NATIONAL TRANSPORTATION SAFETY BOARD

Vehicle Recorders Division
Washington, D.C.

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Specialist's Study
Digital Flight Data Recorder

NTSB Number:
DCA03MA022

A. EVENT

Location:	Charlotte, North Carolina
Date:	January 8, 2003
Aircraft:	Beech 1900D, N233YV
Operator:	Air Midwest, Inc.

B. GROUP

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C. SUMMARY

This study is preceded by the DFDR Group Chairman's Factual Report of Investigation. This study presents previous flights recorded on the accident aircraft's DFDR and DFDR data relating to ground testing performed in Wichita on a Beech 1900D Airliner in support of this accident. This report also addresses the anomaly found in the lateral acceleration parameter.

D. DETAILS OF STUDY

Previous DFDR Data from Accident Aircraft

The DFDR retrieved from the accident aircraft contained about 95 hours of recorded data. The accident flight was the 10th flight since scheduled maintenance. The 19 flights immediately before the accident flight were examined in order to document data from before the aircraft went into maintenance and after the aircraft came out of maintenance.

Plots A-S in Attachment I contain select parameters[1] plotted for the last 10 flights prior to maintenance and the following nine flights after maintenance. The flights are identified in the lower left corner by sequence, origination and destination airport identifiers, and the date of the flight. The time period of these plots vary depending on the length of the flight. The difference in trends of the takeoff and cruise values of the pitch control position parameter[2] before and after maintenance can be noted from these plots. Before maintenance, the cruise values recorded for this parameter were normally about -4 degrees while after maintenance the values in cruise were about -13 degrees. Attachment II contains plots 1-19 which expand a 60 second time window highlighting the takeoffs of each of the last 19 flights.

Table 1, included below, contains the forward and aft pitch control position values recorded during each control check[3] as well as the maximum aft pitch control position value that was recorded during the takeoff portion of the flights reviewed. In the Beech 1900D Airliner, on the ground (when air loads are not present), the control column normally sits full forward. Before each flight, a control check is performed which involves, in the Beech 1900D, bringing the control column from the full forward position to the full aft position. These values may differ between flights because the pitch control position parameter is only sampled once a second so the maximum aft limit may not be captured in the recorded DFDR

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[1] Due to a bias in the pneumatic F-1000 DFDR system (discussed in the DFDR Group Chairman's Factual Report of Investigation) an offset of 65 feet was applied to the recorded altitude data values. The plotted and tabular altitude data for the previous flights reflect that offset. The movement in parameter values associated with a climbing, right turn shall be considered positive for this report.

[2] The pitch control position values presented in this report were converted from the raw recorded value using the equation supplied by Raytheon Aircraft Company (the aircraft manufacturer) for a typical flight control rigging.

[3] A control check consists of fully deflecting the flight controls by moving the control column and wheel aft and clockwise and then forward and counterclockwise; this is referred to as a box-shaped pattern.

data. Also, the pilot may not exercise the full aft authority during a control check. The control checks of the last 19 flights are not included in the plotted data but the associated tabular data for plots A-S, plots 1-19 and for the control checks can be found in Attachment V.

Table 1. DFDR Pitch Control Positions for Last 20 Flights of Recorded Data

Flight	**Control Sweep Fwd**	**Control Sweep Aft**	**Max At Rotation**
Accident Flight	-16.5	+15	-9.5
Previous Flight LYH-CLT	-16.4	+13	-1
2nd Previous Flight CLT-LYH	-16.6	+13.5	-0.6
3rd Previous Flight LYH-CLT	-16.5	+14.8	-0.6
4th Previous Flight CLT-LYH	-16.5	+15.1	-1.3
5th Previous Flight LWB-CLT	-16.5	+13.4	-3.3
6th Previous Flight CLT-LWB	-16.5	+14.8	-2.0
7th Previous Flight AHN-CLT	-16.5	+14.7	-3.4
8th Previous Flight CLT-AHN	-16.5	+14.8	-4.2
9th Previous Flight HTS-CLT	-16.3	+11.6	+0.2
Maintenance			
1st Prior to Maintenance CLT-HTS	-15.6	+16.2	+7.1
2nd Prior to Maintenance AHN-CLT	-15.7	+16.1	+7.1
3rd Prior to Maintenance CLT-AHN	-15.7	+17.3	+6.6
4th Prior to Maintenance LYH-CLT	-15.6	+16.8	+6.6
5th Prior to Maintenance CLT-LYH	-15.6	+19.1	+4.7
6th Prior to Maintenance LYH-CLT	-15.5	+13.5	+5.1
7th Prior to Maintenance CLT-LYH	-15.5	+16.5	+4.5
8th Prior to Maintenance GSP-CLT	-15.4	+8.7	-2.7
9th Prior to Maintenance RDU-GSP	-15.4	+16.0	+4.3
10th Prior to Maintenance AVL-RDU	-15.9	+9.7	+4.5

Prior to maintenance, during the control checks, a maximum full aft position of 19.1 degrees was recorded and a minimum full forward of -15.9 was recorded. The full forward position was usually about -15.6. After maintenance, the full forward position usually registered about -16.5. According to maintenance interviews, the DFDR sensor was not recalibrated following the maintenance work on the primary pitch control system (see Group Chairman's Aircraft Maintenance and Records Group Factual). In the control checks for the flights after maintenance, the maximum full forward position obtained was -16.6 and full aft was +15.1. During the accident flight, a minimum full forward position of -17.2 was recorded and maximum full aft position of +19.2 was recorded.

DFDR Data Timing

The DFDR data in this report are presented in Subframe Reference Numbers (SRN)[4].

Wichita Ground Testing

On January 21 and 22, 2003, the Systems Group and Aircraft Maintenance and Records Group convened at Raytheon Aerospace in Wichita, Kansas. Ground tests were conducted on the primary pitch and pitch trim control systems of a Beech 1900D Airliner to document the relationship between the control column, cable, elevator, elevator tab positions and DFDR recording for various test conditions. For more detailed information on the ground tests, see the Systems Group Chairman's Factual Report (1.3 Wichita Ground Testing).

The ground test DFDR values are presented in tables within this report and as plots in Attachment III. The following tables illustrate the DFDR pitch control position values recorded and the left elevator position as measured by a travel board or inclinometer for various test conditions. Elevator trailing edge down (TED) is denoted in the DFDR values as negative and trailing edge up (TEU) is positive.

Prior to the first test, the primary pitch and pitch trim control systems were rigged according to the Aircraft Maintenance Manual (AMM). Table 2 illustrates the values obtained for the measurements involving the baseline positions, system compliance and gust lock installation tests. Plot 1 presents the testing sequence graphically.

Table 2. Primary Pitch Control System Rigged per AMM

Test Condition	DFDR Pitch Control Pos (deg)	Left Elevator Pos (deg)	Plot
	Primary Pitch System Baseline Positions		
Pin in Aft Bellcrank	-.5	0.0	1
Column Full Aft	19.6	20.0 TEU	1
Column Full Fwd	-17.1	14.75 TED	1
	Primary Pitch System Compliance		
Column Full Fwd +30lbs	-17.9	14.75 TED	1
Column Full Aft +100lbs	20.4	20.0 TEU	1
	Gust Lock Pin		
Gust Lock Pin Installed in Control Yoke Tube	12.1	10.5 TED	1

[4] The FDR Subframe Reference Number is a measure of relative time on the DFDR. One subframe is equivalent to one second.

With the primary pitch control system still rigged per AMM, the Captain's control column was moved throughout the full range of travel. The control column was initially positioned to full forward and was then moved aft in 2 degree increments according to the elevator displacement (14 TED to 20 TEU). Plot 2 illustrates the results of the full range of travel exercise.

Table 3 displays the limits attained when the existing cable tension was increased and decreased by the noted amounts. Plot 3 and Plot 4 show the results of this test in a graphical format.

Table 3. Cable Tension Variation in Primary Pitch Control System

Test Condition	DFDR Pitch Control Pos (deg)	Left Elevator Pos (deg)	Plot
	Cable Tension +33 lbs		
Column Full Fwd	-17.2	14.8 TED	3
Column Full Aft	+19.6	19.9 TEU	3
	Cable Tension -25 lbs		
Column Full Fwd	-17.2	14.5 TED	4
Column Full Aft	+19.6	19.9 TEU	4

Three control checks, with the primary pitch control system rigged to the AMM were conducted during the ground testing. The results are illustrated on Plot 5.

The aircraft's pitch control system components were then adjusted to match the dimensions found on the components recovered from the wreckage of the accident aircraft. The following components were adjusted: turnbuckles, forward push-pull tube, aft push rod, and forward bellcrank stop bolts. Table 4 contains the results and Plot 6, Plot 7, and Plot 8 illustrate the test results.

Table 4. Pitch Control System Adjusted to Dimensions from Accident Aircraft

Test Condition	DFDR Pitch Control Pos (deg)	Left Elevator Pos (deg)	Plot
	After changing turnbuckle length		
Pin in Aft Bellcrank	-7.0	0.0	6
Pin in Fwd Bellcrank	0	5.4 TEU	6
Gust Lock Pin in Control Yoke Tube	-11.9	4.4 TED	6
No Pin Installed Elevator Full Down	-19.4	10.2 TED	6
Column Full Aft	+15.5	20.2 TEU	6
	After changing turnbuckle length & aft rod end		
Pin in Aft Bellcrank	-7.0	0.5 TEU	7
Pin in Fwd Bellcrank	0	5.8 TEU	7
Gust Lock Pin in Control Yoke Tube	-12.0	4.1 TED	7
No Pin Installed Elevator Full Down	-19.3	9.7 TED	7

Column Full Aft	15.0	19.0 TEU	7
	Following adjustments to the turnbuckle length, aft rod end, fwd push-pull tube, and forward bellcrank stop bolts		
Pin in Aft Bellcrank	-2.0	0.8 TEU	8
Pin in Fwd Bellcrank	+3.8	6.1 TEU	8
Gust Lock Pin in Control Yoke Tube	-11.4	8.1 TED	8
No Pin Installed Elevator Full Down	-11.9	8.4 TED	8
Column Full Aft	+17.8	20.3 TEU	8

Three control checks were performed with the aircraft in the above configuration. Plot 9 contains the plotted data for these control checks.

The positions of the pitch control system components were then documented with the gust lock pin installed in the control yoke tube. This gust lock evaluation consisted of two tests whose results are found in Table 5. For both tests the gust lock pin was installed and the elevator trailing edge was positioned to fair with the horizontal stabilizer. Plot 10 and Plot 11 demonstrate the test results in a graphical format.

Table 5. Pitch Control System Positions with Gust Lock Pin Installed

Column Position	**DFDR Pitch Control Pos (deg)**	**Left Elevator Pos (deg)**	**Plot**
	rigging found in wreckage		
Full Forward	-12.1	0.5 TED	10
Full Aft	+11.6	19.5 TEU	10
	rigging initially to AMM		
Full Forward	-18.3	4.5 TED	11
Full Aft	+12.2	19.5 TEU	11

The tabular data associated with the ground testing data plots can be found in Attachment VI.

Lateral Acceleration Parameter Anomaly

The DFDR system on the accident aircraft, N233YV, was upgraded to accommodate additional recorded parameters, including lateral acceleration. The aircraft was originally equipped with a bi-axial accelerometer and to record the lateral acceleration parameter, a stand-alone accelerometer was added. Wiring modifications were made to the bi-axial accelerometer so that the stand-alone could share a common excitation voltage with the bi-axial. While the vertical and longitudinal acceleration values appear reasonable, there is an anomaly with the lateral acceleration values.

The parameter, at times, exhibits values characteristic of lateral acceleration based on examining the magnetic heading and yaw control values. However, during portions of the recording the lateral acceleration values shift from the nominal position of 0 g's to an offset of approximately -.77g's. While the shift is occurring, and during some instances when the offset is present, the data becomes noisy and fluctuates. Most of the time, when the neutral value is offset to -.77g's, the acceleration trend is again consistent with lateral acceleration but with an offset. Occasionally, the magnitude of the lateral acceleration values is greater than expected but the trend is still consistent with an expected pattern.

The cause of the lateral accelerometer anomaly was not determined. It is possible that either a bad accelerometer sensor or a bad electrical input resulted in the offset. Since the recorded lateral acceleration parameter could provide useful information in determining the performance of the aircraft, the individual flights of interest will be examined to determine if the lateral acceleration values can be considered valid during those portions of the recording. A determination of which data the offset will be added to will be made based on examining individual data sets. A plot illustrating an example of the lateral acceleration anomaly can be found in Attachment IV and the associated tabular data in Attachment VII.

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<u>Attachments</u>

Attachment I: DFDR Plotted Data of Previous 19 Flights
Attachment II: DFDR Plotted Data of Previous 19 Takeoffs
Attachment III: DFDR Plotted Data of Wichita Ground Testing
Attachment IV: DFDR Plotted Data of Example Lateral Acceleration Anomaly
Attachment V: DFDR Tabular Data of Previous 19 Flights (including control check, takeoff and landing data - electronic only)
Attachment VI: DFDR Tabular Data of Wichita Ground Testing (electronic only)
Attachment VII: DFDR Tabular Data of Example Lateral Acceleration Anomaly (electronic only)