NATIONAL TRANSPORTATION SAFETY BOARD

Vehicle Recorder Division Washington, D.C. 20594

March 21, 2014

Flight Data Recorder - 10

Specialist's Factual Report By Cassandra Johnson

1. EVENT SUMMARY

Location: Milwaukee, Wisconsin

Date: June 06, 2011

Aircraft: Bombardier CL-600-2B19

Registration: N866AS

Operator: Skywest Airlines NTSB Number: CEN11IA379

On June 6, 2011, about 9:32 p.m. central daylight time (CDT), N866AS, a Bombardier CL-600-2B19, operated as Skywest Airlines flight 4443, landed with the right main landing gear retracted on runway 19R at the General Mitchell International Airport (MKE), Milwaukee, Wisconsin. The 2 pilots, 1 flight attendant, and 41 passengers reported no injuries. All of the airplane occupants evacuated the airplane via the main cabin door. The scheduled domestic passenger flight was conducted under the provisions of Title 14 *Code of Federal Regulations* Part 121. Visual meteorological conditions prevailed and an activated instrument flight rules flight plan was on file.

2. FLIGHT DATA RECORDER GROUP

A flight data recorder (FDR) group was not convened.

3. FDR Carriage Requirements

The event aircraft, N866AS, was manufactured in 2001 and was operating such that it was required to be equipped with an FDR that recorded, at a minimum, 57 parameters, as cited in Title 14 CFR Part 121.344(e).

4. DETAILS OF FLIGHT DATA RECORDER INVESTIGATION

The Safety Board's Vehicle Recorder Division received the following FDR:

Recorder Manufacturer/Model: L-3/Fairchild FA2100

Recorder Serial Number: 000174026

4.1. L-3/Fairchild FA2100 Description

This model FDR records airplane flight information in a digital format using solid-state flash memory as the recording medium. The FA2100 can receive data in the ARINC 573/717/747 configurations and can record a minimum of 25 hours of flight data. It is configured to record 128 12-bit words of digital information every second. Each grouping of 128 words (each second) is called a subframe. Each subframe has a unique 12-bit

synchronization (sync) word identifying it as subframe 1, 2, 3, or 4. The sync word is the first word in each subframe. The data stream is "in sync" when successive sync words appear at proper 128-word intervals. Each data parameter (for example, pressure altitude, magnetic heading, computed airspeed) has a specifically assigned word number within the subframe. The FA2100 is designed to meet the crash-survivability requirements of TSO-C124a.

4.1.1. Recorder Condition

The recorder was in good condition and the data were extracted normally from the recorder.

4.1.2. Recording Description

The FDR recording contained approximately 119.4 hours of data. Timing of the FDR data is measured in subframe reference number (SRN), where each SRN equals one elapsed second. The event flight was the last flight of the recording and its duration was approximately 1 hour and 42 minutes. The parameters evaluated for the purpose of this report appeared to be in accordance with the federal FDR carriage requirements.

4.1.3. Engineering Units Conversions

The engineering units conversions used for the data contained in this report are based on documentation from the aircraft manufacturer. Where applicable, the conversions have been changed to ensure that the parameters conform to the NTSB's standard sign convention that climbing right turns are positive (CRT=+).

Table A-1 lists the FDR parameters verified and provided in this report. Additionally, table A-2 describes the unit and discrete state abbreviations used in this report.

4.2. Time Correlation

Correlation of the FDR data from SRN to the event local time, CDT, was established by using the recorded GMT² hours, GMT Minutes, and GMT Seconds and then applying an additional 5 hours offset to change GMT to CDT.

Accordingly, the time offset for the event flight data from SRN to local CDT is the following: CDT = SRN - 352,195. Therefore, for the rest of this report, all times for the event flight are referenced as CDT, not SRN. However, the previous flight is referenced as SRN, not local time.

4.3. FDR Plots and Corresponding Tabular Data

Figures 1 to 5 contain FDR data recorded during the June 06, 2011 event. Figures 6 to 9 contain FDR data recorded during the previous flight. All the parameters listed in table A-1 are plotted except GMT Hours, GMT Minutes, and GMT Seconds. Figures 1 and 6 contain

¹ CRT=+ means that for any parameter recorded that indicates a climb or a right turn, the sign for that value is positive. Also, for any parameter recorded that indicates an action or deflection, if it induces a climb or right turn, the value is positive. Examples: Right Roll = +, Pitch Up = +, Elevator Trailing Edge Up = +, Right Rudder = +

² GMT is Greenwich Mean Time which is also known as Coordinated Universal Time (UTC).

the basic parameters. Figures 2, 3 and 7 contain landing gear parameters plus some hydraulic parameters. Lastly, figures 4, 5, 8, and 9 contain select parameters.

Figures 1 and 2 cover the entire event flight from 19:45:00 CDT to 21:35:00 CDT. Figure 3 covers the last 42 minutes of data from 20:52:00 CDT to the end of the recording at 21:34:00 CDT (the x-axis ends at 21:35:00 CDT). Figure 4 covers 29 minutes of data from 20:51:45 CDT to 21:20:45 CDT. Lastly, figure 5 covers 5 minutes of data from 20:51:45 CDT to 21:56:45 CDT when the landing gear disagree warning first transitioned from "Not Active" to "Active".

Figures 6 and 7 cover the entire previous flight from 420,600 SRN to 423,240 SRN. Figure 8 covers the previous takeoff from 420,735 SRN to 420,790 SRN. Lastly, figure 9 covers the previous landing from 422,850 SRN to 422,900 SRN.

These figures are configured such that right turns are indicated by the trace moving toward the bottom of the page, left turns towards the top of the page, and nose up attitudes towards the top of the page.

In brief, the FDR data indicated the following for the event flight:

- About 1 hour after takeoff at 20:52:36 CDT while descending through a pressure altitude of approximately 2,745 feet (ft), the left landing gear transitioned from "Not Down and Locked" to "Down and Locked".
- At 20:52:40 CDT, the nose landing gear transitioned from "Not Down and Locked" to "Down and Locked". At this time, the pressure altitude decreased to approximately 2,618 ft.
- At 20:52:58 CDT, the landing gear disagree warning transitioned from "Not Active" to "Active". At this time, the pressure altitude decreased to approximately 2,217 ft.
- At 20:54:20 CDT, the right landing gear transitioned from "Not Down and Locked" to "Down and Locked". At this time, the pressure altitude increased to approximately 2,869 ft. A second later at 20:54:21 CDT, the landing gear disagree warning transitioned back to "Not Active".
- At 20:54:57 CDT, the right landing gear transitioned back to "Not Down and Locked". By 20:55:00 CDT, both the left and nose landing gear transitioned back to "Not Down and Locked".
- Over approximately the next 10 minutes until 21:04:57 CDT, the nose landing gear transitioned six times from "Not Down and Locked" to "Down and Locked" then remained at "Down and Locked" until touchdown. Additionally during this time from 21:00:36 CDT to 21:01:06 CDT, the right landing gear transitioned to "Down and Locked" and back to "Not Down and Locked". During this time, the pressure altitude was steady at about 4,150 ft.
- About 43 seconds later at 21:05:40 CDT, the Hydraulic Pressure #3 decreased from approximately 2,720 pounds per square inch (psi) to 14 psi. At this time, the pressure altitude remained at about 4,150 ft.
- Over the approximately the next 7.5 minutes until 21:13:14 CDT, the Hydraulic Pressure #3 increased to about 2,720 psi, decreased to about 10 psi, increased to about 2,700 psi, decreased to about 14 psi, and then increased to about 2,680 psi where it remained until touchdown. During this time, the pressure altitude remained at about 4,150 ft.

- Six minutes and 36 seconds later at 21:19:50 CDT, the left landing gear transitioned from "Not Down and Locked" to "Down and Locked" and remained at "Down and Locked" until touchdown. At this time, the pressure altitude had decreased to about 900 ft.
- About 13 minutes and 14 seconds later at 21:33:04 CDT, the left landing gear weight on wheels transitioned from "Air" to "Ground". One second later at 21:33:05 CDT, the nose landing gear transitioned from "Air" to "Ground".

The corresponding tabular data used to create figures 1 to 5 including GMT Hours, GMT Minutes, and GMT Seconds are provided in electronic comma separated value (*.csv) format as attachment 1 to this report. Additionally, the corresponding tabular data used to create figures 6 to 9 are provided in electronic comma separated value (*.csv) format as attachment 2 to this report.

Accel Vert -0.3 Accel Long (g) 0.3 - 0.0 - at (g) -0.3 -20 Roll-R (deg) Roll-L (deg) Heading Mag-R (deg) Heading Mag-L (deg) 50 40 Flap-L (deg) Heading Mag-L+Heading Mag-R 360 10 -Flap-L+Flap-R 30000 Altitude Press-L+Altitude Press-R -15000 Press-R (ff) Key Mic--5000 Airspeed Comp-R (kts) Airspeed Comp-L (kts) Airspeed Comp-L+Airspeed Comp-R -21:30:00 -20:05:00 -21:00:00 Revised: 14 February 2014 Basic Parameters - Entire Flight National Transportation Safety Board

Figure 1. Basic parameters for entire event flight.

Active Hyd Press Low-1 Caut Hyd Press Low-2 Caut Hyd Press Low-1 Caut+Hyd Press Low-2 Caut 4000 Hyd Press-3 (psi) Hyd Press-2 (psi) Warn Hyd Press-1 (psi) Hyd Press-3 Hyd Press-1+Hyd Press-2 Brake Press-LOB (psi)
Brake Press-LIB (psi)
Brake Press-RIB (psi) Nose Door Warn Nose Door Warn No Warn Brake Press-LOB+Brake Press-LIB+Brake Press-RIB 0 00 20 Brake Press-ROB (psi) Active Hyd Press Low-3 Caut Not Active -No Warn -Up+Lck Gear Uplock-L -Not Up+Lck -Up+Lck Gear Uplock-R Not Up+Lck Not Up+Lck Dn+Lck Gear Dnlock-Not Dn+Lck Gear Dnlock-I Not Dn+Lck -Dn+Lck Gear Dnlock-R Not Dn+Lck Not Active -Active Gear Disagree Warr -Not Active -Active Gear WOW Output Caut ar WOW-R Gear WOW-N -30000 Attitude -20000 de e Altitude Pressure-L+R e Press-R (ft) e Press-L (ft) Air speed Comp-R (kts)
Air speed Comp-L (kts) 10000 Airspeed Comp-L+R -21:10:00 -21:30:00 -20:05:00 Revised: 14 February 2014 More Parameters - Entire Flight National Transportation Safety Board

Figure 2. Landing gear and some hydraulic parameters for entire event flight.

Hyd Press Low-1 Caut Hyd Press Low-2 Caut Hyd Press Low-1 Caut+Hyd Press Low-2 Caut 4000 Hyd Press Hyd Press-2 (psi) Hyd Press-1 (psi) Hyd Press-3 (isd) Hyd Press-1+Hyd Press-2 Nose Door Warn Nose Door Warn Brake Press-LOB (psi) Brake Press-LIB (psi) Brake Press-RIB (psi) No Warn Brake Press-ROB (psi) Brake Press-LOB+Brake Press-LIB+Brake Press-RIB Active Hyd Press Low-3 Caut Hyd Press Low-3 Caut Not Active -No Warn -Up+Lck Gear Uplock-L Gear Uplock-L -Not Up+Lck -Up+Lck -Not Up+Lck Gear Uplock-N Not Up+Lck -Not Dn+Lck Gear Dnlock-L Gear Dnlock-L Gear Dnlock-N -Not Dn+Lck Gear Dnlock-R Gear Dnlock-R -Dn+Lck Gear WOW Input Caut Active Gear Disagree Warn Gear Disagree Warn -Not Active Gear WOW Output Caut Gear WOW Output Caut **Not Active** Gear WOW-R ear WOW-R Gear WOW-N Gear WOW-N Gear WOW-L Grnd Airspeed Comp-R (Kts) e Press-R (ft) e Press-L (ft) Altitude Pressure-L+Altitude Pressure-R Airspeed Comp-L+Airspeed Comp-R -21:05:00 -21:07:00 -21:12:00 -21:11:00 -21:15:00 -21:16:00 -21:20:00 -21:21:00 -21:28:00 -21:00:00 -21:08:00 -21:24:00 -21:32:00 -20:59:00 -21:03:00 -21:04:00 -21:26:00 -21:23:00 21:02:00 Revised: 14 February 2014 More Parameters - Last 42 Minutes **National Transportation Safety Board**

Figure 3. Landing gear and some hydraulic parameters during last 42 minutes of the event flight.

3000 Hyd Press-3 2900 2850 Flap-R (deg) 2800 Flap-L+Flap-R ₹²⁷⁵⁰-Flap-L+Flap-R 2700 2650 ٽي ≗ 2600 2550 2500 2450 2400 2350 -Active Hyd Press Low-3 Caut Not Active Warn Master Warn Master -No Warn Nose Door Warn Nose Door Warn -Up+Lck Gear Uplock-L -Not Up+Lck -Up+Lck Gear Uplock-N Not Up+Lck -Up+Lck Gear Uplock-R Gear Uplock-R Not Up+Lck -Not Dn+Lck Gear Dnlock-L -Dn+Lck Not Dn+Lck Gear Dnlock-N Dn+Lck -Not Dn+Lck Gear Dnlock-R -Dn+Lck Gear Disagree Warn Not Active -6000 Attitude Press-R (ft)
Attitude Press-L (ft) Altitude Pressure-L+Altitude Pressure-R -21:01:45 -21:03:45 -21:04:45 -21:07:45 -21:08:45 Central Daylight Time (HH:MM:SS) Revised: 14 February 2014 Selected Parameters - 29 Minutes National Transportation Safety Board

Figure 4. Select parameters during last 29 minutes of the event flight.

2990 2980 2970 2960 2950 2940 돌^{2930 -} 2920 Flap-L+R డ్ 2910 2890 2880 2870 2860 -Active Hyd Press Low-3 Caut Narn Master 2840 -No Warn Nose Door Warn -Up+Lck Gear Uplock-L Gear Uplock-L Not Up+Lck Gear Uplock-N Gear Uplock-N Not Up+Lck -Up+Lck Gear Uplock-R Gear Uplock-R Not Up+Lck -Not Dn+Lck Gear Dnlock-L -Dn+Lck Not Dn+Lck Dn+Lck -Not Dn+Lck Gear Dnlock-R Dn+Lck Gear Disagree Warn Not Active 6000 Altitude Press-R (ft)
Altitude Press-L (ft) 20:51:55 20:54:05 -20:54:15 20:54:25 20:54:35 Revised: 14 February 2014 Selected Parameters - 5 Minutes National Transportation Safety Board

Figure 5. Select parameters with expanded 5 minute scale from the event flight.

Accel Vert -0.3 Accel Long (g) Accel Long Accel Lat Pitch-L+Pitch-R Roll-R (deg) Heading Mag-R (deg) Heading Mag-L (deg) Heading Mag-L+Heading Mag-R 50 40 -Flap-L (deg) Flap-L+Flap-R Altitude Press-L+Altitude Press-R 15000 (tude Press-R (ft) 10000 (ft) 5000 Key Mic-R Key Mic-L Airspeed Comp-R (kts) Airspeed Comp-L (kts) Airspeed Comp-L+Airspeed Comp-R -421200 -421800 421920 FDR SRN (sec) -422160 -422400 -422760 423120 -421680 Revised: 14 February 2014 Basic Parameters - Entire Previous Flight National Transportation Safety Board

Figure 6. Basic parameters for entire previous flight.

Active Hyd Press Low-1 Caut Hyd Press Low-2 Caut Hyd Press Low-1 Caut+Hyd Press Low-2 Caut 4000 ₹ ₽ Hyd Press-2 (psi) Hyd Press-3 ess-3 (psi) 2000 Hyd Press-1+Hyd Press-2 Brake Press-LOB (psi) Brake Press-LIB (psi) Brake Press-RIB (psi) Nose Door Warn Nose Door Warn No Warn Brake Press-LOB+Brake Press-LIB+Brake Press-RIB 0 00 20 Brake Press-ROB (psi) Brake Press-ROB Active Hyd Press Low-3 Caut **Not Active** Warn -No Warn -Up+Lck Gear Uplock-L -Up+Lck Gear Uplock-R -Not Up+Lck -Up+Lck Not Up+Lck Not Dn+Lck Dn+Lck Gear Dnlock-I -Dn+Lck Gear Dnlock-R Not Dn+Lck Gear WOW Input Cau Not Active -Active Gear Disagree Warn Not Active r WOW-R ar WOW-N 20000 Attitude Press-R (ft) Altitude Pressure-L+R Airspeed Comp-R (kts) Airspeed Comp-L (kts) Airspeed Comp-L+R -421680 -422400 -421560 -421800 -422040 -422160 -422760 423120 Revised: 14 February 2014 More Parameters - Entire Previous Flight National Transportation Safety Board

Figure 7. Landing gear and some hydraulic parameters for entire previous flight.

2990 Hyd Press-3 2970 Hyd Press-3 2960 2940 -2930 -2920 2870 Hyd Press Low-3 Caut -Warn Warn Master -No Warn Nose Door Warn -Up+Lck Gear Uplock-L -Not Up+Lck -Up+Lck 2820 Gear Uplock-N Not Up+Lck 2810 --Up+Lck Gear Uplock-R -Not Up+Lck Not Dn+Lck Gear Dnlock-L -Dn+Lck Not Dn+Lck Gear Dnlock-N Dn+Lck -Not Dn+Lck Gear Dnlock-R -Dn+Lck -Active Gear Disagree Warn -2000 Attitude Press-R (ft)
1000 -1000 -0 Altitude Pressure-L+Altitude Pressure-R 420781
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420776 FDR SRN (sec)

Figure 8. Select parameters during previous takeoff.

2980 Hyd Press-3 Hyd Press-3 2950 2930 -2920 -₹²⁹¹⁰-2870 2860 Hyd Press-3 Hyd Press Low-3 Caut -Warn Warn Master -No Warn Nose Door Warn 2820 -Up+Lck Gear Uplock-L Not Up+Lck 2810 -Gear Uplock-N Not Up+Lck -Up+Lck Gear Uplock-R Gear Uplock-R Not Up+Lck Not Dn+Lck Gear Dnlock-L -Dn+Lck Not Dn+Lck Dn+Lck -Not Dn+Lck Gear Dnlock-R -Dn+Lck Gear Disagree Warn 2500 Press R (ft) Altitude Pressure-L+Altitude Pressure-R 422860 422859 422858 422857 422856 422856 422854 422854 422853 422852 422852 422893 422891 422890 422889 422888 422886 422886 422887 422877 -422861 -422862 -422864 -422863

Selected Parameters - Previous Landing

Revised: 14 February 2014

Figure 9. Select parameters during previous landing.

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APPENDIX A

This appendix describes the parameters provided and verified in this report. Table A-1 lists the parameters and table A-2 describes the unit and discrete state abbreviations used in this report.

Table A-1. Verified and provided FDR parameters.

Parameter Name	Parameter Description
1. Accel Lat (g)	Lateral Acceleration
2. Accel Long (g)	Longitudinal Acceleration
3. Accel Vert (g)	Vertical Acceleration
4. Airspeed Comp-L (kts)	Left Computed Airspeed
5. Airspeed Comp-R (kts)	Right Computed Airspeed
6. Altitude Press-L (ft)	Left Pressure Altitude
7. Altitude Press-R (ft)	Right Pressure Altitude
8. Brake Press-LIB (psi)	Left Inboard Brake Pressure
9. Brake Press-LOB (psi)	Left Outboard Brake Pressure
10. Brake Press-RIB (psi)	Right Inboard Brake Pressure
11. Brake Press-ROB (psi)	Right Outboard Brake Pressure
12. Flap-L (deg)	Left Flap Position
13. Flap-R (deg)	Right Flap Position
14. Gear Disagree Warn (discrete)	Landing Gear Disagree Warn
15. Gear Dnlock-L (discrete)	Left Landing Gear Down and Locked
16. Gear Dnlock-N (discrete)	Nose Landing Gear Down and Locked
17. Gear Dnlock-R (discrete)	Right Landing Gear Down and Locked
18. Gear Uplock-L (discrete)	Left Landing Gear Up and Locked
19. Gear Uplock-N (discrete)	Nose Landing Gear Up and Locked
20. Gear Uplock-R (discrete)	Right Landing Gear Up and Locked
21. Gear WOW Input Caut (discrete)	Weight on Wheels Gear Input Caution
22. Gear WOW Output Caut (discrete)	Weight on Wheels Gear Output Caution
23. Gear WOW-L (discrete)	Left Landing Gear Weight on Wheels
24. Gear WOW-N (discrete)	Nose Landing Gear Weight on Wheels
25. Gear WOW-R (discrete)	Right Landing Gear Weight on Wheels
26. Heading Mag-L (deg)	Left Magnetic Heading
27. Heading Mag-R (deg)	Right Magnetic Heading
28. Hyd Press Low-1 Caut (discrete)	Hydraulic Pressure Low-1 Caution
29. Hyd Press Low-2 Caut (discrete)	Hydraulic Pressure Low-2 Caution
30. Hyd Press Low-3 Caut (discrete)	Hydraulic Pressure Low-3 Caution
31. Hyd Press-1 (psi)	Hydraulic Pressure 1
32. Hyd Press-2 (psi)	Hydraulic Pressure 2
33. Hyd Press-3 (psi)	Hydraulic Pressure 3
34. Key Mic-L	Left Microphone Keyed
35. Key Mic-R	Right Microphone Keyed
36. Nose Door Warn (discrete)	Nose Door Warning
37. Pitch-L (deg)	Left Pitch Angle
38. Pitch-R (deg)	Right Pitch Angle

Parameter Name	Parameter Description
39. Roll-L (deg)	Left Roll Angle
40. Roll-R (deg)	Right Roll Angle
41. Time GMT Hrs (hrs)	Greenwhich Mean Time Hours
42. Time GMT Min (min)	Greenwhich Mean Time Minutes
43. Time GMT Sec (sec)	Greenwhich Mean Time Seconds
44. Warn Master (discrete)	Master Warning

NOTE: This FDR records pressure altitude, which is based on a standard altimeter setting of 29.92 inches of mercury (in Hg). The pressure altitude information presented in the FDR plots and in the electronic data has not been corrected for the local altimeter setting at the time of the event.

Table A-2. Unit and discrete state abbreviations.

Unit and Discrete Abbreviation	Description
deg	degrees
discrete	discrete
Dn+Lck	Down and Locked
ft	feet
g	g
Grnd	Ground
hrs	hours
kts	knots
min	minutes
Not Dn+Lck	Not Down and Locked
Not Up+Lck	Not Up and Locked
psi	pounds per square inch
sec	seconds
Up+Lck	Up and Locked

NOTE: For parameters with a unit description of discrete, a discrete is typically a 1-bit parameter that is either a 0 state or a 1 state where each state is uniquely defined for each parameter.