) and Flight Data Recorder (FDR) Data Plots

Times are based on a 24 hour clock, in the format of hours, minutes, and seconds (HHMM:SS), or total seconds. Times from the CVR transcript were assumed to be correct, so that all other clocks were adjusted (when necessary) to be consistent with the CVR transcript.

Microphone keying information was used to establish a time correlation between the CVR and FDR on the accident airplane. The CVR transcript provides the time of each radio transmission in eastern daylight, or local time. The FDR records whether the microphone is "on" or "off" once each second in elapsed time. Attachments IV-1 and IV-2 compare the times of several radio transmissions recorded by the CVR to the microphone keying data from the FDR. Allowing for realistic variance between CVR microphone "on" segments and FDR binary data, an offset of 0852:16 (31936 seconds) was found between CVR times and the elapsed times recorded by the FDR. Therefore, the following equation applies:

FDR Elapsed Time + 0852:16 = CVR Time (Local, EDT)

Most of the FDR data shown in this report is in local time, but the 0852:16 offset should be added whenever FDR elapsed times are encountered. A graph of altitude versus time was used to compare the radar system clocks to local time, as shown in attachment IV-3. In this case the NTAP and ATL radar clocks were not adjusted since they were in fairly close agreement with the corrected FDR local timebase.

A list of all the FDR[1] parameters along with their range, resolution, and sampling intervals is shown in attachment IV-4. Selected FDR parameters are graphed in attachments IV-5 though IV-12. These graphs cover several different timeframes, starting 45 seconds before the left engine failure and ending with the crash landing. Selected sounds from the CVR are overlaid onto each of the FDR graphs. Please refer to the CVR Factual Report for the complete transcript of cockpit sounds. The flaps and landing gear were up at the start of the upset, and both remained retracted for the rest of the flight. Approximately 9 minutes and 20 seconds of time elapsed between the left engine failure at 1243:25 and the crash landing at 1252:45 EDT.

Attachment IV-12 is a graph of the entire flight after the upset. In general terms, the airplane started on an initial heading of 250°, then turned 300° to the left within 3 1/2 minutes, then flew for 2 minutes at 310°, then turned 130° to the right within 40 seconds, then flew for 1 1/2 minutes at 80°, then turned 70° to the right within 40 seconds, then turned 180° to the left within the final minute before first impact occurred on a heading of 330°. The airplane was turning left at the time of first impact, and the last recorded roll attitude was 6° left wing down. Roll attitudes varied between approximately 30° left and 30° right during the last 9 1/2 minutes of the flight. Control wheel position was 0° before the upset, then averaged about 30° right, and reached a maximum of 51° right shortly before impact. Pitch attitude was approximately 5° aircraft-nose-up (A.N.U.) at the time of upset; then varied between a minimum of 10° Aircraft-Nose-Down (A.N.D.) shortly after the upset to a maximum of 11° A.N.U. right before first impact.

Data curves in attachment IV-5 indicate that the airplane was performing normally prior to the left engine failure. At 1243:25 the airplane was climbing through approximately 18,100 feet at 160 knots indicated airspeed (KIAS) when the CVR recorded the sound of several thuds and the torque on the left engine went to zero. The airplane then abruptly rolled to the left, pitched down, and subsequently started to descend. Control wheel position moved to about 40° right, and control column moved from approximately 0° to 4° A.N.U.. The initial left roll angle was 20° to 30°, which then gradually decreased to around 5° about 25 seconds after the upset. During this 25 second period the pitch attitude decreased from approximately 5° A.N.U. to about 9° A.N.D., and the descent rate[2] reached a maximum of approximately 5500 feet-per-minute.

---

[1] FDR Rudder pedal position data was erroneous and is not included in this report. See the FDR Group Chairman's Factual Report for further information, and for all tabular data.
[2] Descent rate (Vertical Speed) is plotted in attachment IV-12.

At 1244:20 the airplane was at approximately 195 KIAS, descending at 3500 feet-per-minute (fpm), at 5° A.N.D. pitch attitude, and in a 15° left roll. At this point the captain states "I can't hold this thing", then "help me hold it" to the first officer. The first officer says "OK" and then at 1244:26 he radios Atlanta center and declares an emergency. Airspeed continues to gradually increase, and descent rate increases from approximately 3500 to 5000 fpm. Airspeed reaches a maximum of 200 KIAS at 1244:50, and some abrupt excursions begin in the vertical and lateral acceleration values. However, at 1244:50 left engine torque was reduced, pitch attitude started to rise, and the airspeed subsequently began to decrease.

By 1245:17 the airspeed was down to 165 KIAS, and the acceleration values had stabilized considerably when the captain stated "alright, it's, it's getting more controllable here...the engine...let's watch our speed". Right engine torque values then began to increase, eventually stabilizing at 90% to 95%. From 1245:17 until 1251:30 airspeeds varied between approximately 153 KIAS and 175 KIAS. After 1251:30 airspeeds steadily decreased, from 168 KIAS down to about 120 KIAS when first impact occurred at 1252:45.

After 1245:17 the descent rate varied between approximately 1000 to 3000 fpm until 1247:00, then stabilized somewhat (between 1000 to 2000 fpm) until 1251:30. Right engine torque values increase and decrease several times during the final minute of the flight, with values ranging between approximately 37% and 99%. The descent rate gradually decreased after 1251:30, until it reached a minimum of approximately 300 fpm at 1252:35. The descent rate then increased to almost 1500 fpm just before first impact occurred at 1252:45. Some of the final FDR values recorded the second before impact were:

altitude =	1088 ft-msl	heading =	330°
airspeed =	120 kias	pitch =	11° A.N.U.
roll =	6° left	control wheel =	35° right
control column =	8° aft	right,left eng. torque =	38, 0 %
flap position =	0°	right,left prop. rpm =	100, 24 %

Section V - Airplane Groundtrack and Flightcrew Dialogue

Composite plots are provided in this section which show in a graphical format the location of the flight when key events occurred. Radar data, weather data, Cockpit Voice Recorder (CVR) data, and Flight Data Recorder (FDR) information were used to develop these graphs.

Because of large gaps in radar coverage, data from the FDR were used to get a complete groundtrack for the accident flight. A Safety Board computer program, INT3D, was used to calculate the groundtrack from 1243:04 until 1252:45. FDR airspeeds, headings, and altitudes were input to INT3D to calculate the flightpath plotted in attachment V-1. However, the flightpath in attachment V-1 ends over a mile from the accident site since the computer program assumes that the airplane is moving with no sideslip, and no upper air wind vectors were used in the calculations. Therefore, an artificial "wind" vector of 131° at 6.5 knots was input to the program in order to produce a groundtrack that ended at the crash site. The resulting groundtrack is plotted in attachment V-2.

Attachment V-3 is a table of 55 events that were selected from the CVR transcript. Attachments V-4 through V-6 are plots of the accident flight groundtrack that show the location, altitude, and airspeed of the airplane when each CVR event occurred. The location of the airplane at each point is marked with the appropriate number from the table in attachment V-3.

Section VI - EMB-120 Flight Simulation Data

Attachments VI-1 through VI-3 show results obtained by Embraer using their EMB-120 simulator. A simulator flight was made to simulate the lift, drag, rolling moment, and yawing moment coefficient changes due to the engine nacelle and propeller bending on the accident airplane. According to attachment IV-1, "the time of 14150[3] sec. was chosen as a reference for comparison with the simulator due to the fact that the airplane was stable and with roll angle and pitch angle close to zero." FDR data are plotted for this time in attachment VI-4.

It should be noted that the flight condition used in the EMB-120 simulation was determined from low-resolution graphical data that was provided early in the investigation. Embraer used an average of the FDR values around 14150 sec to determine the flight condition, and not the exact values recorded by the FDR at that time. Two discrepancies were found by the group when reviewing the flight condition used: 1) right propeller rpm was read as 100% instead of the correct value of 90%, and 2) engine torque was read as 92% but actually varied between approximately 92% and 97% around 14150 sec. According to Embraer, both of these differences are minor and would not produce a noticeable change to the values obtained from the simulator.

The simulator comparison to FDR data indicates that the flight performance of the airplane was degraded after the loss of the propeller blade piece. The degradation in

[3] This time was modified according to the message from Embraer shown in attachment VI-3.

aerodynamic coefficients is given in attachment VI-2. In this case maximum rudder deflection and about 28° of right control wheel was necessary to maintain airplane heading and a wings-level attitude at 165 KIAS. The rate of descent in this configuration was approximately 1400 fpm.

[redacted]

James H. Ritter
Senior Aerospace Engineer-Performance