

National Transportation Safety Board
Office of Research and Engineering
Washington, D.C. 20594

Aircraft Performance

Group Chairman's Aircraft Performance Study

A. ACCIDENT

Location: Lexington, KY
Date: August 27, 2006
Time: 1007 GMT (6:07 am EDT)
Airplane: Bombardier CRJ-100, N431CA
NTSB Number: DCA06MA064

B. GROUP

Chairman: Timothy Burtch
National Transportation Safety Board
Washington, DC

Member: Brandon Helm
CRJ Program Coordinator, Flight Operations
Comair Airlines

Member: Pierre Huggins
Staff Engineer, Air Safety Department
Air Line Pilots Association

C. SUMMARY

On August 27, 2006, about 0607 eastern daylight time, Comair Flight 5191, a Bombardier CL-600-2B19 (CRJ-100), N431CA, crashed during takeoff from Blue Grass Airport, Lexington, Kentucky (LEX). The airplane, which had been cleared for runway 22, taxied onto runway 26 instead and ran off the end of runway 26. Of the 47 passengers and 3 crewmembers on board the airplane, 49 were killed, and 1 received serious injuries. The airplane was destroyed by impact forces and postcrash fire. The flight was operating under the provisions of 14 *Code of Federal Regulations* Part 121 and was en route to Hartsfield-Jackson Atlanta International Airport, Atlanta, Georgia (ATL).

D. DETAILS OF INVESTIGATION

The NTSB arrived at the accident site on Sunday morning, August 27, 2006. The investigative team first surveyed the entire wreckage area. The Performance Group Chairman then retraced and documented the accident flight track. The area of focus included the last 2000 ft of LEX runway 26 and stretched to the main wreckage located approximately 1800 ft off the west end of

the runway. The factual information gathered at the scene is contained in the Aircraft Performance Wreckage Site Factual Report.

1. Wreckage Location

The wreckage was located off of the departure end of Runway 26 at Lexington, Kentucky's, Blue Grass Airport. The runway end is located at 38° 2' 20.352" N latitude and 84° 36' 34.498" W longitude. The wreckage was found approximately on the extended runway centerline between 200 ft and 1900 ft off of the runway end. Details of the wreckage can be found in the Aircraft Performance Wreckage Site Factual Report.

2. Radar Data

The Airport Surveillance Radar for Lexington (38° 2' 1.30" N, 84° 35' 40.79" W, 979.4 ft elevation) had three hits on Comair Flight 5191's beacon code of 6641. The three hits were approximately four seconds apart and showed the aircraft on or slightly off of the last half of runway 26. All altitudes were reported at 900 ft. No other useful information was obtained. More details on the radar data can be found in the Air Traffic Control report.

3. Aircraft Configuration

The aircraft Load Manifest showed an aircraft takeoff weight of 49,087 lb and a center of gravity of 12% MAC. Of the 49,087 lb, 7300 lb was fuel, 8648 lb was passengers, and 1640 lb was baggage. The Dispatch Release indicated a maximum structural weight of 53,000 lb (MTOW), a maximum ramp weight of 53,250 lb, and a basic operating weight of 31,499 lb.

The aircraft was configured with 20° flaps, the bleeds were closed on the GE CF34-3A1 engines, and the auxiliary power reserve was armed. The thrust setting designated for the takeoff was 90% N1, not a reduced "flex" thrust setting. (Flex thrust take-off settings are often used to extend the engine life.)

4. Meteorological Conditions

Weather reported at the time of the takeoff was information Bravo: Wind 220°/7 kts, visibility 8 statute miles, a few clouds at 9,000 ft, scattered clouds at 12,000 ft, temperature 24°C, dew point 19°C, altimeter setting 30.00 in Hg, active runway 22. Field elevation was 979 ft. Sunrise was at 7:03 am EDT.

5. Ground/Flight Path Description

Flight Data Recorder (FDR) and Cockpit Voice Recorder (CVR) data have been correlated and overlaid for the Lexington accident. The overlay will be included in a future addendum once the CVR data have been released. This study includes the FDR aircraft accelerations and attitudes that were used to calculate Flight 5191's position and speed through most of the flight. (The calculated position and speed are included in Section 6, "FDR Integration Results".)

The FDR from Comair Flight 5191 recorded over 300 parameters and captured the aircraft's state and configuration. However, some parameters on the FDR were inaccurate or invalid during some or all of the flight. Latitude and longitude, for example, were not recorded on the

FDR to the resolution necessary to accurately locate Flight 5191 on the airport. As a result, the FDR latitude and longitude data showed the aircraft oscillating from one side of the airport ramp to the other, often showing the aircraft off of the airport's hard surfaces. Groundspeed and airspeed, on the other hand, were invalid during the low-speed (taxi) portion. However, the recorded speeds shown in Figure 4 appear valid once the flight is approximately two seconds into the take-off roll and correlate well with the integration results contained in Section 6.

The accelerations and attitudes recorded on the FDR and used in the study are shown in Figures 1 and 2, respectively. The time segment that was used in the study begins shortly after the aircraft tug released Comair 5191 from the pushback and ends when the aircraft impacted the first tree and the FDR stopped recording.

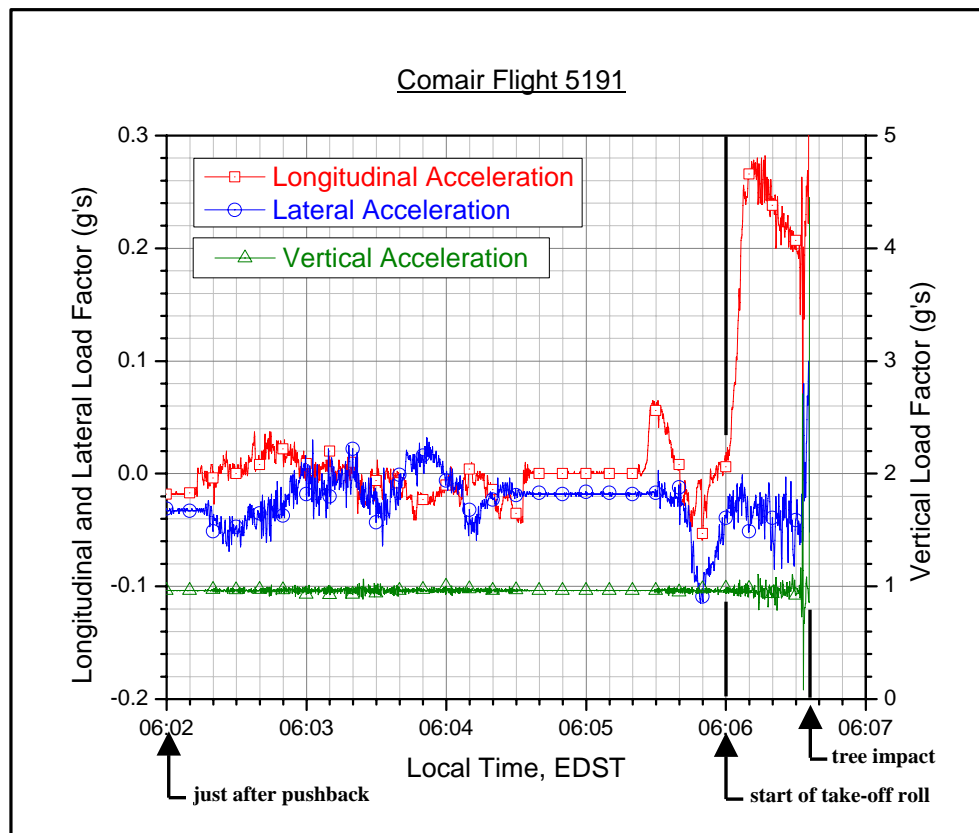


Figure 1: FDR Acceleration from Pushback

The time scale is expanded to just the take-off roll for vertical load factor in Figure 3. This highlights the impact with both the perimeter fence and the first tree. Figure 3 shows that Comair Flight 5191 impacted the fence around 6:06:32 EDT and experienced approximately a 2.5 g spike in vertical load factor. At 6:06:35, the FDR data show approximately a 4.0 g spike in vertical load factor when the aircraft impacted the first tree. These two impact points are supported by the FDR speed data and the distance measurements taken at the accident site: average speed calculations indicate that it would take approximately 2.5 sec for Flight 5191 to travel the 530 ft from the fence to the first tree at an average speed of 126 kt. The FDR speed and altitude data are shown in Figures 4 thru 7. These data show that Comair Flight 5191 had a positive acceleration of approximately 4.3 kt/sec until impacting the fence and that the aircraft never climbed more than about 20 ft off of the ground.

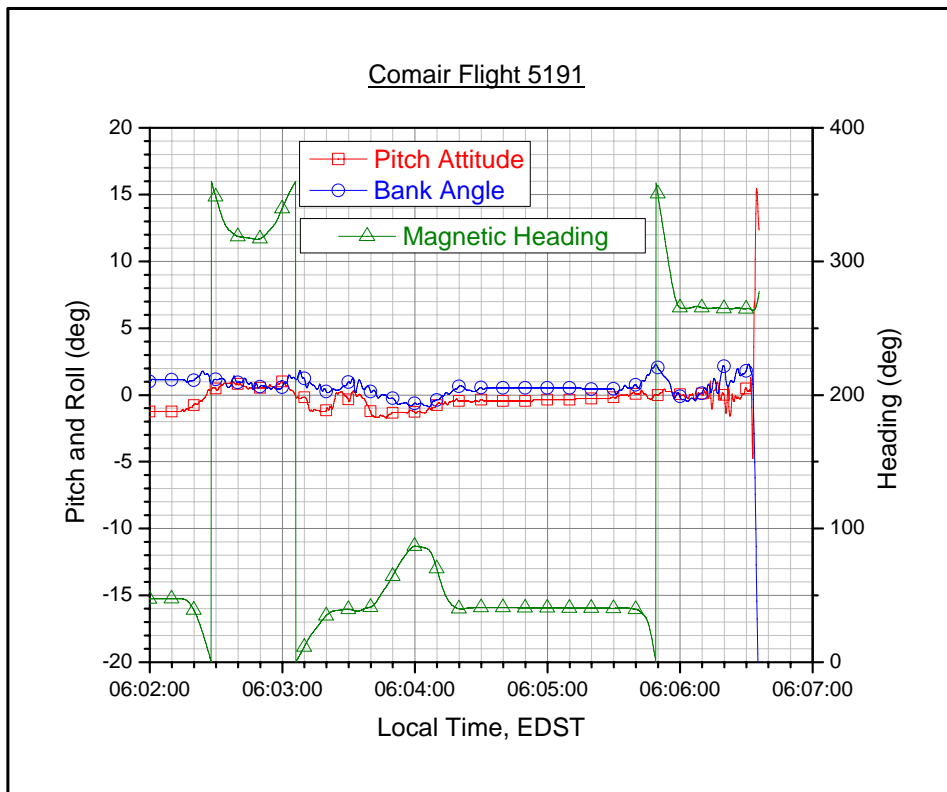


Figure 2: FDR Attitude from Pushback

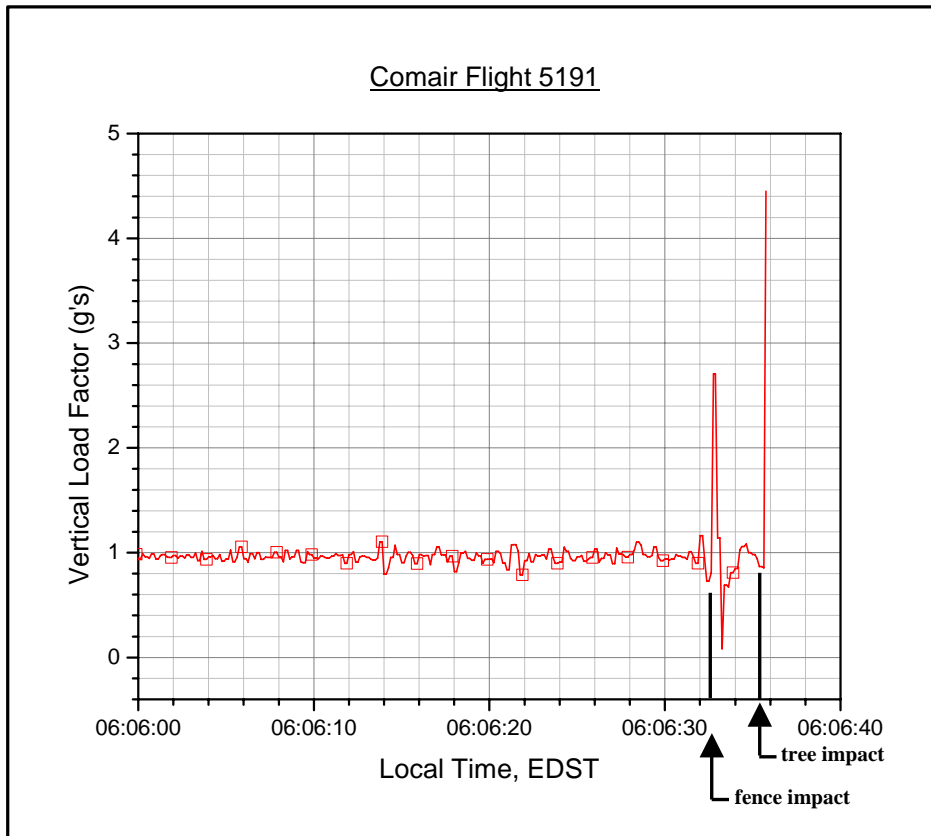


Figure 3: FDR Vertical Acceleration during Take-off Roll

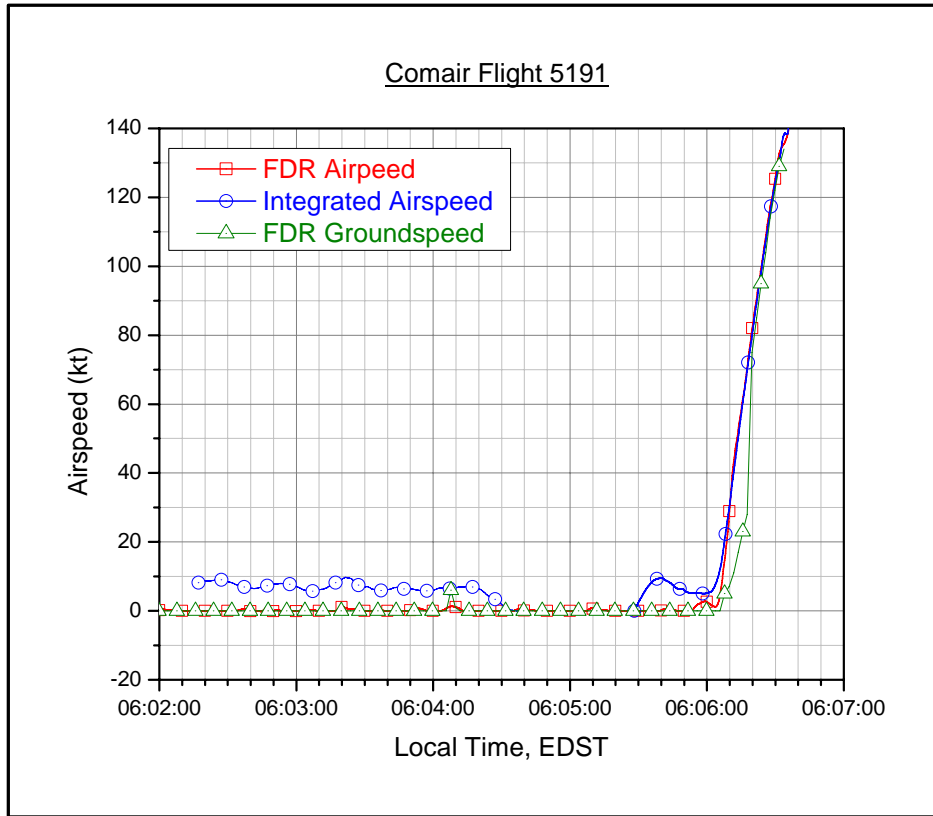


Figure 4: FDR Speed from Pushback

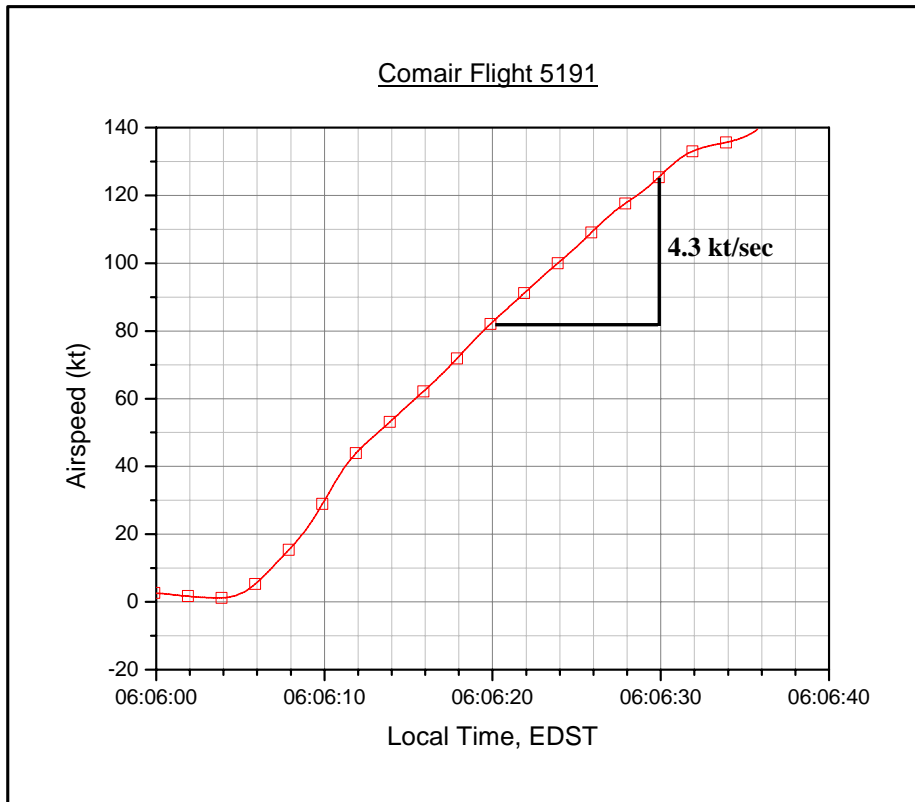


Figure 5: FDR Pilot-side Airspeed during Take-off Roll

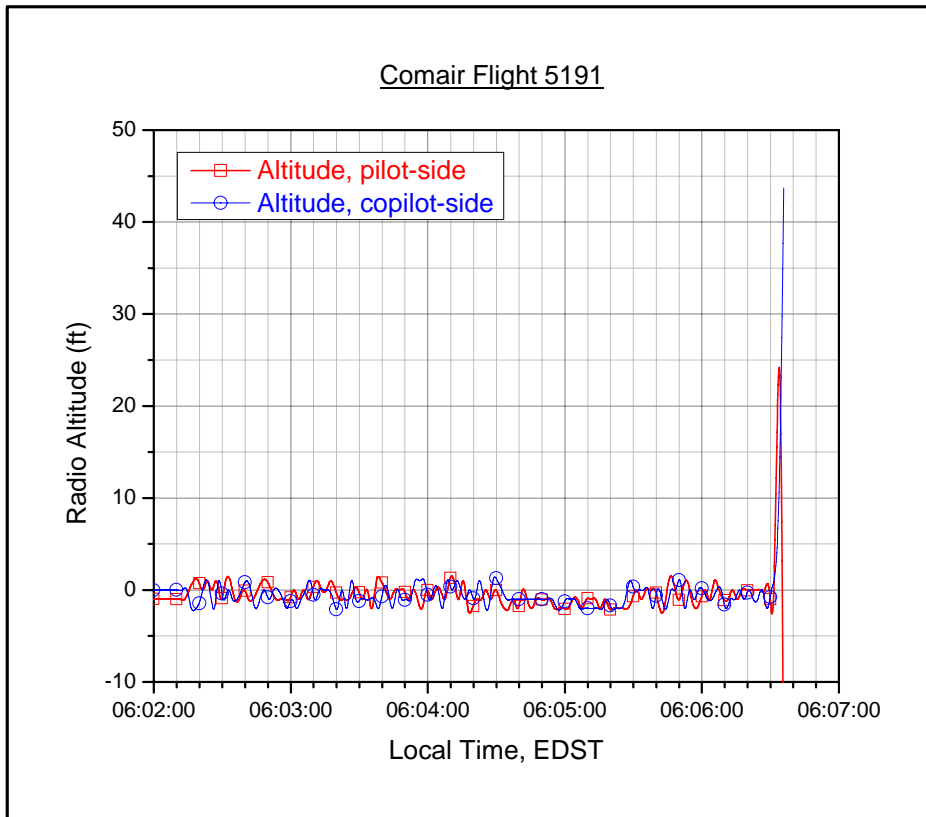


Figure 6: FDR Altitude from Pushback

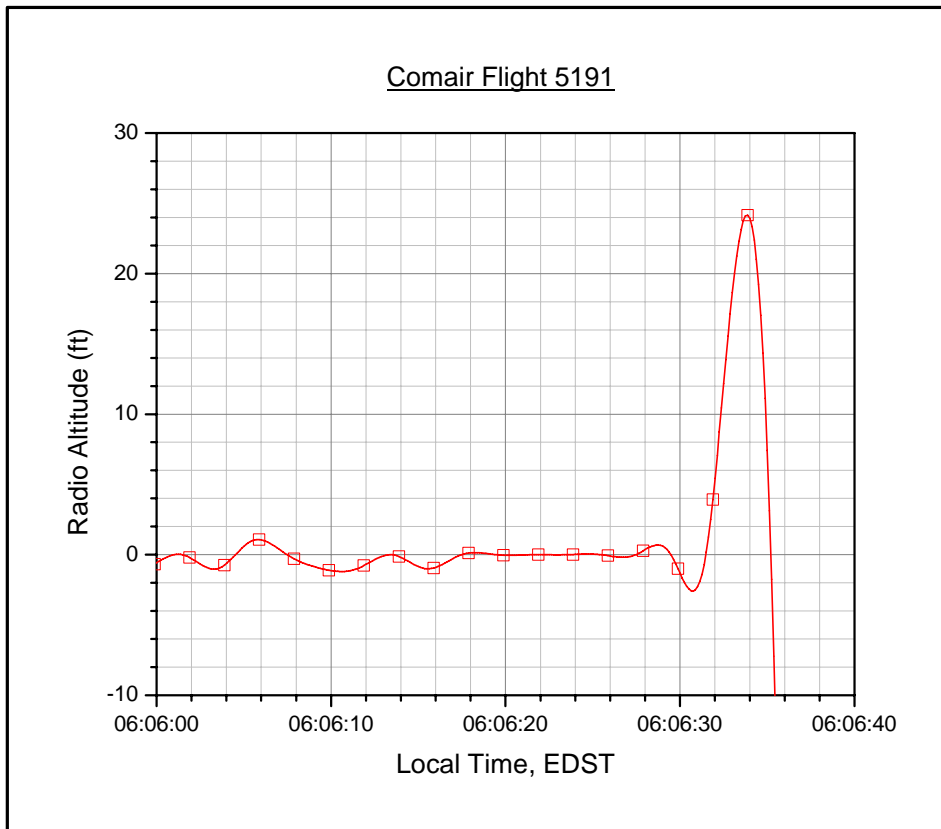


Figure 7: FDR Altitude during Take-off Roll

6. FDR Integration Results

The load factors from the FDR are shown in Figure 1. These body axis accelerations were integrated to obtain aircraft body axis rates. The FDR attitude data shown in Figure 2 were then used to transform the integration results into an inertial frame e.g., north, east, and down. Finally, the integration results were combined with the wind and atmospheric data reported at the time of the accident (and contained in Section 4) to obtain airspeed. The integration was required because the FDR installation on Comair Flight 5191 did not include a reliable source for aircraft position. Knowing the location of the aircraft in the context of the transmissions recorded on the CVR provides a clearer picture of what the crew was experiencing.

In order to obtain meaningful integrations results, boundary conditions were required to constrain the integration output and to refine the initial conditions. One set of boundary conditions in the Comair integration came from the airport geometry (e.g., gate information, taxiway and runway locations, hold-short line, etc.) The second set of boundary conditions came from the wreckage documented during the on-scene investigation. Details of the wreckage can be found in the Aircraft Performance Wreckage Site Factual Report. The final integration results and the associated boundary conditions are shown in Figure 8 in an overhead image of the Blue Grass Airport.

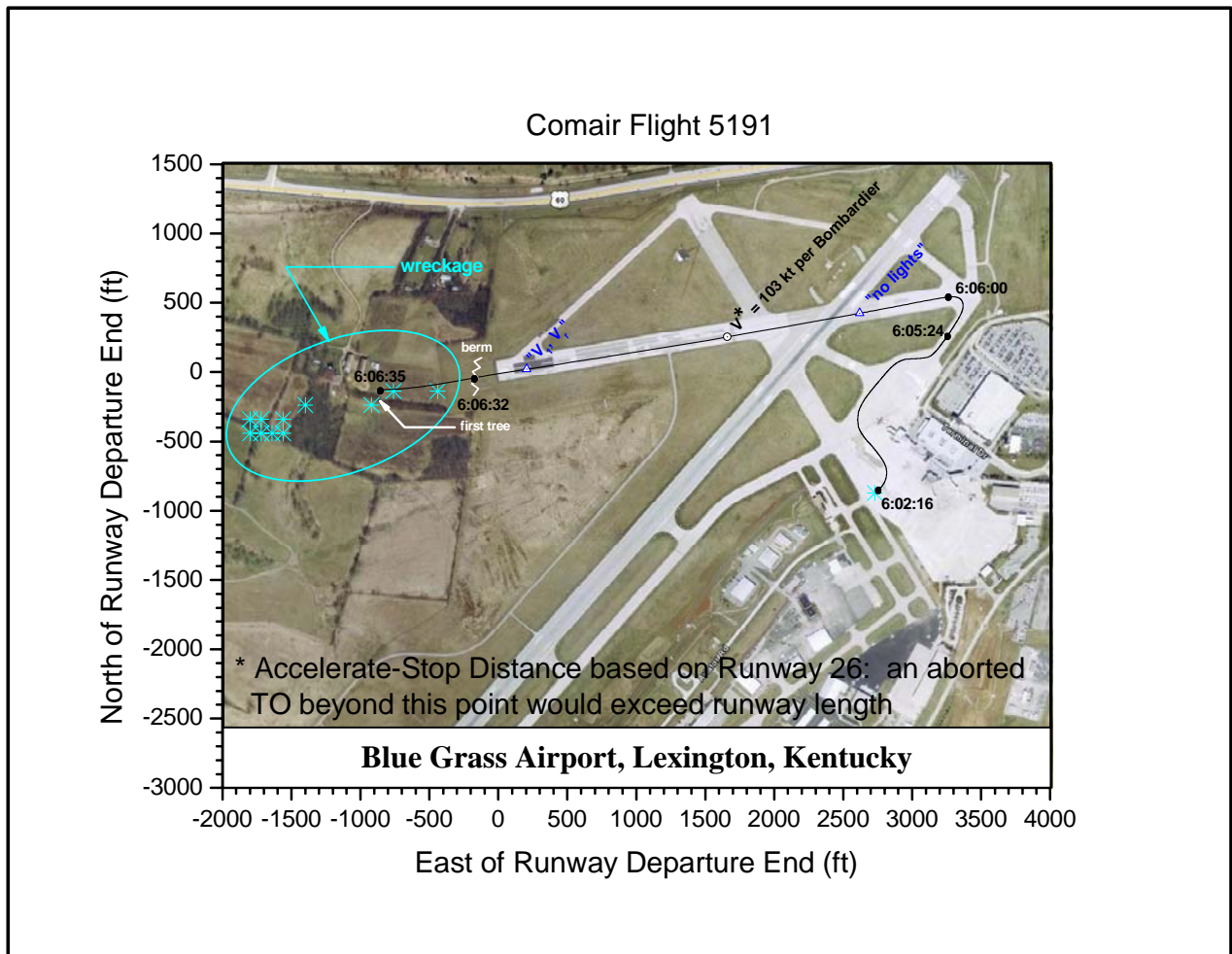


Figure 8: FDR Load Factor Integration Results

The integration result (shown in black in Figure 8) represents the aircraft track. The integration started shortly after push-back from gate at 6:02:16. The integration stopped at the end of the FDR data that, as previously mentioned, occurred when the aircraft impacted the first tree approximately 920 ft off the end of runway 26. Various pieces of the left winglet and other debris are highlighted in cyan (*) in the figure around the first tree. The wreckage cluster located furthest from the runway is where the cockpit and fuselage were found. As indicated in Figure 8, the bulk of the wreckage was found approximately 1820 ft off the departure end of runway 26.

Figure 9 shows a comparison of the speeds recorded on the FDR and the speed that resulted from the integration. The comparison shows a good correlation above approximately 10 kt. Below 10 kt the FDR speed was reported as invalid by the FDR group.

Figure 9 also highlights that the integration was done in two segments to avoid “integrator wind-up” when the aircraft was not moving. As a result, the integration starts just into the taxi at approximately 6:02:17 EDT and pauses while Comair Flight 5191 sat on the runway hold line between 6:04:33 and 6:05:24 EDT. (Note: The centerline to runway 26 was captured at approximately 6:06:00.)

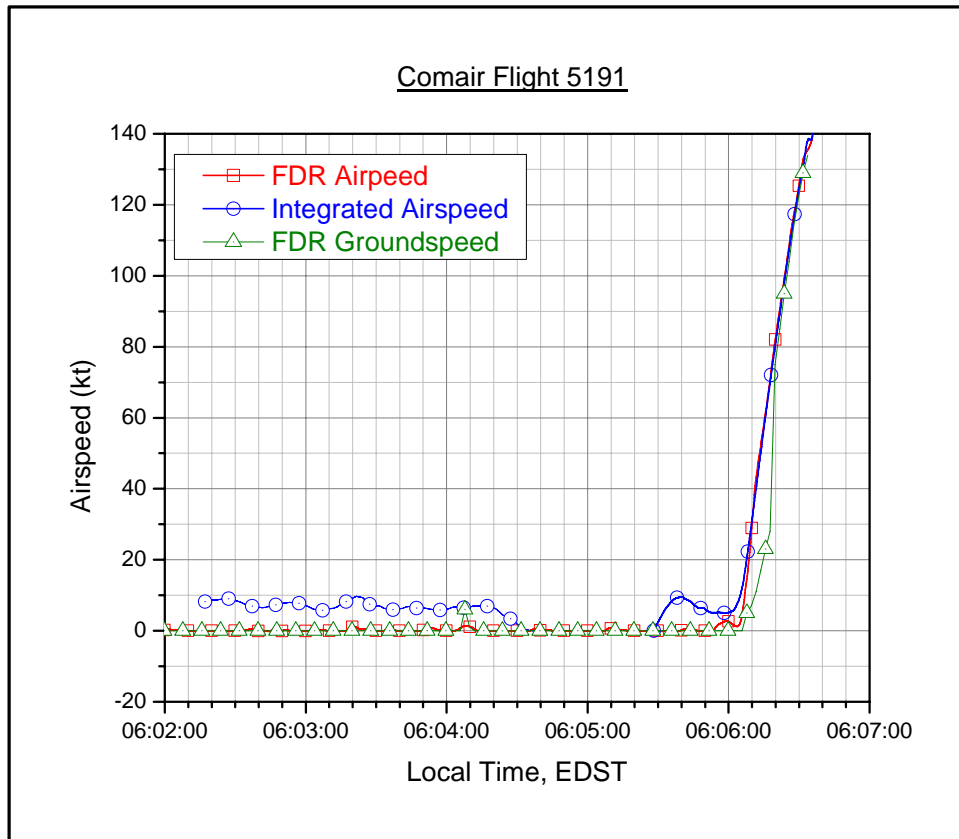


Figure 9: Comparison of FDR Speed with Integration Result

7. Bombardier CRJ Accelerate-Stop Performance Calculations for Runway 26

Figure 8 also shows the location beyond which an aborted take-off would exceed the length available on LEX runway 26 (black circle). It represents the point beyond which a CRJ-100

aircraft could not be stopped on the available runway, even with maximum braking applied. Prior to this point, a CRJ could be stopped before reaching the end of the runway. Beyond this point, a CRJ would overrun the runway. The speed calculated at this critical point (assuming a normal Airplane Flight Manual take-off) for the accident aircraft configuration and the atmospheric conditions reported the morning of the accident is 103 kt. This speed would be reached 1834 ft down the runway (approximately five seconds beyond the lighted runway 22 at LEX), leaving 1667 ft for stopping. However, because these calculations are based on runway 26 and not the intended take-off runway 22, Comair Flight 5191 would not have known of this limit. Comair 5191 would not have knowingly taken off on runway 26 based on published CRJ performance. Flight 5191 was appropriately using take-off performance numbers based on runway 22.

8. Bombardier CRJ BFL Performance Calculations for Runway 22

A summary of balanced field length (BFL) take-off performance from the aircraft manufacturer's analysis is shown below. The calculations are based on runway 22 and should be similar to those performed or provided to the crew of Flight 5191. It should be noted that the distance required to rotate a CRJ-100 is 243 ft off the end of LEX runway 26. This is approximately where the FDR recorded the rotation for Comair 5191.

Assumptions

aircraft = CRJ-100	wind = 200° @ 7 kt
engine = CF34-3A1(GE engines)	altimeter setting = 30.00 in Hg
take-off weight = 49,087 lb	bleed air off
flap setting = 20°	dry runway
temperature = 24° deg. C	

Take-off Performance Based on a BFL Calculation, AFM

V_1 = 135 Kias with a 3593 feet ground roll
 V_R = 138 Kias with a 3744 feet ground roll

9. Comair CRJ Flight Standards Manual BFL Performance Calculations for Runway 22

The decision and rotation speeds from Comair's Flight Standards manual with similar conditions and assumptions are shown below. The numbers are within two knots of those in Section 8 from the CRJ AFM.

Take-off Performance Based on BFL Calculation, Comair Flight Standards Manual

take-off weight = 49,000 lb
 V_1 = 135 Kias
 V_R = 139 Kias
take-off weight = 50,000 lb
 V_1 = 137 Kias
 V_R = 142 Kias

E. SUMMARY AND CONCLUSIONS

The crew of Comair Flight 5191 unknowingly took off on the 3,501 ft runway 26 at Lexington Bluegrass Airport, thinking they were on the 7,002 ft runway 22. All of the aircraft performance that the crew utilized for the take-off was based on the longer LEX runway, and the take-off was performed as would be expected for the longer runway. However, because Flight 5191 was on the shorter runway 26, rotation and lift-off occurred beyond the runway end. The CRJ-100 was damaged when it impacted a berm approximately 265 ft off runway 26 and just before the aircraft temporarily became airborne. The aircraft ultimately came to rest about 1820 ft off the departure end of runway 26.

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