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

Performance Study

Specialist Report
Marie Moler

A. ACCIDENT

Location:	Aspen, Colorado
Date:	January 5, 2014
Time:	1222 MST
Airplane:	Bombardier CL-600-2B16, N115WF
NTSB Number:	CEN14FA099

B. GROUP

No vehicle performance group was formed.

C. SUMMARY

On January 5, 2014, at 1222 mountain standard time (MST), a Bombardier CL-600-2B16, N115WF, impacted the runway while attempting to land on Runway 15 at Aspen-Pitkin County Airport/Sardy Field (KASE), Aspen, Colorado. There were two crewmembers and one passenger onboard. One crewmember was fatally injured; the other crewmember and the passenger received serious injuries. The airplane was destroyed. The airplane was registered to the Bank of Utah Trustee and operated by Vineland Corporation Company, Panama, South America under the provisions of 14 Code of Federal Regulations Part 91. Visual meteorological conditions prevailed for the flight, which operated on an instrument flight rules flight plan. The flight originated from Tucson International Airport (KTUS), Tucson, Arizona, at 1004.

PERFORMANCE STUDY

The aircraft was equipped with a flight data recorder (FDR), cockpit voice recorder (CVR), and an enhanced ground proximity warning system (EGPWS). Data from the FDR was analyzed for this study. All times displayed are from the internal flight data recorder clock and have not been synchronized with an outside source.

The elevation at Aspen-Pitkin County Airport (KASE) is 7837 ft. The landing weight calculated by the crew was 35,881 lbs and the CG was 512.6 in.

Weather Observation

The weather conditions reported by Aspen-Pitkin County Airport (KASE) automated surface observation system (ASOS) at 1220 were winds from 320° at 14 kts, gusting to 25 kts, variable from 280° to 360°. Temperature was 10°F (-12°C), the dew point -6°F (-21°C), and the altimeter setting was 30.07 inHg. Visibility was 10 miles in haze, scattered clouds at 4,700 feet above ground level, and a broken ceiling at 6,000 feet.

Aircraft Approach and Landing

During the last six minutes of flight, the aircraft descended from 13,500 ft and slowed from an airspeed of 220 kts (Figure 1). The aircraft's descent angle for the last nautical mile of flight was approximately 4° and its airspeed was about 140 kts (Figure 2).

Runway 15 at KASE is on a magnetic heading of 151° (160° true), begins at an elevation of 7680 ft, and slopes upward at a gradient of 1.9% [1]. During the last minute of flight the aircraft track aligned with the runway heading. The winds (report in *Weather Observation*) were variable from 280° to 360° at 14 kts gusting to 25 kts. A 25 kts gust from 280° would be a 21 kts crosswind and a 12 kts tail wind. Winds from 340° would be a pure tailwind. The aircraft's maximum tailwind component for takeoff and landing as reported in the Airplane Flight Manual (AFM) [2] was 10 kts. The maximum crosswind component for landing on a dry runway was 24 kts.

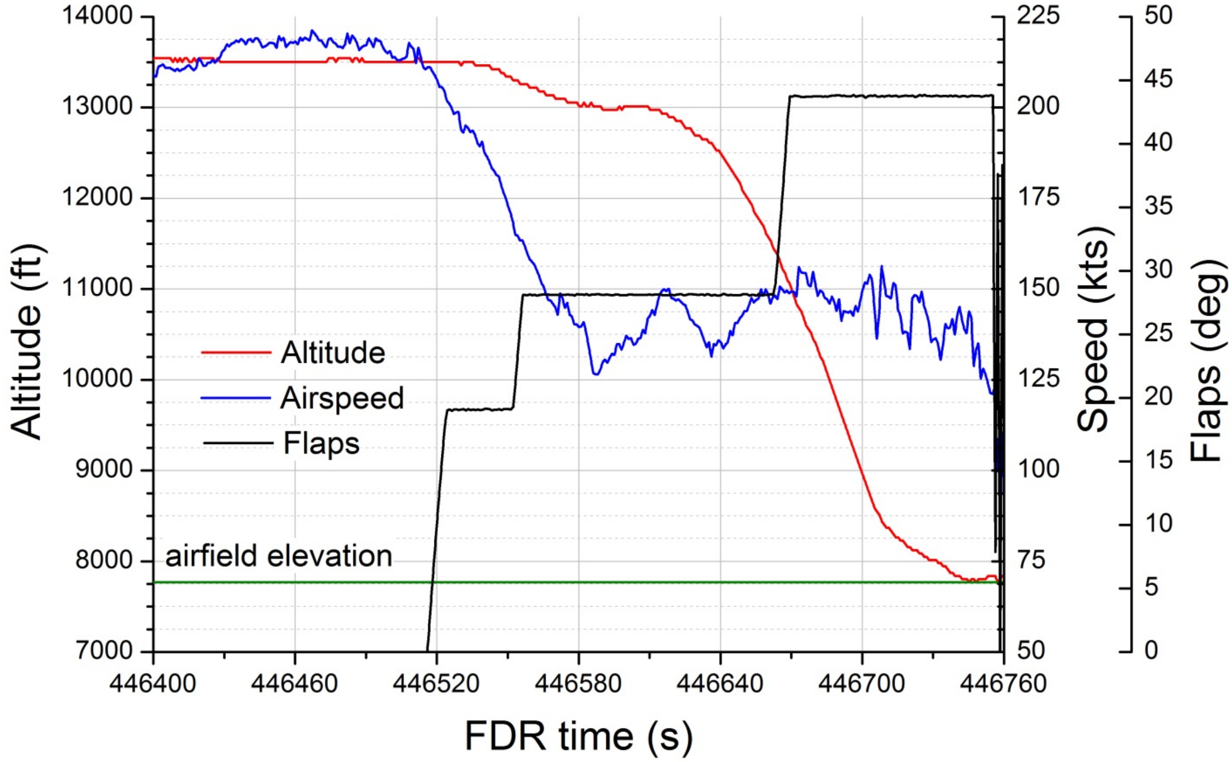


Figure 1. Aircraft recorded altitude, airspeed, and flaps for the last six minutes of flight.

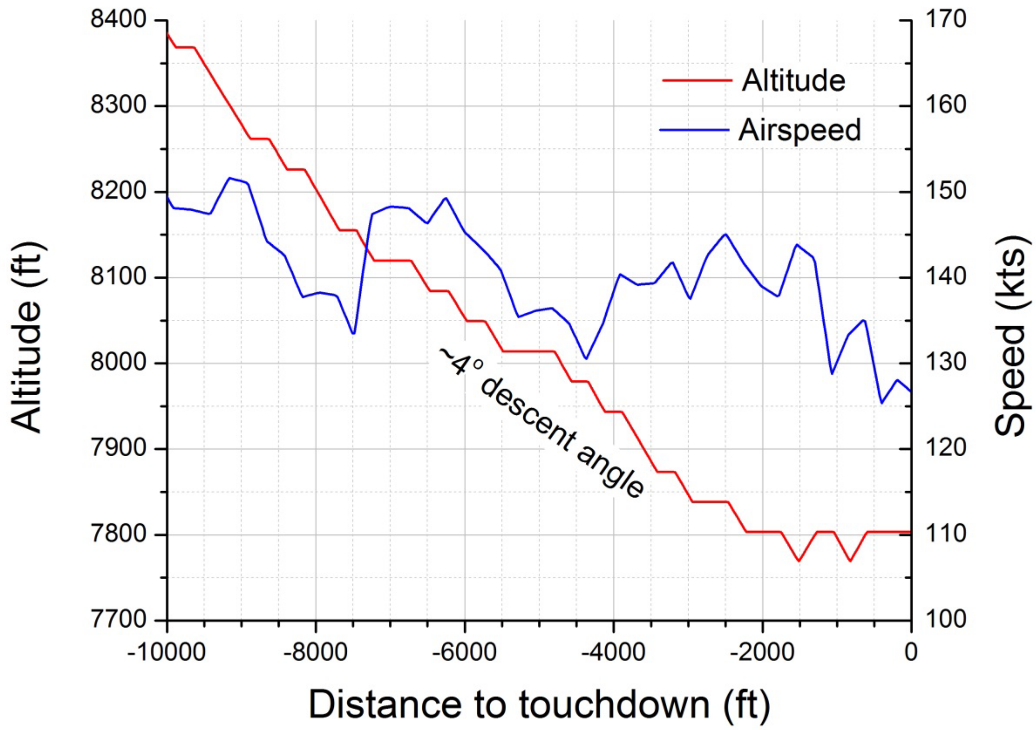


Figure 2. Aircraft altitude and airspeed for the last 10,000 ft of flight.

Video of the runway showed the accident aircraft landing at KASE. The sequence of events in the video was: the aircraft above the runway in a slightly nose down configuration, a flash of light indicating a runway strike, the aircraft in the air above the runway and nose down, and then the aircraft impacting the runway nose down and being engulfed in light. In Figure 3, six stills from the video are overlaid to show these events. The motion is from right to left. Approximately four seconds elapse between the runway strike and the final impact.

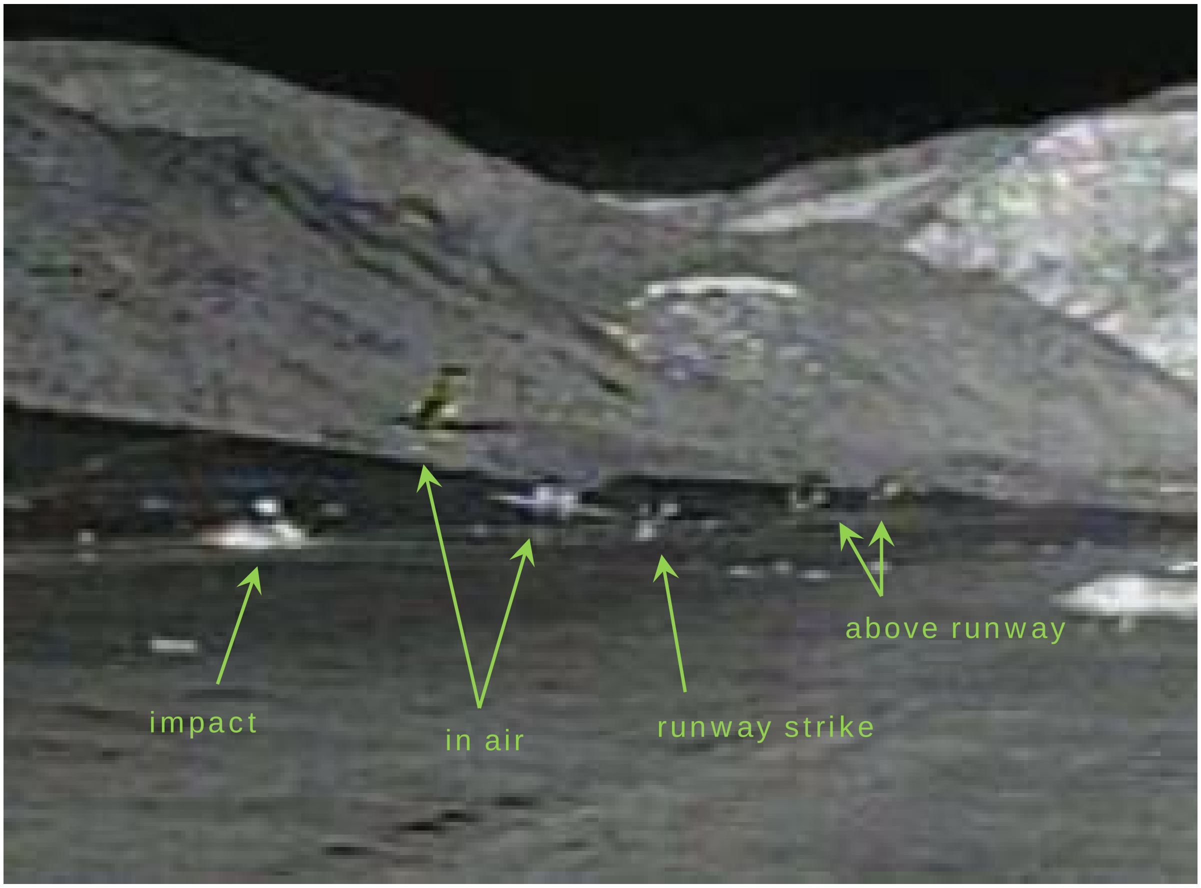


Figure 3. Overlaid stills of landing from runway video.

The vertical acceleration (N_Z) from the FDR (Figure 4) was consistent with the video. At 446752 s FDR time there was a spike in N_Z from 1g to 3g's followed by a second spike to nearly 6g's about four seconds later. These points likely are the runway strike and final impact seen in Figure 3. The touchdown N_Z is typically between 1.1 and 1.5g's depending on the landing. Figure 4 shows five N_Z peaks to just below 1.5g that occurred before the runway strike. The N_Z data indicates that the aircraft oscillated above the runway a number of times before the 3g runway strike.

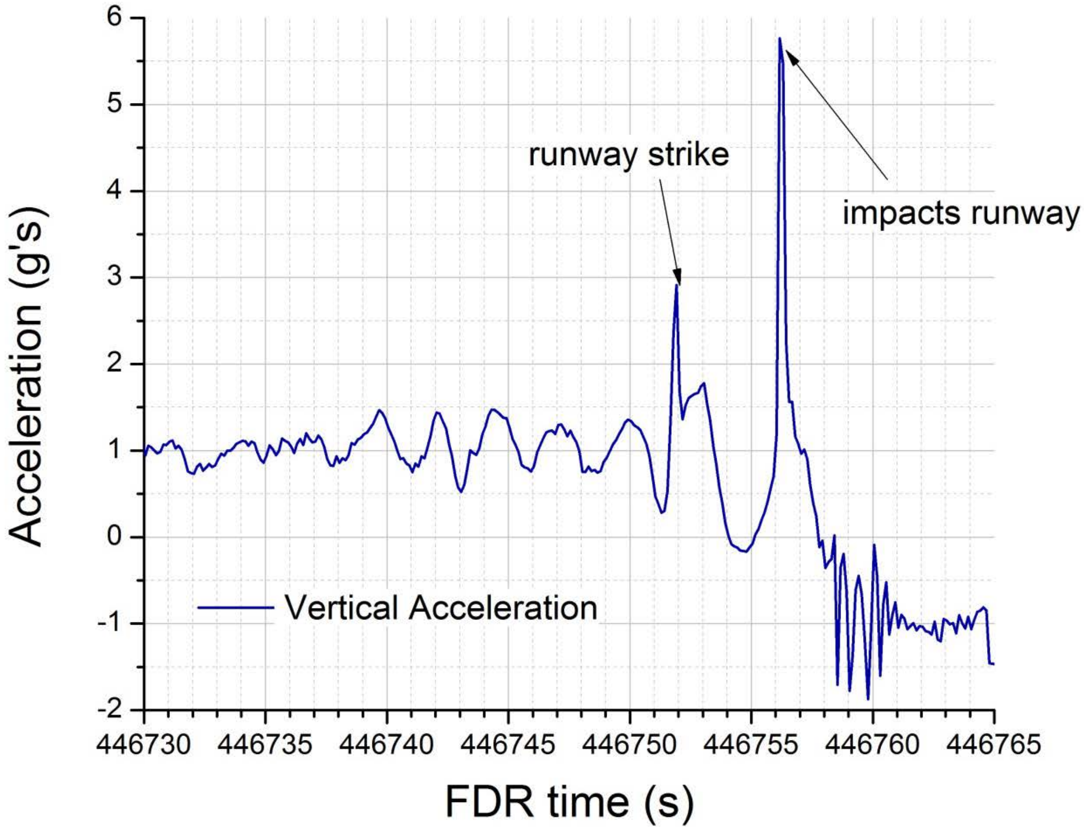


Figure 4. Aircraft vertical acceleration for last 30 seconds of flight.

Figure 5 shows the aircraft's pitch and altitude for the final 200 ft of descent. The aircraft remained nose down (negative pitch value) until the third N_Z oscillation. Figure 6 shows both N_Z and pitch. The recorded pitch indicates that the aircraft did not rotate into a nose up position for the main gear to touchdown first.

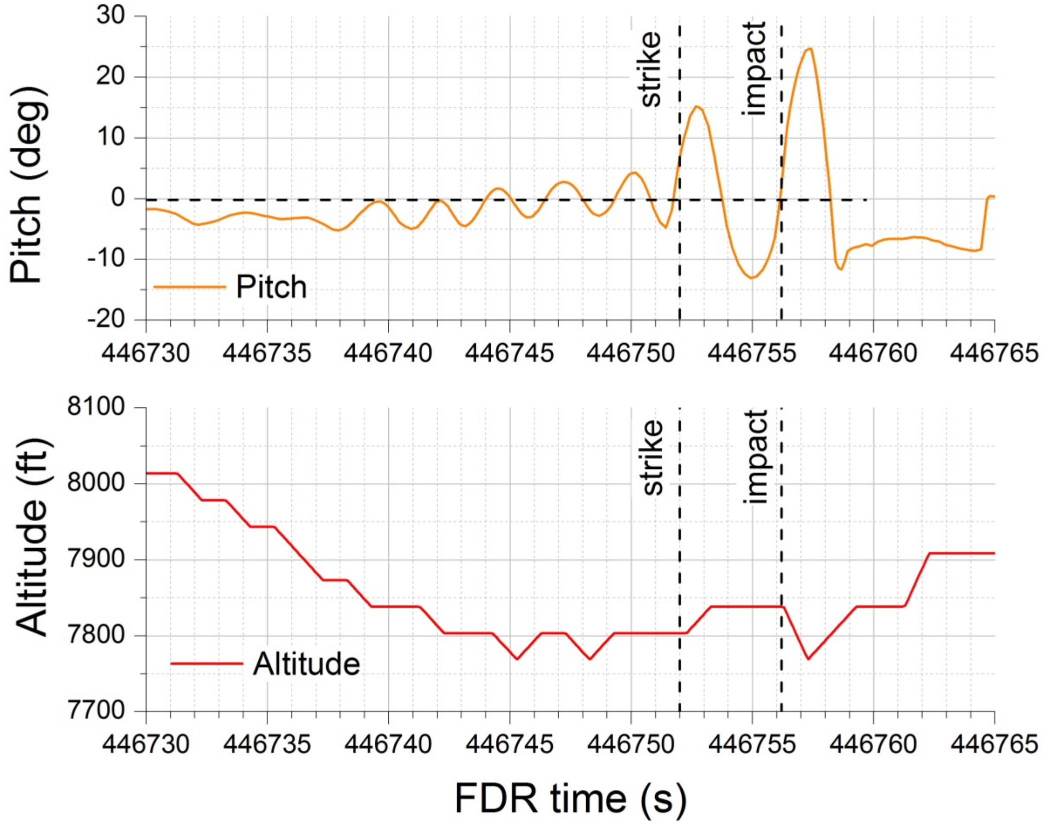


Figure 5. Aircraft pitch and altitude. The horizontal black dotted line corresponds with 0° pitch.

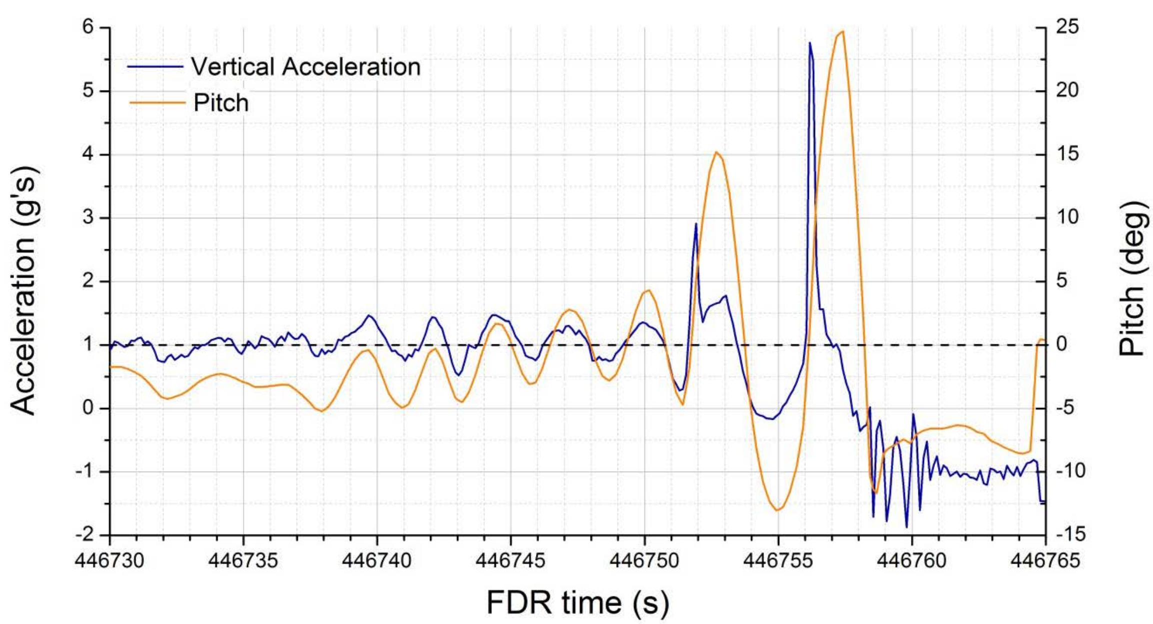


Figure 6. Aircraft vertical acceleration and pitch during touchdown and impact. The black dotted line corresponds to 1 g of vertical acceleration and 0° of pitch.

During the last minute of flight, the aircraft's engines were advanced and pulled back five times (Figure 7). N2 begins at about 65% at 446690 s, then transitions between 75% and 85%. N1 begins at about 30%, then transitions between 45% and 75%.

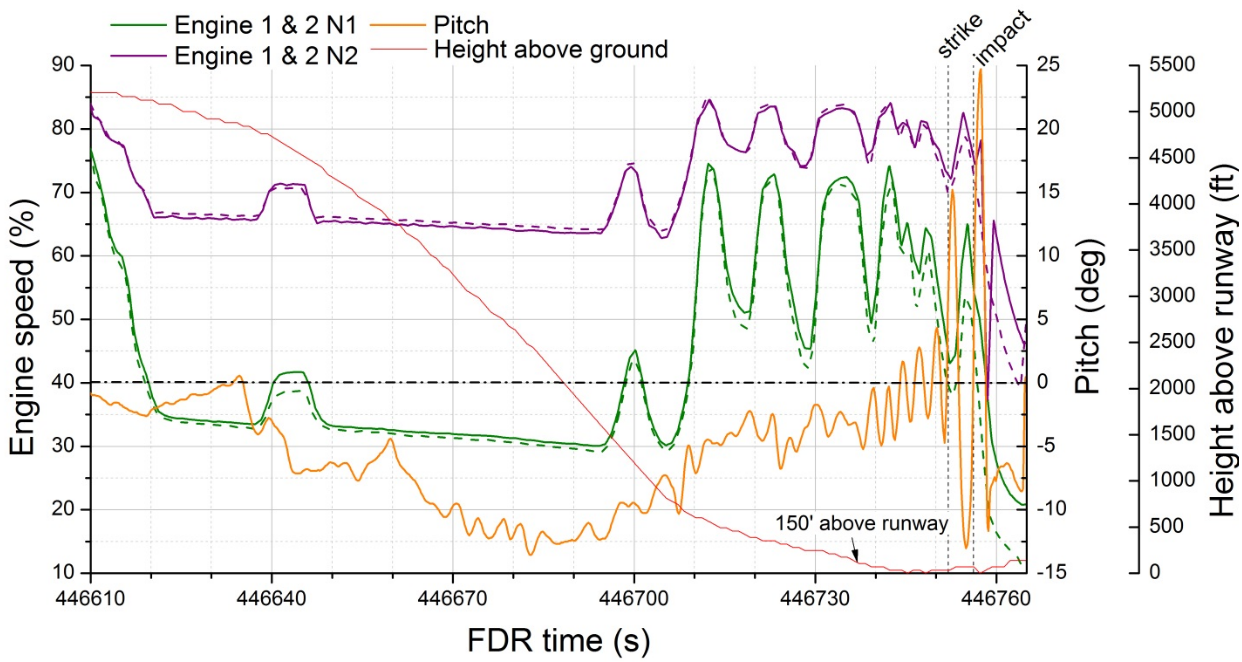


Figure 7. N1 and N2 speeds, and pitch and height above ground for approach.

As the oscillation in pitch began, the engines were retarded to 70% for N2 and 45% for N1 (Figure 8). After the strike the engines were briefly advanced. GE Aviation, Inc. commented that the CF34-3 engines installed on the accident aircraft are mechanically controlled and do not have a FADEC (full authority digital engine control). For the speeds of both engines to vary together as recorded by the FDR, it would have had to have been commanded at the throttle.

Figure 9 shows N1 and airspeed during the final approach (same time scale as Figure 7. At 446675 s to 446695 s the aircraft lost about 15 kts of airspeed and the engine speed was briefly advanced. The engine speed then led changes in airspeed (engine speed was reduced, airspeed dropped, engine speed was increased, airspeed increased) for about 40 s before the pitch oscillation began.

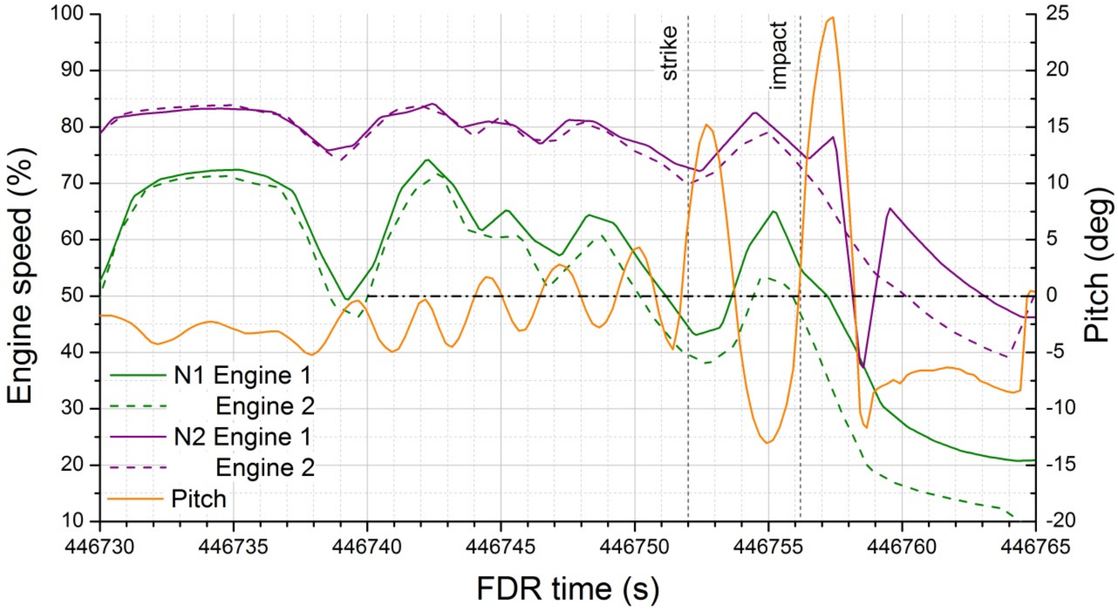


Figure 8. N1 and N2 speeds and pitch for the final seconds of flight and runway impact.

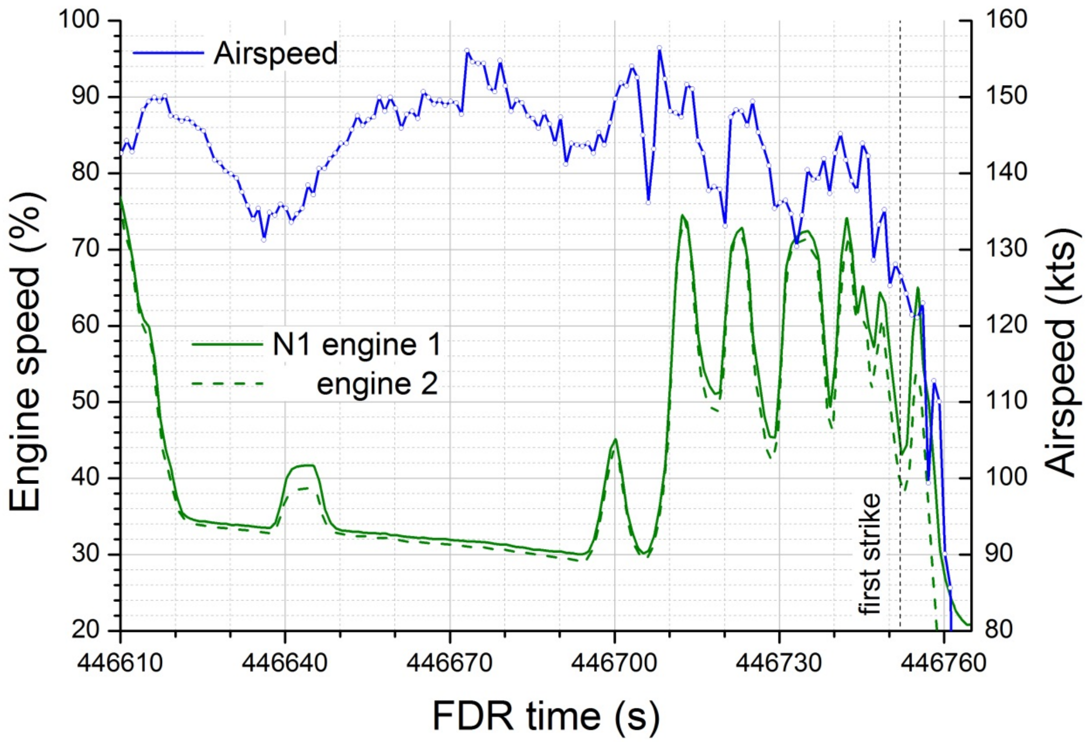


Figure 9. N1 speeds and recorded airspeed on final approach.

Figure 10 shows that flaps were at 45° during the approach and landing. Three seconds after the runway strike the ground spoilers deployed. After the 6 g impact, the flaps and spoilers moved out of position, possibly due to the force of the impact. The flap and spoiler positions were as expected for this aircraft during approach and landing. The FDR did not record elevator or aileron positions. Thrust reversers were not deployed.

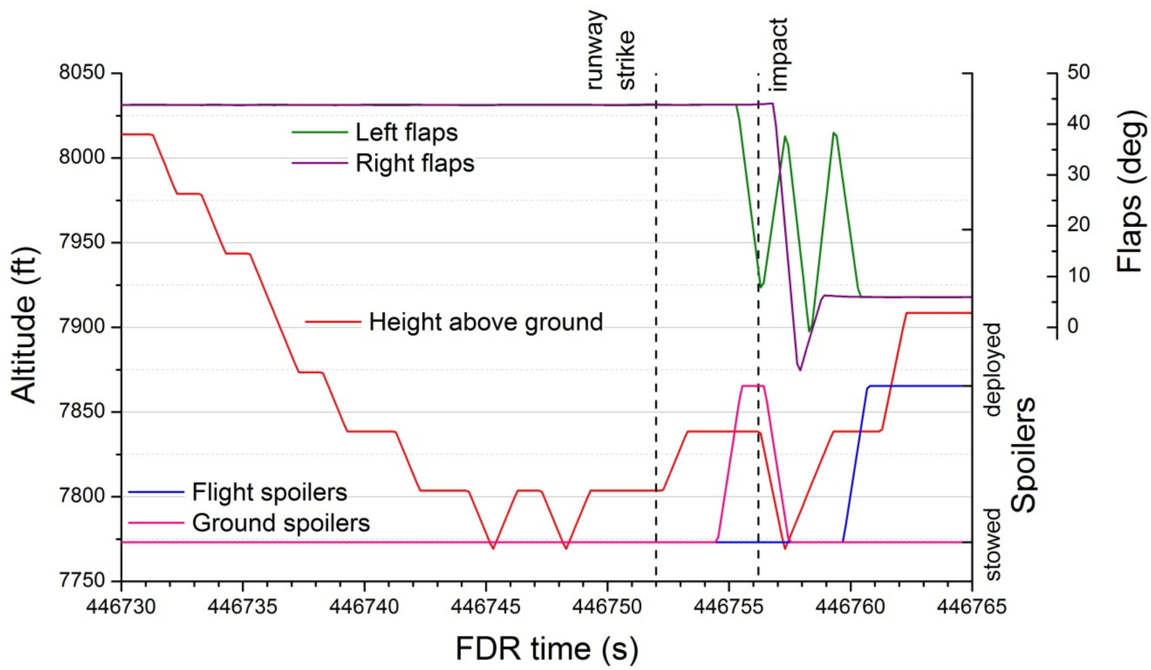


Figure 10. Aircraft altitude, flaps, and spoilers during approach and landing.

At 8,000 ft at -12°C, the take-off power setting for engine N1 is 90% [2]. N1 was at 70% at the beginning of the pitch oscillations and had been reduced to 45% when the aircraft first struck the runway. The aircraft's speed was about 145 kts when the pitch oscillations began and about 125 kts when it first struck the runway.

Go-around and Climb Gradient Calculations

KASE is a high-altitude terrain limited airport. The missed approach procedure is to execute a climbing right turn to 14,000 ft on 300°. The missed approach point is between 1.4 NM from the threshold to runway 15 (VHF Omni Directional Radio Range (VOR) approach) and 2.6 NM from the threshold (localizer (LOC) approach) (see APPENDIX for KASE approach plate). The accident aircraft had performed a missed approach before the accident landing.

It was requested to determine if the aircraft could have completed a go-around while over the runway and continued along the heading of runway 15 (151° magnetic, 160° true) and cleared the mountainous terrain beyond the airport. Figure 11 and Figure 12 show three selected points of high terrain beyond the end of runway 15.

Figure 11. Runway 15 at KASE and three points of high terrain: Aspen Mountain, the I-PKN localizer location, and Richmond Hill.

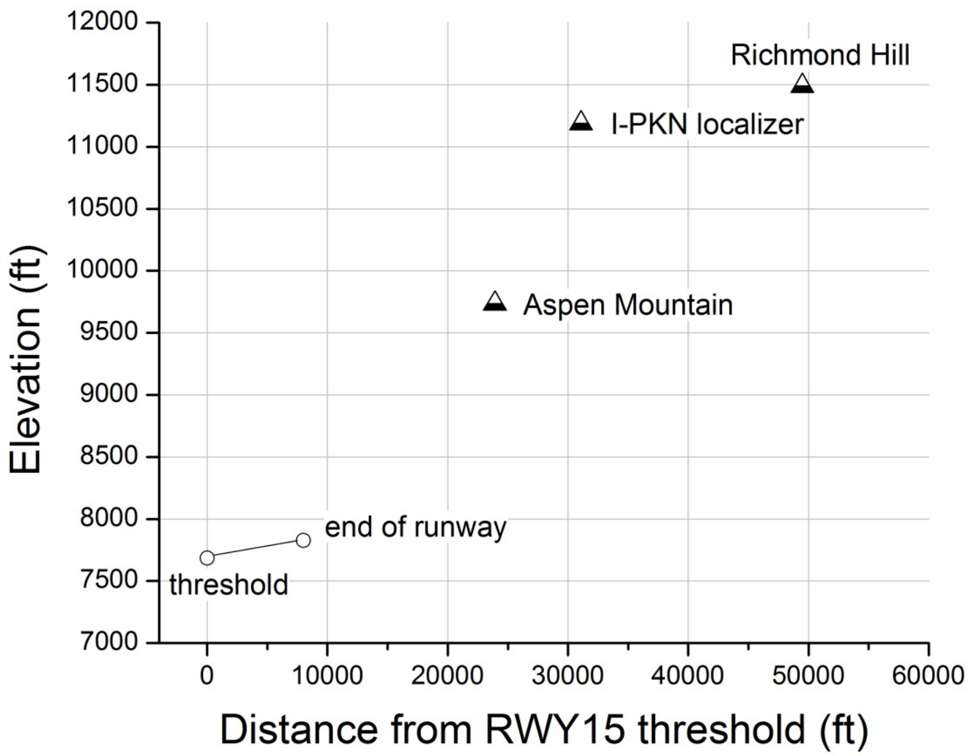


Figure 12. Elevation and distance from runway 15 at KASE for three points of high terrain: Aspen Mountain, the I-PKN localizer location, and Richmond Hill.

Figure 12 shows the elevation of these three points of terrain (Aspen Mountain, the location of the I-PKN localizer, and Richmond Hill) and the distance of each from the threshold of runway 15. Of the three, the location of the I-PKN localizer requires the steepest climb gradient from the runway threshold. To clear the I-PKN localizer, an aircraft has 31,000 ft (5.1 NM) of horizontal distance to climb 3,500 ft to an altitude above 11,188 ft.

Figure 13 shows the landing climb gradient for the approximate temperature, altitude, and weight of the accident aircraft [2]. This plot is for landing climb gradients with flaps 45 and landing gear down and applies to the first portion of flight. For cowl and wing anti-ice on, the landing climb gradient is about 10.5%. If the anti-ice is off, the climb gradient is about 15%. Cowl and wing anti-ice degrade the climb performance by 30%. This data assumes no wind component.

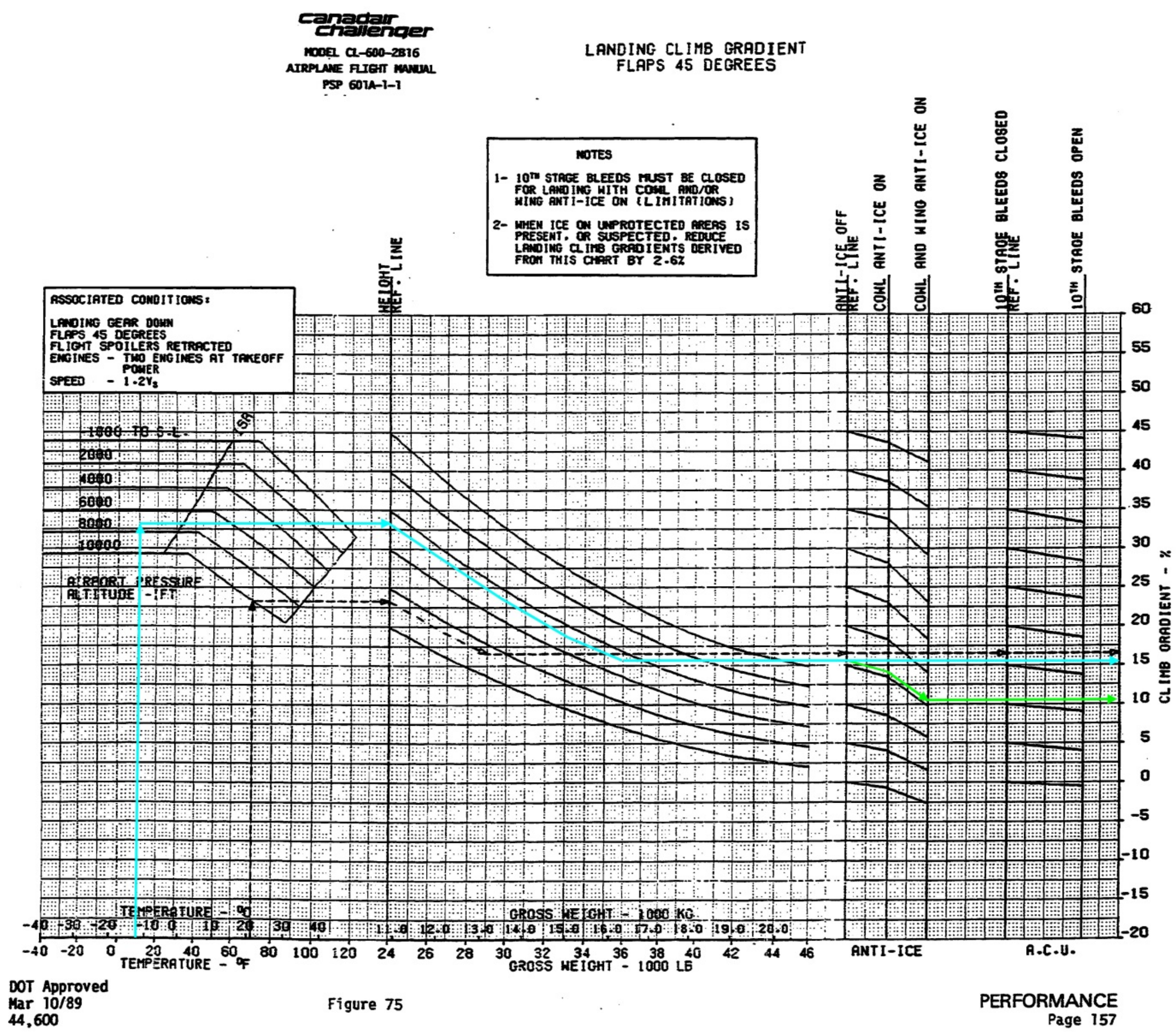


Figure 13. Landing climb gradient for -12°C, 7,600 ft, 36,000 lbs is approximately 10.5% for cowl and wind anti-ice on (green line) and 15% for anti-ice off (blue line).

The data from Figure 13 only applies to the earliest portion of a climb when the landing gear are still down and take-off flaps are used. The Aircraft Operating Manual [3] provided climb data from sea level to various altitudes for different take-off weights for international standard atmospheric conditions (ISA). The temperature on the day of the accident was colder than ISA, so climb performance would have been better than this data indicates, making the following evaluation conservative. Data provided were the altitude gain, time, ground distance, and fuel burn for conditions with both engines operating; no information was provided to indicate the change in climb performance with the anti-icing systems on. The solid green line in Figure 14 shows the altitude versus ground distance from the manual. The solid blue line shows a 30% degradation in altitude gain with cowl and wing anti-ice use, assuming a similar performance penalty as was found in the landing climb gradient chart. The average ground speed was determined from the provided data to be 311 kts. The dotted green and blue lines show the climb performance with an added worst case tailwind of 25 kts.

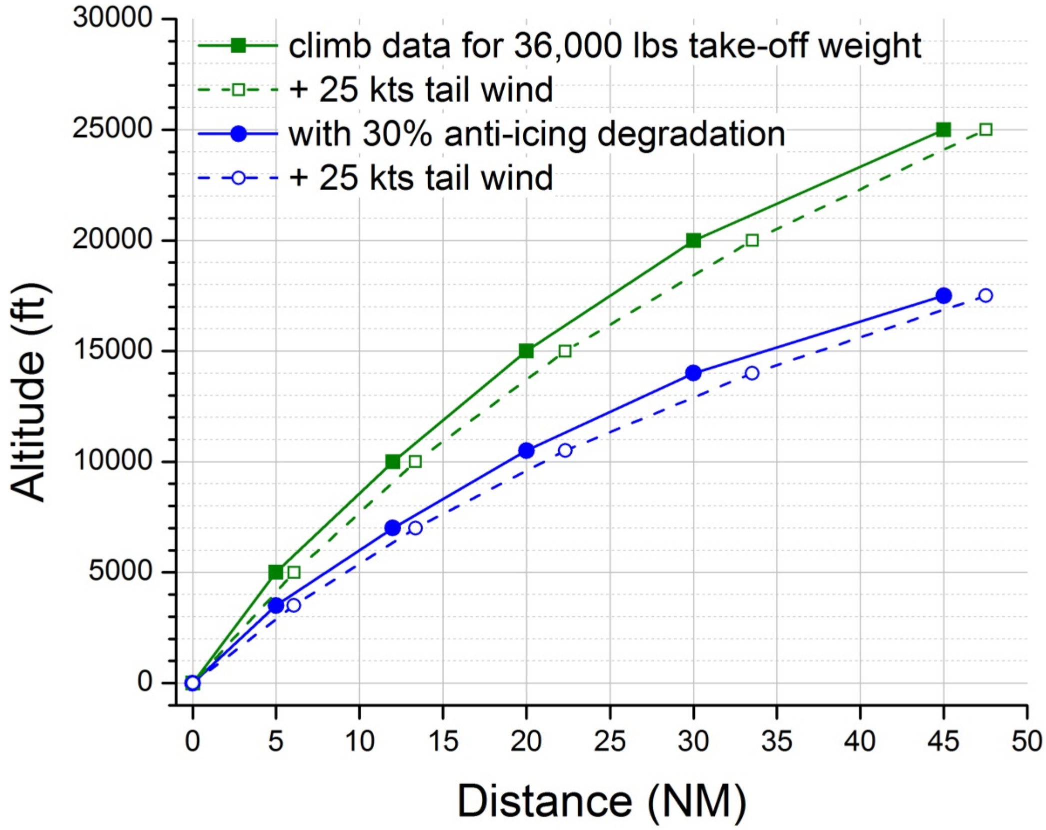


Figure 14. Climb data from sea level to various altitudes for 36,000 lbs take-off weight.

The field elevation at KASE was 7,837 ft. Shifting the plots from Figure 14 and adding in the obstacles to be cleared from Figure 12 yields Figure 15. Zero on the horizontal axis is the threshold to runway 15. If the anti-ice protection was not used during the climb, the aircraft should be able to clear both Aspen Mountain and Richmond Hill. Clearing the I-PKN localizer would require a more optimal climb performance and less than a 25 kts tailwind.

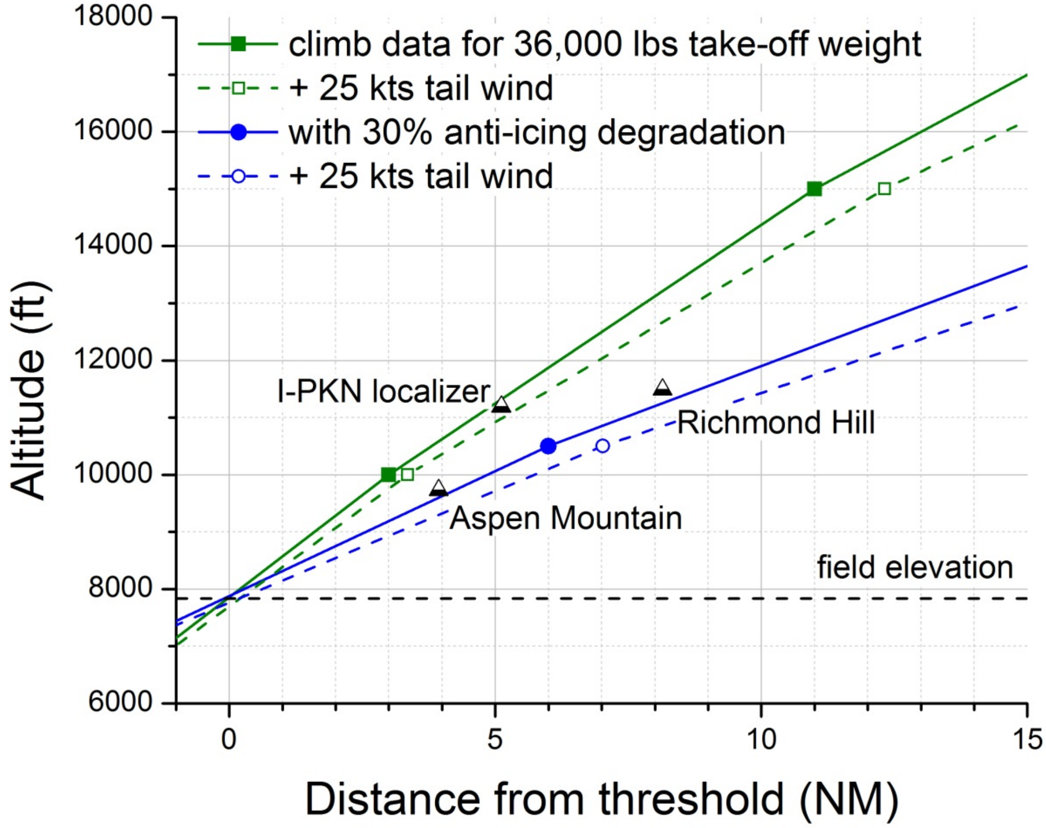


Figure 15. Climb data for 36,000 lbs take-off weight and terrain obstacles.

The climb performance data calculated in this report is likely conservative. The atmosphere was cooler, the winds were variable, and anti-ice protection may not have been used. Additionally, the weather (scattered clouds at 4,700 feet above ground level, and a broken ceiling at 6,000 feet) could have allowed the crew to maneuver around the worst case terrain obstacles (see Figure 11).

D. CONCLUSIONS

The initial part of the aircraft's approach into KASE was as expected for descent angle, flap setting, and spoilers. During the final minute of flight the engines were advanced and retarded five times between N1 speeds of 30% to 75% and the aircraft's airspeed varied between 135 kts and 150 kts. The aircraft stayed nose down (negative pitch) during its final descent and initial contact with the runway. The vertical acceleration and pitch parameters were consistent with the aircraft pitch oscillating above the runway for a number of seconds before a hard runway strike, a gain in altitude, and a final 6 g impact into the runway. The final portion of the approach into KASE was not consistent with a stabilized approach.

The weather at the time of the accident was near or in exceedance of the aircraft's maximum tailwind and crosswind component for landing. During the aircraft's pitch oscillation, its N1 speed was 15% to 45% lower than the specified take-off power for the airplane weight and atmospheric conditions.

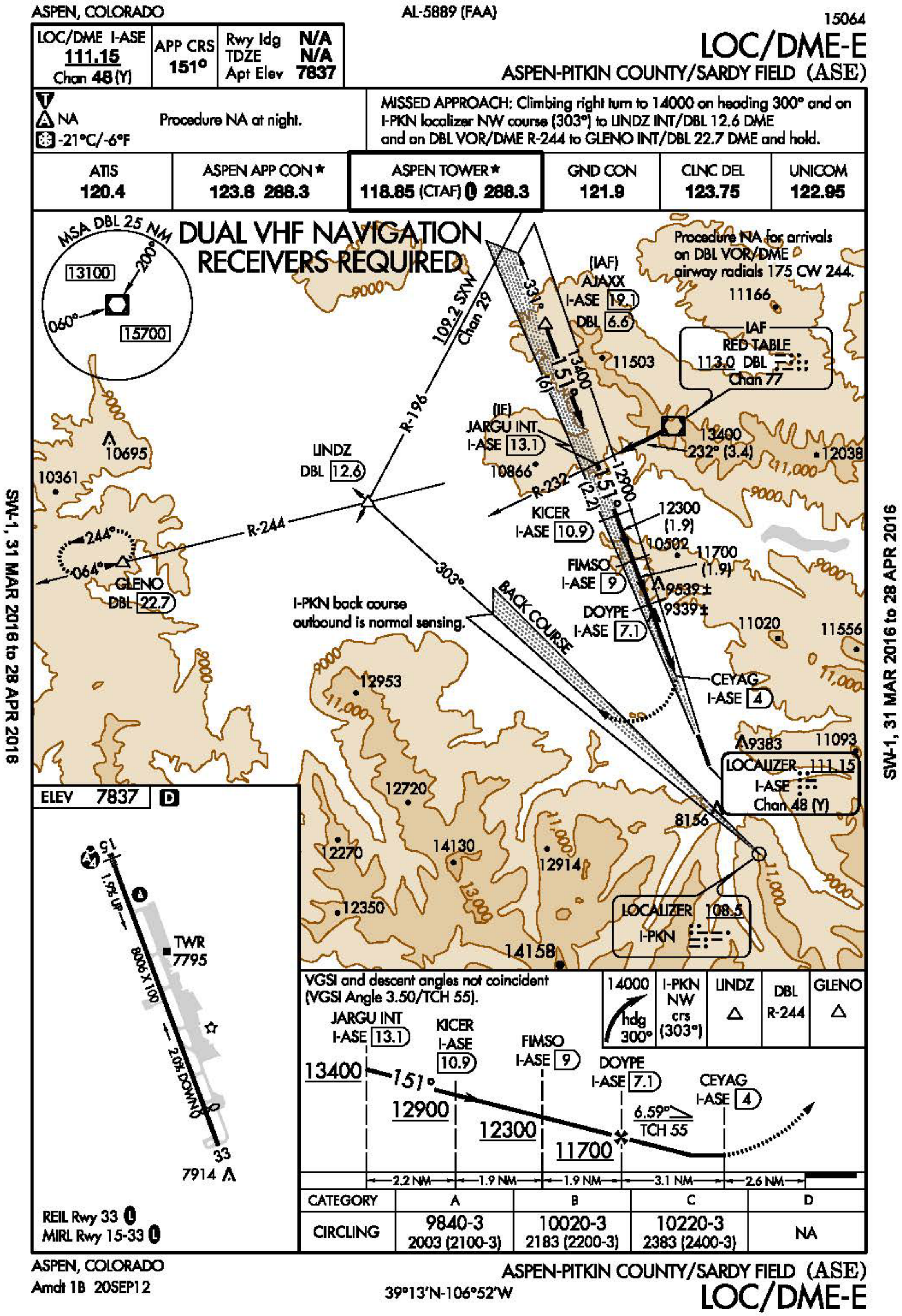
Assuming the crew had control of the aircraft, engines were advanced to the appropriate climb setting, anti-ice was off, and tailwinds were less than a sustained 25 kts, the aircraft could have continued along the runway heading and completed a go-around, clearing the local obstacles along that path.

Marie Moler
Specialist – Airplane Performance
National Transportation Safety Board

E. REFERENCES

1. http://www.airnav.com/airport/KASE
2. Bombardier Challenger 300 Airplane Flight Manual, Revision 6, Approved July 31, 2006.
3. Bombardier Challenger 300 Operating Manual, May 28th, 1982.

F. APPENDIX


ASPEN, COLORADO
AL-5889 (FAA)
15064
LOC/DME I-ASE
111.15
Chan 48 (Y)
APP CRS
151°
Rwy ldg N/A
TDZE N/A
Apt Elev 7837
LOC/DME-E
ASPEN-PITKIN COUNTY/SARDY FIELD (ASE)
A NA
-21°C/-6°F
Procedure NA at night.
MISSED APPROACH: Climbing right turn to 14000 on heading 300° and on I-PKN localizer NW course (303°) to LINDZ INT/DBL 12.6 DME and on DBL VOR/DME R-244 to GLENO INT/DBL 22.7 DME and hold.
ATIS 120.4
ASPEN APP CON★ 123.8 288.3
ASPEN TOWER★ 118.85 (CTAF) 288.3
GND CON 121.9
CLNC DEL 123.75
UNICOM 122.95
MSA DBL 25 NM
DUAL VHF NAVIGATION RECEIVERS REQUIRED
Procedure NA for arrivals on DBL VOR/DME airway radials 175 CW 244.
(IAF) AJAXX I-ASE 19.1 DBL 6.6
IAF RED TABLE 113.0 DBL Chan 77
109.2 SXW Chan 29
(IF) JARGU INT I-ASE 13.1
LINDZ DBL 12.6
KICER I-ASE 10.9
FIMSO I-ASE 9
DOYPE I-ASE 7.1
CEYAG I-ASE 4
GLENO DBL 22.7
I-PKN back course outbound is normal sensing.
BACK COURSE
LOCALIZER 111.15 I-ASE Chan 48 (Y)
LOCALIZER 108.5 I-PKN
ELEV 7837
TWR 7795
8006 X 100
7914
REIL Rwy 33
MIRL Rwy 15-33
VGSI and descent angles not coincident (VGSI Angle 3.50/TCH 55).
14000 hdg 300°
I-PKN NW crs (303°)
LINDZ
DBL R-244
GLENO
6.59°
TCH 55
2.2 NM 1.9 NM 1.9 NM 3.1 NM 2.6 NM
CATEGORY A B C D
CIRCLING 9840-3 2003 (2100-3) 10020-3 2183 (2200-3) 10220-3 2383 (2400-3) NA
ASPEN, COLORADO
Amdt 1B 20SEP12
39°13'N-106°52'W
ASPEN-PITKIN COUNTY/SARDY FIELD (ASE)
LOC/DME-E
SW-1, 31 MAR 2016 to 28 APR 2016