Transportation Safety Board of Canada
Bureau de la sécurité des transports du Canada

AIR TRANSPORTATION SAFETY INVESTIGATION REPORT A22C0093

AFT FUSELAGE STRIKE ON LANDING

Perimeter Aviation LP
de Havilland DHC-8-314, C-GJYZ
Sandy Lake Airport, Ontario
19 October 2022

Canada

ABOUT THIS INVESTIGATION REPORT

This report is the result of an investigation into a class 3 occurrence. For more information, see the Policy on Occurrence Classification at www.tsb.gc.ca

The Transportation Safety Board of Canada (TSB) investigated this occurrence for the purpose of advancing transportation safety. It is not the function of the Board to assign fault or determine civil or criminal liability.

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Summary

On 19 October 2022 at 2130 Central Daylight Time, the Perimeter Aviation LP de Havilland DHC-8-314 (registration C-GJYZ, serial number 368) aircraft departed Pikangikum Airport, Ontario, on an instrument flight rules flight to Sandy Lake Airport, Ontario, with 3 crew members and 28 passengers on board.

At 2158 Central Daylight Time, during the nighttime landing on Runway 29, the aircraft's main landing gear made contact with the runway approximately 350 feet past the runway threshold. The aircraft bounced and briefly became airborne again as the first officer, who was the pilot flying, attempted to continue the landing. He pitched the aircraft up in an attempt to soften the ensuing touchdown. After the aircraft touched down firmly for a 2nd time, he indicated that he would go-around and began increasing the throttles. The captain, who was the pilot monitoring, noticed that an aft fuselage strike had occurred and took control of the aircraft, bringing the throttles to idle. He completed the landing roll with approximately 1600 feet of runway remaining and proceeded to taxi normally to the apron.

There were no confirmed injuries. There was significant damage to the lower aft fuselage structure of the aircraft.

1.0 FACTUAL INFORMATION

1.1 History of the flight

On 18 October 2022, the occurrence flight crew was notified by the Systems Operations Control Centre (SOCC) at Perimeter Aviation LP (Perimeter Aviation) that they would be conducting flight 663/664,[1] from Pikangikum Airport (CYPM), Ontario, to Sandy Lake Airport (CZSJ), Ontario, the following day. The captain had initially been assigned to a different flight but was reassigned to this one after changes had been made to his schedule. The first officer (FO), on the other hand, had originally been scheduled for flight 663/664.

On 19 October, flight 664 on the de Havilland DHC-8-314 had been scheduled to depart CYPM at 1830[2] and arrive at CZSJ at 1900. However, owing to a ground delay, the aircraft departed CYPM at 2130, during the hours of darkness.

On board were 28 passengers, 2 pilots, and 1 flight attendant. The captain designated himself to perform the duties of pilot monitoring (PM) and the FO to perform those of pilot flying (PF).

While the aircraft was in cruise at 7000 feet above sea level (ASL) en route to CZSJ, the flight crew conducted an approach briefing. The PF planned a visual approach into CZSJ on Runway 29 with satellite-based vertical navigation guidance, and the PM subsequently programmed the localizer performance with vertical guidance (LPV) approach for Runway 29 into the flight management system (FMS). The pilots then discussed the use of the abbreviated precision approach path indicator (APAPI). Both were aware that with the APAPI's guidance, the aircraft would touch down within the first 1000 feet of the runway, and, in accordance with Perimeter Aviation's *Dash 8 Standard Operating Procedures* (SOP),[3] they took this into consideration given that they would be conducting a short-field landing at CZSJ. After consulting the landing performance charts for the aircraft's weight, the pilots determined the landing reference speed (V_{ref}) to be 105 knots and set their speed bugs.[4] At 2141, the pilots received the latest automated weather report for CZSJ, indicating visual weather conditions and light winds from the northwest.

At 2150, the captain and FO observed an "LPV APPR INHIBITED" message displayed on the aircraft's FMS, indicating a fault. As a result, the aircraft's LPV approach capabilities were inhibited for the remainder of the flight. Shortly afterwards, the PF initiated a visual descent for CZSJ.

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1 Perimeter Aviation flight 663/664 is a multi-leg flight that services multiple destinations between Winnipeg, Manitoba, and Northwestern Ontario. The route from Pikangikum Airport, Ontario to Sandy Lake Airport, Ontario constituted 1 leg of flight 664.

2 All times are Central Daylight Time (Coordinated Universal Time minus 5 hours).

3 Perimeter Aviation LP, *Dash 8 Standard Operating Procedures (SOP)* (01 August 2021), Section 2.8.4: Short Field Landing, p. 150 (see section 1.10.1 *General information* of this report).

4 Speed bugs are a set of small, movable markers on the airspeed indicator that serve as a visual reminder for pilots of important take-off and landing speeds.

At 10 nautical miles (NM), during the turn onto the final approach course, the PF levelled the aircraft at 4000 feet ASL. After confirming with the PF that he was comfortable with continuing the flight visually, the PM directed the PF to continue the visual descent. The PF proceeded to disconnect the autopilot and fly the aircraft manually for the remainder of the flight.

When the aircraft was 5 NM on final for Runway 29 at 3200 feet ASL (2254 feet above ground level [AGL]), the PM determined that the approach and landing were feasible, even though the aircraft was flying over 500 feet above the 3.29° APAPI approach slope.[5]

At 2157, the aircraft was 3 NM from the threshold, and it descended through 2300 feet ASL (1354 feet AGL) at a speed of 120 knots indicated airspeed (KIAS) and a rate of descent of 1000 fpm. At this time, the flaps were set to 15°, the landing gear was extended, the power levers were set at 15% torque, and the propellers were set to a speed of 1200 rpm. The aircraft was still approximately 300 feet above the 3.29° APAPI approach slope.

Approximately 1 minute later, the aircraft reached 500 feet AGL at 1.2 NM from the threshold, with a rate of descent of 900 fpm, a speed of 109 KIAS, and 10% engine torque. The PM announced that the approach was stabilized and advised the PF to maintain the descent profile. Simultaneously, the PF reduced the rate of descent to 500 fpm and increased engine torque. The PM mentioned the APAPI lights again and informed the PF that an adjustment needed to be made to maintain the correct approach path.

At 2158:35, the aircraft remained above the APAPI approach slope, and the PF reduced the engine torque to approximately 10% at 0.63 NM from the runway threshold. The indicated airspeed remained relatively constant between 109 and 112 KIAS.

The aircraft then descended onto the APAPI approach slope, and the PF increased the torque from 10% to approximately 57% and decreased the descent rate to approximately 160 fpm. When the aircraft was 0.2 NM from the threshold, the PF reduced the power lever settings to flight idle, which resulted in approximately 0% torque, and decreased the aircraft pitch angle by 2°. Immediately thereafter, during the flare, the PF made a pronounced pitch-up control input (3 seconds before the aft fuselage's impact with the runway), increasing the pitch angle in the flare. At the same time, the torque began to gradually increase from flight idle.

At 2158:58.6, the aircraft's main landing gear touched down on the runway 350 feet past the threshold at a descent rate of 950 fpm, and the pitch angle increased rapidly through 5.8°. A fraction of a second later, as the main landing gear oleos compressed, the maximum recorded vertical acceleration was 3.61 *g*. The aircraft's pitch angle reached 7.24° while the pilot increased the torque to 10%. At this time, the aircraft's aft fuselage struck the surface of the runway.

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5 Refer to Section 1.10.2 *Aerodrome abbreviated precision approach path indicators* of this report for an explanation of abbreviated precision approach path indicator (APAPI) and guidance slope.

At 2158:59.7, the aircraft bounced to a height of approximately 1.5 feet, and the PF rapidly decreased the pitch angle to 2.2°.

Seconds later, while the aircraft touched down again and the weight-on-wheels light illuminated, the PM noticed that the “TOUCHED RUNWAY” indicator had also illuminated. Moments later, the PF called for a go-around and increased the throttles. The captain, having noticed that an aft fuselage strike had occurred, rejected the go-around and took control of the aircraft.

At 2159:17, the aircraft completed the landing roll at approximately 1900 feet from the arrival threshold, with approximately 1600 feet of runway remaining. It subsequently taxied normally to the apron.

In accordance with the aft fuselage strike checklist, the flight crew performed an external inspection of the aircraft and contacted Perimeter Aviation’s maintenance department.

1.2 Injuries to persons

There were no confirmed injuries to any of the 28 passengers on board. None of the 3 crew members were injured.

1.3 Damage to aircraft

The aircraft sustained substantial damage to the lower aft fuselage structure.

1.4 Other damage

There was no other damage.

1.5 Personnel information

Table 1. Personnel information

	Captain	First officer
Pilot licence	Airline transport pilot licence – aeroplane	Commercial pilot licence – aeroplane
Medical expiry date	01 October 2023	01 August 2023
Total flying hours	7721	2368
Flight hours on DHC-8-100 series	294	55.1
Flight hours on DHC-8-300 series	2940	49.9
Total pilot-in-command hours (single-engine aircraft)	213	2028
Pilot-in-command hours on type (both 100 and 300 series)	13.7	0
Second-in-command hours on type (both 100 and 300 series)	3220	92.3
Flight hours in the 7 days before the occurrence	25.5	19.5
Flight hours in the 30 days before the occurrence	90	94
Flight hours in the 90 days before the occurrence	214.5	105

1.5.1 Captain

The captain was hired by Perimeter Aviation in June 2022 as an FO on the DHC-8-100 series and DHC-8-300 series aircraft. Before joining Perimeter Aviation, he worked for an air operator in Barbados, where he accumulated approximately 3000 hours flight time as an FO on DHC-8-100 and -300 series aircraft. He held a valid Category 1 medical certificate with no restrictions.

He successfully completed his initial Perimeter Aviation DHC-8 aircraft training on 16 July 2022 and his DHC-8-100/DHC-8-300 pilot proficiency check (PPC) on 17 July 2022. He completed 69 hours of FO line indoctrination training and was then upgraded to captain. He then conducted 126.5 hours of captain line indoctrination training, bringing his total line indoctrination training time to 195.5 hours, where 20 hours are required.[6] He completed his DHC-8 captain line check on 14 October 2022. Before joining Perimeter Aviation, the captain had no experience flying in northern Canada.

On the day of the occurrence, 19 October 2022, the captain was on his 2nd flight day after his line check and had accumulated 13.7 hours as a DHC-8 pilot-in-command (PIC) during the 2 flight days leading up to the occurrence.

Records indicate that the captain held the appropriate licence and ratings for the flight in accordance with existing regulations. Based on a review of the captain's work and rest schedules, he had a 39-hour rest period between flight duty periods. There was no indication that the captain's performance was degraded by fatigue.

1.5.2 First officer

The FO was hired by Perimeter Aviation in July 2022. Before joining the company, he worked for an air operator with which he had accumulated approximately 2200 hours on a Cessna 172 aircraft. The FO held a valid Category 1 medical certificate with no restrictions and obtained his instrument rating in May 2022. His position at Perimeter Aviation was his first commercial flight position in a 2-flight crew environment, and his first experience flying in northern Canada.

The FO completed the FO initial DHC-8 flight training on 14 September 2022. The next day, he successfully completed his DHC-8-100/DHC-8-300 PPC. He conducted 73.9 hours of line indoctrination and completed his DHC-8 FO line check on 13 October 2022.

The day of the occurrence, 19 October 2022, marked the FO's 3rd flight day since his line check. He had accumulated 18.4 hours during the 3 flight days leading up to the time of the occurrence.

The FO held the appropriate licence and ratings for the flight in accordance with existing regulations. A review of his work and rest schedules revealed that he had a 15-hour rest

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6 Transport Canada, SOR/96-433, *Canadian Aviation Regulations, Commercial Air Service Standards*, Standard 725: Airline Operations – Aeroplanes, subclause 725.124(33)(d)(iv)(B)(I).

period between duty periods. There was no indication that the FO's performance was degraded by fatigue.

1.6 Aircraft information

The DHC-8-314 aircraft is a pressurized, high-wing, twin-engine turboprop aircraft that has retractable landing gear. The occurrence aircraft is certified for a minimum flight crew of 2 pilots, and has a passenger/cargo configuration that can carry up to 45 passengers, with a minimum of 1 cabin crew member. It is commercially registered to Perimeter Aviation and was manufactured by de Havilland Inc. (currently De Havilland Aircraft of Canada Limited), in 1993.

A review of the aircraft's journey and technical records did not reveal any outstanding defects that may have contributed to the occurrence.

Table 2. Aircraft information

Manufacturer	de Havilland Inc.
Type, model, and registration	DHC-8-314, C-GJYZ
Year of manufacture	1993
Serial number	368
Certificate of airworthiness/flight permit issue date	05 October 2012
Total airframe time	57 349 hours
Engine type (number of engines)	Pratt and Whitney Canada PW123B (2)
Propeller/Rotor type (number of propellers)	Hamilton Standard, M/N – 14SF-23 (2)
Maximum allowable take-off weight	43 000 pounds
Recommended fuel type(s)	Jet A, Jet A-1, Jet B, JP-4, JP-5, JP-8
Fuel type used	Jet A

1.6.1 "TOUCHED RUNWAY" warning light

The "TOUCHED RUNWAY" warning light located on the annunciator panel informs the flight crew of contact made by the lower aft fuselage structure with the runway. The system consists of a frangible tail strike switch mounted on the lower aft section of the fuselage that illuminates a red warning light on the overhead annunciator panel in the cockpit. The switch can not be reset and must be replaced after it has been activated. Illumination of the "TOUCHED RUNWAY" warning light requires an inspection of the aircraft by qualified maintenance personnel before further flight.[7]

1.6.2 Hard landing inspection

Section 05-50-11 of the aircraft maintenance manual for the DHC-8-311, DHC-8-314, and DHC-8-315 specifies required inspection procedures to be carried out after the aircraft has

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7 De Havilland Inc. (Bombardier Inc.), *Dash 8 Series 300 Model 311/314/315 Operating Data*, Revision 33 (05 December 2014), Section 22.40, p. 7.

been subject to a hard landing and before the aircraft can be returned to service.[8] Hard landings are recorded by the flight data recorder (FDR) and are expressed in terms of vertical acceleration (N_Z). Inspections are categorized as level 1 or level 2 based on the aircraft landing weight.

For aircraft with a landing weight of less than 42 000 pounds:

- a level 1 inspection is required with an N_Z of 2.20 to 2.49 *g*; and
- a level 2 inspection is required with an N_Z of 2.50 *g* or greater.

For aircraft with a landing weight of 42 000 to 43 000 pounds:

- a level 1 inspection is required with an N_Z of 1.40 to 1.69 *g*; and
- a level 2 inspection is required with an N_Z of 1.70 *g* or greater.

Following the occurrence, during which the occurrence aircraft made initial contact with the runway with an N_Z of 3.61 *g*, both a level 1 and a level 2 inspection were performed.

1.7 Meteorological information

Weather conditions at CZSJ were favourable for a visual approach at the time of the occurrence. The aerodrome routine meteorological report (METAR) issued at 2200 on 19 October 2022 for CZSJ was as follows:

- Winds from 320° true at 4 knots
- Visibility of 9 statute miles
- Sky clear
- Temperature −1 °C, dew point −3 °C
- Altimeter setting 29.85 inches of mercury

Weather was not considered to be a factor in this occurrence.

1.8 Aids to navigation

Not applicable.

1.9 Communications

Not applicable.

1.10 Aerodrome information

1.10.1 General information

CZSJ is a certified aerodrome located in the community of Sandy Lake First Nation in northern Ontario. The airport has 1 runway, Runway 11/29, that runs east-west, has a

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8 De Havilland Inc., *De Havilland Dash 8 Series 300 Aircraft Maintenance Manual*, (Revised 15 July 2021), Section 05-50-11: Hard Landing Inspection, p. 1.

gravel surface, and is 3507 feet long and 100 feet wide. At the time of the occurrence, 2 area navigation (RNAV) approaches, 1 for Runway 11 and the other for Runway 29, were available. The Runway 29 touch down zone elevation is 946 feet ASL.

According to Perimeter Aviation's SOPs, the runway at CZSJ is considered to be a short runway on which a short-field landing technique is required to ensure that the aircraft crosses the threshold at approximately 30 feet AGL, and touches down within the first 500 feet of the runway.[9]

1.10.2 Aerodrome abbreviated precision approach path indicators

Runway 29 at CZSJ is equipped with a precision approach path indicator (PAPI). These indicators are used as visual guidance for the approach slope when pilots are flying a visual approach at night. The *Canada Flight Supplement* defines 4 different classes of PAPI, based on eye-to-wheel height[10] of the aircraft: P1, P2, P3, and AP.[11] The AP designator appears in the Lighting section of the *Canada Flight Supplement* entry for CZSJ, and indicates that Runway 29 has an abbreviated PAPI (APAPI).

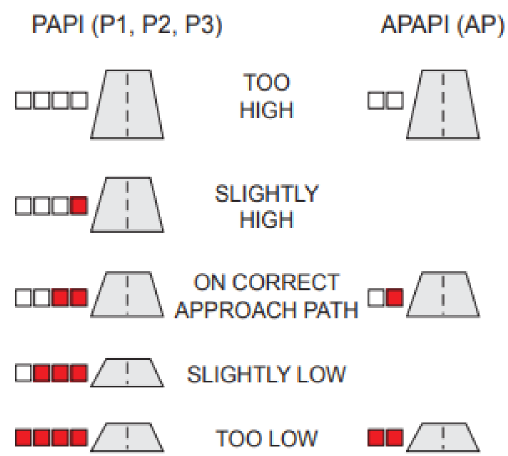
APAPIs consist of 2 light units located on the left side of the runway in the form of a wing bar (Figure 1). When an aircraft is:

(a) above the approach slope, both units show white.

(b) on or close to the approach slope, the unit nearer to the runway edge shows red and the unit farther from the runway edge shows white.

(c) below the approach slope, all units show red.[12]

Figure 1. Precision approach path indicator and abbreviated precision approach path indicator display (Source: Transport Canada, TP 14371E, *Transport Canada Aeronautical Information Manual* [TC AIM], AGA—Aerodrome [06 October 2022], Figure 7-7, p. 68.)



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9 Perimeter Aviation LP, *Dash 8 Standard Operating Procedures (SOP)* (01 August 2021), Section 2.8.4: Short Field Landing, p. 150.

10 Eye-to-wheel height is "the vertical distance in-flight of the eye path to the wheel path […] and is determined by the approach slope angle and the pitch angle for the maximum certified landing weight at VREF." (Source: Transport Canada, TP 14371E, *Transport Canada Aeronautical Information Manual* [TC AIM], AGA—Aerodromes [06 October 2022], Section 7.6.4.1, p. 68.)

11 NAV CANADA, *Canada Flight Supplement* (effective 20 April 2023 to 15 June 2023), General, p. A85.

12 Transport Canada, TP 14371E, *Transport Canada Aeronautical Information Manual* (TC AIM), AGA—Aerodromes (06 October 2022), Section 7.6.3, p. 68.

The geometry of the APAPI at CZSJ was inspected on 17 October 2022. The "centre" of the vertical approach guidance was found to be at a 3.29° slope to the runway, compared to the nominal vertical approach guidance of 3.00°. Therefore, if the aircraft was directly on the "centre" of the slope, it would have been on a 3.29° glidepath. The touchdown aiming point based on the 3.29° glidepath is approximately 330 feet from the threshold.

1.11 Flight recorders

The occurrence aircraft was equipped with a cockpit voice recorder (CVR) capable of recording 120 minutes of audio and an FDR that recorded various parameters, including the weight-on-wheels indication, the "TOUCHED RUNWAY" light indication, and vertical acceleration (N_Z) data. The aircraft was also equipped with an FMS computer that provided centralized control for the aircraft's navigation sensors, computer-based flight planning, and fuel management.

The CVR and FDR were removed from the aircraft and forwarded to the TSB Engineering Laboratory in Ottawa, Ontario, for data download. The CVR provided an audio recording of the communication between the captain and FO before and during the occurrence. The data that revealed a vertical deceleration (N_Z) of 3.61 *g* on initial contact with the runway were obtained from the FDR, as were other parameters for the occurrence flight (Appendix A).

1.11.1 Flight management system

The FMS computer data were downloaded in the aircraft, and a review revealed an "LPV2 APPR INHIBITED" message within the data on both FMS units. Two faults, "Antenna Offset Config Not Confirmed" and "Loss of Guidance Function," were recorded during the start-up built-in test and caused the approach to be inhibited. According to the FMS' internal non-volatile memory, one of the FMS units triggered the faults when there was a power failure, and this caused the LPV to be inhibited. Approximately 1 second after the power loss, the GPS (global positioning system) reinitialized and was working normally again. However, given that the faults were flagged during the built-in test, the LPV remained inhibited for the entire flight, despite the fact that the GPS performed as designed.

1.12 Wreckage and impact information

The first marks made by the occurrence aircraft's main landing gear when it touched down on Runway 29 at CZSJ were approximately 350 feet from the runway threshold. The aft fuselage struck the runway immediately afterward (Figure 2).

Figure 2. Impact mark made by aircraft's fuselage showing the touchdown point on Runway 29 (Source: Sandy Lake Airport)

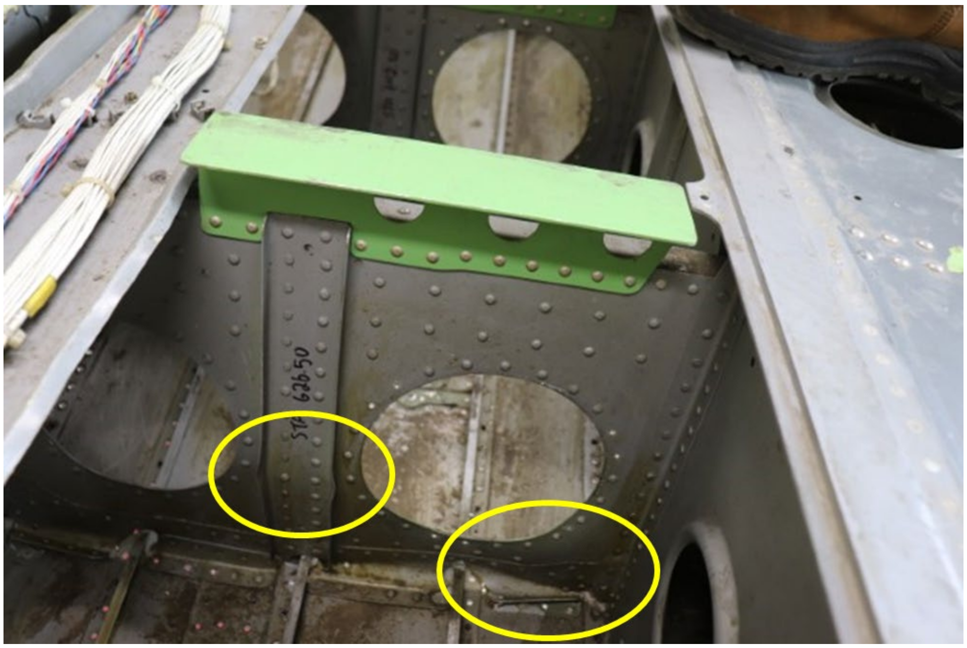
The aircraft sustained substantial damage to the lower aft fuselage structure, which consisted of the deformation of bulkheads and scarred belly skins (Figure 3). In addition, the tail strike switch broke off during the impact.

Figure 3. Exterior view of the occurrence aircraft's rear fuselage, showing the missing tail strike switch (Source: TSB)

The aircraft was inspected on site by company maintenance personnel in consultation with the aircraft manufacturer. The aircraft was then flown back to the operator's maintenance facility under the authority of a company-issued flight permit for repairs.

The aircraft underwent a hard landing inspection (level 1 and level 2), resulting in the replacement of all main landing gear load-absorbing components. An inspection of the engines, engine mounts, and nacelles did not reveal any anomalies. The aircraft also sustained interior structural damage. There was buckling of the structural members in the area that impacted the runway (Figure 4).

Figure 4. Interior structural damage (buckling of structural members) beneath the floorboards and above the missing tail strike switch (Source: TSB)



1.13 Medical and pathological information

According to information gathered during the investigation, there was no indication that the flight crew's performance was affected by medical or physiological factors.

1.14 Fire

Not applicable.

1.15 Survival aspects

Not applicable.

1.16 Tests and research

1.16.1 TSB laboratory reports

The TSB completed the following laboratory reports in support of this investigation:

- LP100/2022 – NVM Recovery - FMS
- LP097/2022 – CVR Data Recovery
- LP096/2022 – FDR Performance Analysis

1.17 Organizational and management information

1.17.1 Air operator

Perimeter Aviation is a regional air operator providing scheduled, charter, and air ambulance services under *Canadian Aviation Regulations* (CARs) subparts 703 (Air Taxi Operations), 704 (Commuter Operations), and 705 (Airline Operations) for many remote communities in Manitoba and northwestern Ontario. Perimeter Aviation's headquarters is located in Winnipeg, Manitoba.

At the time of the occurrence, Perimeter Aviation operated 6 de Havilland DHC-8-100 aircraft and 6 de Havilland DHC-8-300 aircraft under CARs Subpart 705.

1.17.1.1 DHC-8 line pilots

At the time of the occurrence, Perimeter Aviation had a budgeted roster for 40 captains and 44 FOs for DHC-8 operations, and approximately 75% of this budgeted roster had been staffed.

Between 01 October 2021 and 01 October 2022, there was a significant turnover of company DHC-8 pilots; 34 DHC-8 pilots left the company, of which 13 were captains and 21 were FOs. During the same period, the company hired 18 new DHC-8 pilots, including the occurrence pilots.

1.17.1.2 Flight crew scheduling and pairings

The Perimeter Aviation company operations manual (COM) has a section regarding crew pairing restriction and minimum experience, which states:

> In accordance with Commercial Air Service Standard [CASS] 725.108 crew pairing restrictions establish minimum experience requirements for a flight crew. Crew pairing restrictions apply when any of the following situations apply to either the pilot-in-command or the second-in-command when employed by Perimeter Aviation LP:
>
> - initial appointment to pilot-in-command or second-in-command;
> - the first upgrade from second-in-command to pilot-in-command on any aeroplane type except the same aeroplane type;
>
> […] When crew pairing restrictions apply, they come into effect after completion of the Pilot Proficiency Check in the new position or new type, and remain in effect until the completion of the consolidation period for this flight crew member.
>
> […] Hours applying to crew pairing restrictions are valid for line indoctrination and the consolidation period referred to in CASS 725.106.[13]

13 Perimeter Aviation LP, *Company Operations Manual (COM) Policies and Procedures*, Rev. 17 (30 March 2022), Section 8.3.2: Crew Pairing Restrictions and Minimum Experience (705), pp. 162-163.

In line with the *Commercial Air Services Standards*,[14] the Perimeter Aviation COM further states the following regarding the consolidation period:

> The consolidation period is the time frame within which a pilot must gain initial operating experience on the aircraft to which he/she has successfully completed an initial PPC. This period is intended to reinforce and enhance retention of the initial training received by the pilot.
>
> […] The consolidation period shall take place in accordance with the time limits from the following sliding scale:
>
> - 50 hours in 60 days;
> - 75 hours in 90 days; or,
> - 100 hours in 120 days.[15]

Both pilots of this occurrence had completed the consolidation period by flying more than 50 hours in the 60 days following their PPCs, during their line indoctrination periods. Even though the captain was on his 2nd flight day and the FO was on his 3rd since their line checks, the crew pairing for the occurrence flight conformed to Perimeter Aviation and regulatory requirements.

Perimeter Aviation's daily operations are managed by the SOCC Duty Manager. The person in this role is delegated by the Operations Manager and is "responsible for the efficient implementation and communication of the daily scheduled and charter operational plan by directing the available resources."[16]

Perimeter Aviation's management approves the monthly pilot schedule and did not initially pair the occurrence pilots together because there was an informal practice of not scheduling pilots with limited experience in their roles on the same flight. While the 2 pilots had completed all the requirements to conduct the flight, both of them had limited experience in their roles: the captain was on his 2nd day in that role and the FO was on his 3rd day. However, the company's SOCC paired the occurrence pilots during a daily reschedule.[17] The investigation determined that Perimeter Aviation's SOCC daily rescheduling did not have a process in place to avoid assigning 2 pilots with limited experience in their roles to the same flight.

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14 Transport Canada, SOR/96-433, *Canadian Aviation Regulations*, *Commercial Air Services Standards*, Standard 725: Airline Operations – Aeroplanes, subsection 725.106(7).

15 Perimeter Aviation LP, *Company Operations Manual (COM) Policies and Procedures*, Rev. 17 (30 March 2022), Section 8.4.13: Consolidation Period (705), p. 168.

16 Ibid., Section 3.2.8: SOCC Duty Manager, p. 48.

17 This is a routine action, given that the air operator may need to perform daily rescheduling when pilots' availability is impacted and they are consequently no longer able to carry out a flight for which they had initially been scheduled.

1.17.2 Stabilized approach training and policies

Although not required by the CARs, training and awareness of the factors that contribute to a stabilized approach is a recommended air operator action in accordance with Transport Canada's Civil Aviation Safety Alert (CASA) 2014-03.[18]

A review of pilot training files and Perimeter Aviation's flight crew training manual[19] determined that stabilized approach factors are not incorporated into Perimeter Aviation's initial or recurrent training fleet-wide. This is not to be confused with Stabilized Constant Descent Angle (SCDA) training, which the company does have in place fleet-wide.[20]

CASA 2014-13 also recommends that air operators use their safety management system (SMS) database to check the occurrence rate of unstable approaches for the purposes of properly assessing the hazards and risks they present. Between October 2021 and October 2022, Perimeter Aviation conducted approximately 34 000 flights. During that time, 36 missed approaches and 3 unstable approaches were reported to the company through its SMS.

1.17.3 Standard operating procedures

Perimeter Aviation requires that its personnel know the contents of the SOPs and apply the policies and procedures accordingly.

The instructions and information necessary to enable the personnel concerned to perform their duties safely, as well as the information required by the CARs and *Commercial Air Service Standards*, are included in the manual. The SOPs are intended to supplement, not replace, existing regulations. The SOPs also incorporate industry best practices that may exceed the requirements of the CARs.

The following sections outline several of the policies and procedures in the SOPs that are relevant to the investigation.

1.17.3.1 Stabilized approach criteria

Section 2.7.21 of the SOPs indicates that under normal conditions and visual meteorological conditions (VMC), the aircraft shall be stabilized on approach no later than 500 feet above the aerodrome elevation.[21]

Stabilized approach factors, as listed in the SOPs, are:

- The aircraft is on the correct flight path

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18 Transport Canada, Civil Aviation Safety Alert (CASA) 2014-03, *Using SMS to address hazards and risks associated with unstable approaches*, Issue 01 (27 June 2014).

19 Perimeter Aviation LP, *Flight Crew Training Manual (FCTM)*, Rev. 6 (01 December 2021).

20 Ibid., Section 12.7: Stabilized Constant Descent Angle (SCDA) Non-Precision Approach Training, p. 221.

21 Perimeter Aviation LP, *Dash 8 Standard Operating Procedures (SOP), Policies and Procedures,* (01 August 2021), section 2.7.21: Stabilized Approach Factors, p. 143.

> - Only small changes in heading/pitch are necessary to maintain the correct flight path
> - The airspeed is not more than V_{ref}+20kts indicated speed (for the selected Flap) and not less than V_{ref} plus any associated correction factors (Wind, etc.)
> - The aircraft is in the correct landing configuration
> - Sink rate is no greater than 1000 feet/minute; if an approach requires a sink rate greater than 1000 feet/minute a special briefing should be conducted
> - Power setting is appropriate for the aircraft configuration and is not below the minimum power for the approach as defined by the operating manual
> - All briefings and checklists have been conducted
>
> […]
>
> **Note**: Any deviation(s) from the above criteria and a Go-Around must be initiated. An SMS Report must be submitted within 24 hours for statistical tracking.[22]

Although this guidance requires power to be maintained above the minimum setting defined by the operating manual, the DHC-8 operating manual[23] contains no such minimum. The closest recommended power setting in the SOPs, based on the conditions present at the time of the occurrence, is a power setting of 10% torque with the flaps set to 15°, both engines operating, and an aircraft speed of 120 knots. According the SOPs, this recommended power setting and aircraft configuration would result in a 1000 fpm rate of descent while on approach.[24]

1.17.3.2 Normal landing procedure

The SOPs explain that it is critical that pilots establish a stabilized approach on final to ensure that the aircraft is in an appropriate energy state (with the proper attitude, power, and resulting performance) for landing. In the final 500 feet of the approach, only minimal adjustments should be made to the power lever settings, and the aircraft should be trimmed for the appropriate energy state so that the aircraft follows a consistent path.[25]

The SOPs also describe the flap 15° approach. In this approach, when the aircraft is 20 feet above touchdown, the pilot is to "smoothly bring the aircraft nose up into the flare, while reducing power as required allowing the aircraft to descend to the runway."[26] During the flare, the pitch attitude change is approximately 4° or 5° (approximately 0° to 1° nose up to 4° to 5° nose up).[27]

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22 Ibid., pp. 142-143.

23 De Havilland Inc. (Bombardier Inc.), *Dash 8 Series 300 Model 311/314/315 Operating Data*, Revision 33 (05 December 2014).

24 Perimeter Aviation LP, *Dash 8 Standard Operating Procedures (SOP), Policies and Procedures,* (01 August 2021), Section 2.7.23: Target Power Settings, p. 144.

25 Ibid., Section 2.8.3: Normal Landing, p. 147.

26 Ibid.

27 Ibid.

1.17.3.2.1 Pitch awareness calls

During the landing, pitch awareness calls (Table 3) must be spoken aloud. In the event that the PF does not adjust the power, pitch, and speed when a call is made, the PM must call "Attitude" again, and the PF must take corrective action to avoid an aft fuselage strike. The SOPs caution that if a flare is performed with a pitch attitude greater than 6° on a DHC-8-300 series aircraft, the aircraft's aft fuselage may come into contact with the runway.[28]

Table 3. Pitch awareness calls (Source: Perimeter Aviation LP, *Dash 8 Standard Operating Procedures [SOP], Policies and Procedures,* [01 August 2021], Section 2.8.3.1: Pitch Awareness Calls, p. 148.)

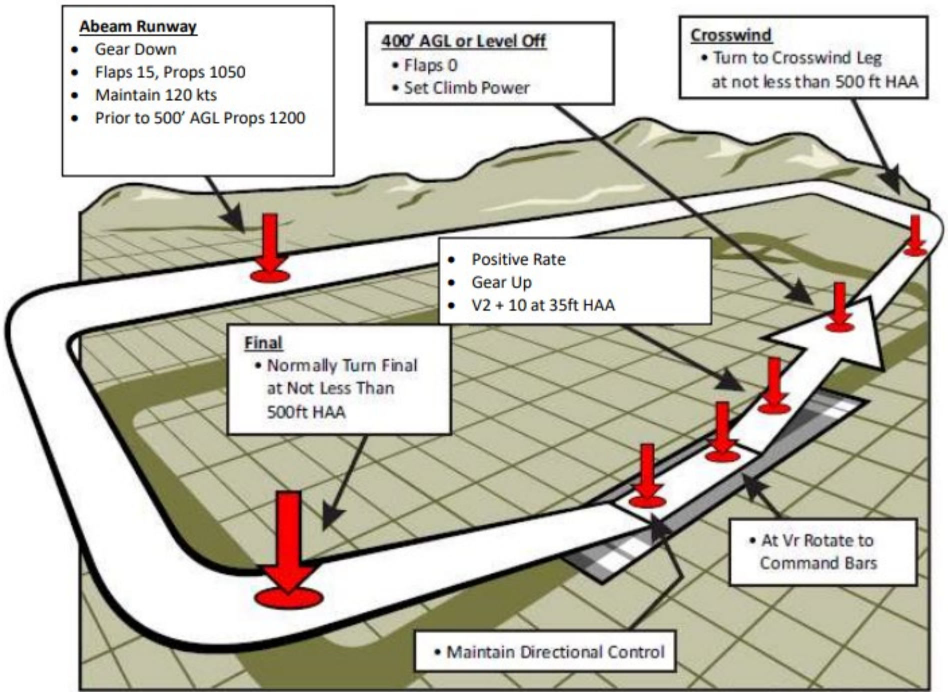
Location	PM – Call	PF – Response
5 degree pitch	**"5 degrees"**	**"Check"**
6 degree pitch or above • LDG ATT 6 DEG- (DH3 AD Message)	<aircraft pitch> **"degrees"**	**"Correcting"**

1.17.3.3 Visual approach procedure

Although Perimeter Aviation's SOPs describe instrument flight rules approaches in detail, they do not describe visual approaches, nor do they provide a visual flight rules (VFR) descent profile. They provide only the VFR circuit profile (Figure 5).

28 Ibid., Section 2.8.3.1: Pitch Awareness Calls, p. 149.

Figure 5. Diagram of visual flight rules circuit in Perimeter Aviation LP's standard operating procedures manual (Source: Perimeter Aviation LP, *Dash 8 Standard Operating Procedures [SOP], Policies and Procedures* [01 August 2021], Section 5.9: VFR Circuit, p. 258.)



1.17.3.3.1 Visual approach calls

The SOPs also provide calls for stabilized or unstable approach in visual conditions, which must be spoken aloud at the indicated location (Table 4).

Table 4. Standard calls for a visual approach (Source: Perimeter Aviation LP, *Dash 8 Standard Operating Procedures [SOP], Policies and Procedures,* [01 August 2021], Section 1.2.13.1: Enroute Calls, a. Visual Conditions, p. 30.)

Location	PM – Call	PF – Response
GPWS [ground proximity warning system] "500"	**"Stable, Bleeds off, Landing Check complete"** or **"Unstable"**	**"Check"** **"Go-around Max Power"**

The SOPs further state that

> An Instrument approach shall be loaded into the FMS with the applicable Approach chart available for all visual approaches.
>
> […] If there is no visual guidance available for the runway (i.e.: VASIS's [visual approach slope indicator system] or PAPI's), then, if possible the flight crew should brief a Visual Descent Point.[29]

The following criteria for visual descent point are also provided:

[29] Ibid., Section 2.7.20.6: Visual Approach Calls, pp. 141-142.

> It is therefore suggested that the crew evaluate the minimum distance required from the airport that is needed to conduct a normal descent to the runway touchdown point. In most cases, a 3° slope.
>
> […] To utilize this technique requires a quantified method of determining the distance from the runway threshold, using either ground based [*sic*] nav aids or GPS distance.[30]

The SOPs outline how to mathematically calculate a 3° glide slope[31] to maintain safe operations when vertical guidance assistance is not available. The calculation is the 1 in 60 rule and is equivalent to a gradient of approximately 300 vertical feet per NM.

1.17.4 Safety management system

Perimeter Aviation has a Transport Canada-approved SMS. According to the company's SMS manual, company departments are divided into 4 groups within the company's SMS database: Flight Operations, Safety and Quality, Maintenance, and Commercial Services. Submitted SMS reports are assigned to 1 of the 4 groups for further investigation.[32]

The occurrence flight crew reported this occurrence as required by the company's SMS. The Flight Operations department investigated the event and populated the SMS report file, detailing the root cause analysis, causal factors, and corrective/mitigation plan for the investigation.

As part of its investigation, the company linked to the occurrence a similar event involving one of its DHC-8-314 aircraft, which struck its aft fuselage on landing at Big Trout Lake Airport (CYTL), Ontario, on 27 October 2022, just over 1 week after the occurrence at CZSJ.

One item in the company investigation's root cause analysis identified an unstable approach and landing as a factor. During the root cause analysis, Perimeter Aviation's Flight Operations department did not analyze recorded flight data from either of the 2 FDRs to understand the individual flights or to determine whether the unstable approaches were an isolated or systemic issue. There was a corrective/mitigation plan detailed in the report for unstable approach causal factors.

Under the Causal Factors heading in the SMS report, the report stated "ground strike damage," "tail strike," and "training program / content /methods."[33]

The corrective/mitigation plan detailed in the report for causal factors included the following items:[34]

- Set FO restrictions and send Pitch Awareness to crews

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30 Ibid., p. 142.

31 Ibid.

32 Perimeter Aviation LP, *Safety Management System Manual (SMS), Policies and Procedures*, Revision 9 (14 April 2022), p. 11-12.

33 Perimeter Aviation LP, Safety Management System Report #22-1021-13-1144 (20 February 2023), p. 9.

34 Ibid., pp. 9-13.

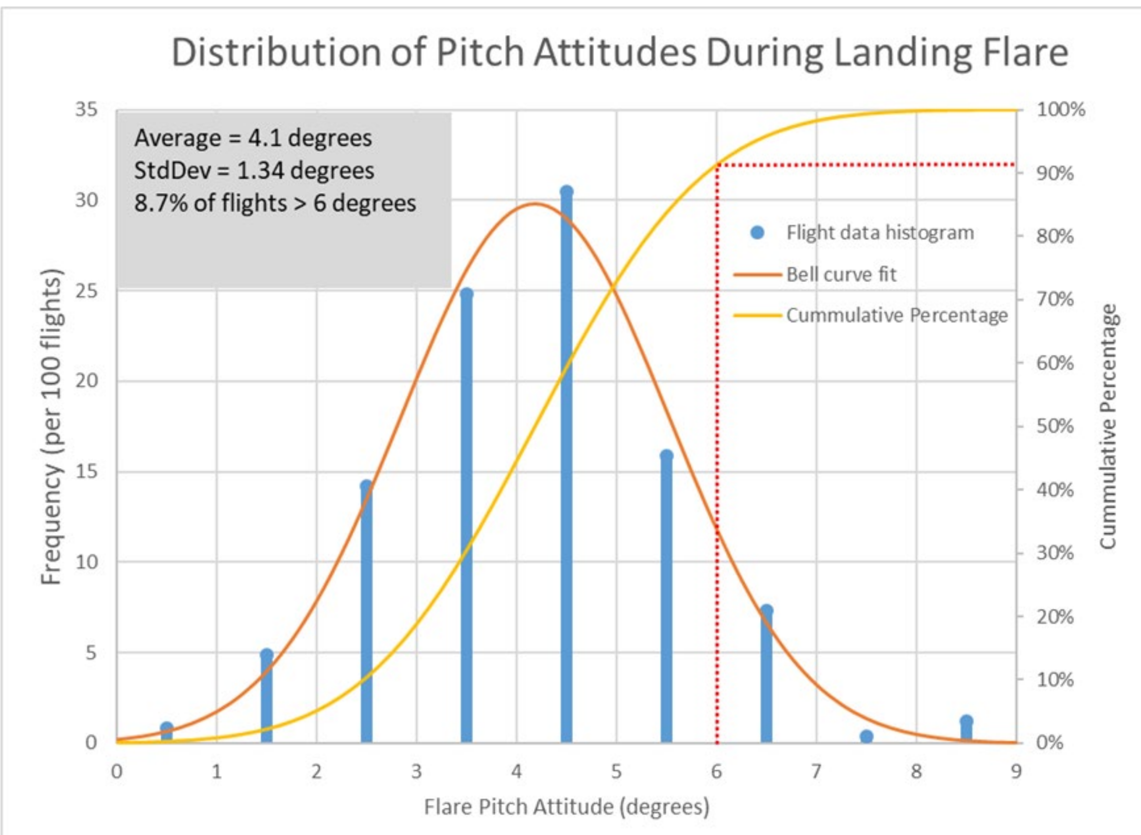
- Implement clear approach and landing criteria for the Dash 8 300 series
- Remove crew from duty pending investigation
- Review and amend line indoctrination process and expectations
- Command and decision making review with PIC
- Additional simulator training for captain
- Review training program
- Implement a formal restricted captain and restricted FO pairing policy

1.17.4.1 Flight data monitoring program

The TSB conducted an investigation into the flight history of Perimeter Aviation's DHC-8-314 aircraft, including previous flight data. The FDR data for both aircraft were analyzed by the TSB. There were data from a total of 246 flights combined. This amount of flight data was considered to be a statistically relevant representation of the operation of DHC-8-314 aircraft by the air operator.

Of particular interest was the peak pitch attitude of the aircraft during landing. Custom algorithms were created by the TSB to scan the flight data to detect the peak pitch attitude during the final moments of the flare and touchdown (Figure 6).

Figure 6. Graph showing pitch attitudes during the landing flare (Source: TSB)



The pitch attitude at which the DHC-8-314 aircraft's aft fuselage contacts the ground ranges from 6.8° to 11.9°, depending on the extent to which the main landing gear is compressed.

The air operator's SOPs state that pitch should not exceed 6° during the landing flare. However, the results from the statistical analysis show that 8.7% of the recorded landings had pitch attitudes exceeding this threshold.

Flight data monitoring (FDM) programs and software possess the capability to detect these and other potential risks. A functioning program could proactively identify adverse safety trends and provide timely information, allowing the air operator to implement additional measures to mitigate the risk of the hazards. At the time of the occurrence, Perimeter Aviation did not have an FDM program.

1.18 Additional information

1.18.1 Manufacturer

1.18.1.1 Pitch awareness

In 2003, after a series of aft fuselage strike incidents in which the pilots reacted instinctively by quickly nosing up the aircraft to stop an excessive rate of descent near the ground, the aircraft manufacturer produced a training video entitled "Dash 8-Q400 Pitch Awareness."[35] The video stresses the importance of monitoring the aircraft's pitch and managing its energy by controlling an excessive rate of descent through the application of engine power rather than the increase of the pitch attitude near the ground.

From the beginning, the video states that the content also applies to all DH8C (including DHC-8-300 series) aircraft. Although the Dash 8-Q400 (DH8D) is approximately 23 feet longer than the DHC-8-300 series aircraft, when the main landing gear oleos are compressed during a hard landing, the fuselage of both aircraft touches the ground at approximately 7° pitch attitude.

After several incidents involving aft fuselage strikes, the manufacturer released a service letter on 11 September 2008.[36] This service letter was intended solely for DH8D (Dash 8-Q400) operators and reiterated the importance of pitch awareness during the flare and touchdown. The letter recommended including standard 5- and 6-degree pitch awareness calls in the procedures (similar to Table 3), and managing the rate of descent below 200 feet AGL by managing the power levers. The service letter also made reference to the "Dash 8-Q400 Pitch Awareness" training video and suggested that air operators offer initial and recurrent training on pitch awareness.

Although the service letter was intended only for DH8D (Dash 8-Q400) operators and was, therefore, not sent to DHC-8-300 series operators, Perimeter Aviation included standard 5- and 6-degree pitch awareness calls in its SOPs. According to Perimeter Aviation, at the time of the occurrence, the company was unaware that the manufacturer had produced a pitch

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35 De Havilland Inc. (Bombardier Inc.), "Dash 8-Q400 Pitch Awareness" [video], (2003).

36 Bombardier Inc., Service Letter DH8-400-SL-00-020: Q400 Pitch Awareness Training (11 September 2008).

awareness video and had recommended that air operators offer pitch awareness training to their crews.

1.18.2 Stabilized approaches

1.18.2.1 Description

As established in previous investigations conducted by the TSB[37] and by safety organizations in other countries, unstable approaches pose a high risk to aviation operations.

According to Civil Aviation Safety Alert (CASA) 2015-04,

> [r]ushed and unstabilized approaches remain a significant factor in Controlled Flight Into Terrain (CFIT) and other Approach and Landing Accidents (ALA). […] [M]aintaining a stable speed, descent rate, and vertical/lateral flight path in the landing configuration is commonly referred to as the stabilized approach concept.[38]

Based on the findings and conclusions of the Go-Around Safety Forum published on 26 June 2013, the Flight Safety Foundation (FSF) indicated in its final report on the *Go-Around Decision-Making and Execution Project* that "[f]ailure to conduct a go-around is the number one risk factor in approach and landing accidents (ALAs) and the number one cause of runway excursions."[39]

The report adds, "[g]o-arounds, although considered a normal flight maneuver, are rare."[40] Go-around procedures are included in pilots' initial and recurrent training. During training, pilots are prepared for this manoeuvre and execute it in a controlled environment. The altitude at which a go-around decision is made determines the difficulties related to this manoeuvre. If a go-around is needed, the PF must take action immediately. When the aircraft is descending and is near the ground, this decision becomes critical because of the loss of altitude between the moment that the pilot begins the go-around and the moment the aircraft begins to climb.

According to the findings of the Go-Around Safety Forum, a short-haul commercial pilot may make a go-around only once or twice a year, on average. The fact that the manoeuvre is rarely executed may partially explain pilot reluctance to perform a go-around.[41]

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37 TSB aviation investigation reports A20Q0013, A19A0055, A18W0129, A17F0052, A16A0032, A15P0217, A15O0015, A14O0218, A14Q0148, A14F0065, A13O0098, A12Q0161, A12P0034, A12O0005, A12W0004, A11H0002, and A10P0244.

38 Transport Canada, Civil Aviation Safety Alert (CASA) 2015-04, *Stabilized Approach*, Issue 02 (05 August 2019).

39 Flight Safety Foundation, *Final Report to Flight Safety Foundation, Go-Around Decision-Making and Execution Project* (March 2017), Section 4, p. 6.

40 Ibid., Section 3.3, p. 4.

41 Flight Safety Foundation, *Go-around Safety Forum, 18 June 2013, Brussels: Findings and Conclusions* (26 June 2013), Chapter 2, p. 5.

1.18.2.2 Benefits of a stabilized approach

The safety benefits derived from a stabilized approach have been recognized by many organizations, including the International Civil Aviation Organization, the Federal Aviation Administration of the United States, the European Union Aviation Safety Agency, and Transport Canada Civil Aviation.[42]

According to the FSF,[43] some of the benefits are

- increased flight crew situational awareness;
- more time and attention for monitoring air traffic control communications, weather conditions, and systems operation;
- more time for monitoring and backup by the PM; and
- defined flight-parameter-deviation limits and minimum stabilization heights to support the decision to land or to go-around.

Specific limits on excessive deviation for approach elements, along with a stabilization altitude limit, provide the pilots (PF and PM) with a common frame of reference, thereby reducing the possibility of ambiguity. In this context, deviations are identified faster and callouts are faster and more accurate.

1.18.2.3 Industry standard for stabilized approach criteria

Although not required by regulation, most air operators—including Perimeter Aviation—have incorporated stabilized approach criteria into their SOPs, as a response to the recommendations outlined in CASA 2015-04.[44]

To assist air operators in developing these criteria, numerous organizations have established guidelines as to what factors should be considered or defined as part of these criteria. These guidelines are generally very similar and follow the stabilized concept; however, some differ when it comes to the level of specificity on certain factors. Individual air operators in Canada have adjusted these guidelines as necessary to suit their specific aircraft types and operations.

The investigation examined Perimeter Aviation's criteria for a stabilized approach, as outlined in its SOPs.[45] Table 5 compares these stabilized approach guidelines with the recommended considerations presented in CASA 2015-04.

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42 Transport Canada, Civil Aviation Safety Alert (CASA) 2015-04, *Stabilized Approach*, Issue 02 (05 August 2019).

43 Flight Safety Foundation, "Approach-and-landing Accident Reduction (ALAR) Tool Kit, Briefing Note 7.1 — Stabilized Approach," *Flight Safety Digest* (August–November 2000).

44 Transport Canada, Civil Aviation Safety Alert (CASA) 2015-04, *Stabilized Approach*, Issue 02 (05 August 2019).

45 Perimeter Aviation LP, *Dash 8 Standard Operating Procedures (SOP), Policies and Procedures,* (01 August 2021), section 2.7.21: Stabilized Approach Factors, pp. 142-143.

Table 5. Comparison of the recommended stabilized approach factors to be defined by air operators, according to Transport Canada's Civil Aviation Safety Alert 2015-04, and the stabilized approach criteria outlined in Perimeter Aviation LP's standard operating procedures (Sources: Transport Canada, Civil Aviation Safety Alert [CASA] 2015-04, *Stabilized Approach*, Issue 02 [05 August 2019], and Perimeter Aviation LP, *Dash 8 Standard Operating Procedures [SOP], Policies and Procedures*, [01 August 2021], section 2.7.21: Stabilized Approach Factors, pp. 142-143.)

Recommended factors in CASA 2015-04 *Stabilized Approach*	Stabilized approach criteria in *Dash 8 Standard Operating Procedures (SOP)*
Range of speeds specific to the aircraft type	The airspeed is not more than V_{ref} + 20 kts indicated airspeed (for the selected flap) and not less than V_{ref} plus any associated correction factors (wind, etc.).
Power setting(s) specific to the aircraft type	Power setting is appropriate for the aircraft configuration and is not below the minimum power for the approach as defined by the operating manual.
Range of attitudes specific to the aircraft type	Only small changes in heading/pitch are necessary to maintain the correct flight path.
Configuration(s) specific to the aircraft type	The aircraft is in the correct landing configuration.*
Crossing altitude deviation tolerances	The aircraft is on the correct flight path.
Sink rate	Sink rate is no greater than 1000 fpm; if an approach requires a sink rate greater than 1000 fpm, a special briefing should be conducted.
Completion of checklists and flight crew briefings	All briefings and checklists have been conducted.

* The SOPs' stabilized approach criteria note that the Dash 8 is considered configured in instrument meteorological conditions with flaps at 15° and gear down. In VMC, flaps are at either 15° or 35°, with the gear down.

This comparison revealed that in Perimeter Aviation's SOPs, as well as in de Havilland's *Dash 8 Series 300 Model 311/314/315 Operating Data* manual, not all of the factors involved in conducting a successful stabilized approach are defined with specific details. The power settings, aircraft attitude, and aircraft configuration for VMC are all left to the discretion of the pilot during this phase of flight, and the pilot must determine which conditions are best suited for a stabilized approach.

1.18.2.4 Risks of unstable approaches

The FSF, following the recommendations of its approach and landing accident reduction (ALAR) Task Force, created and distributed an ALAR tool kit that was intended to reduce the number of approach and landing accidents (ALAs). In the tool kit, the FSF stated that the leading cause of ALAs was unstable approaches that continue to landing.

Approaches require flight crews to constantly monitor flight parameters such as airspeed, approach angle, and visual references. Unstable approaches increase the flight crew's workload when compared to a stabilized approach because more frequent adjustments are required to restore and maintain appropriate flight parameters.

Of the accidents recorded in 2022 by the International Air Transport Association, some of the most common contributing factors related to threat and error management were:[46]

- non-compliance with SOPs (26%)
- manual handling and flight control errors (21%)
- abrupt aircraft control and vertical, lateral, or speed deviations (15%)
- unstable approaches and long landing (13%)

Research conducted in 2013 indicated that 3% to 4% of all approaches are unstable, and 97% of these are continued to a landing.[47]

In a 2015 occurrence[48] involving a DHC-8 aircraft that sustained a hard landing and an aft fuselage strike, the aircraft's unstable approach was linked to reduced situational awareness. In this occurrence, the flight crew had limited experience with conducting landings at night, without FMS vertical guidance, and on a runway in northern Canada. Neither pilot recognized that the approach was unstable, nor did the PM anticipate or perceive the action of the PF, who had reduced the engine power to 0% torque 1 second before landing and had changed pitch angle. As a result, the pilots did not have enough time to react and prevent the aft fuselage strike. At the time of the occurrence, neither pilot had viewed the manufacturer's pitch awareness training video.

In another TSB investigation report, which involved a controlled flight into terrain accident in Resolute Bay, Nunavut, in 2011,[49] the TSB identified the need to reduce the incidence of unstable approaches that are continued to a landing. The Board recommended that

> Transport Canada require CARs Subpart 705 operators to monitor and reduce the incidence of unstable approaches that continue to a landing.
>
> **TSB Recommendation A14-01**

In its March 2018 response to this recommendation, Transport Canada (TC) provided data from some CARs Subpart 705 operators and the results of Internal Process Bulletin (IPB) 2016-01, showing that the rate of unstable approaches that continue to a landing had decreased significantly since 2014. Also, TC's assessment of CARs Subpart 705 operators through the activities in IPB 2016-01 showed encouraging results. As a result, in its March 2019 reassessment of TC's response, the Board stated that it believed that the residual risk associated with this recommendation was low. Therefore, the response to Recommendation A14-01 was considered to be **Fully Satisfactory**.[50]

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46 International Air Transport Association, *IATA Annual Safety Report – 2022, Executive Summary and Safety Overview*, Edition 59 (March 2023), p. 6.

47 J.M. Smith, D.W. Jamieson, and W.F. Curtis, "Failure to Mitigate," *AeroSafety World*, Flight Safety Foundation, Vol. 8, Issue 1 (February 2013).

48 TSB Aviation Investigation Report A15O0015.

49 TSB Aviation Investigation Report A11H0002.

50 Reassessment of the response to TSB Recommendation A14-01, at www.tsb.gc.ca/eng/recommandations-recommendations/aviation/2014/rec-a1401.html (last accessed on 29 April 2024).

1.18.3 Human factors

1.18.3.1 Workload and expertise

Workload is a function of the number of tasks that must be completed within a given time. Workload increases if the number of tasks to be completed increases or if the time available decreases. Excessive workload occurs when performing a task requires more resources (including time) than are available, resulting in reduced performance. An increase in workload can be caused by various factors, including a person's level of experience. For example, novices will typically report experiencing higher workload than experts when performing the same task.[51]

Crew expertise is required for an air operator to manage the variable and unpredictable nature of flight operations. New crew members need time to develop their knowledge and skills, as well as a mental model of their work environment.

This is why many air operators have put measures in place to help inexperienced personnel develop their skills. In 2019, the TSB published Air Transportation Safety Issue Investigation Report A15H0001[52] with the objective of improving safety by reducing the risks in air taxi operations across Canada. The investigation explored the safety theme of the availability of qualified personnel and discussed such issues as training and the risk associated with inexperience. The information gathered indicated that some air operators had adopted the following measures:

- Scheduling a newly hired or promoted captain to fly with experienced first officers for a certain period of time.
- Having new pilots work with maintenance or in other ground positions such as dispatch before they are rewarded with a flying position. This way, the pilot can get acquainted with how the company operates, and the company can get acquainted with the new hire.
- Developing crew-pairing policies, such as a "no green-on-green" policy under which an inexperienced pilot is paired with a more experienced one. For example, using a "green pilot" checklist to optimize crew pairings and guard against pairing 2 less-experienced crew members, or instituting a policy in which a new pilot needs to fly with an experienced pilot for 1000 hours before the new pilot can be paired with any other pilot.
- Having a pilot mentorship program that pairs junior pilots with senior pilots. Many operators were doing this to support knowledge transfer within a

[51] O. Tolvanen, A.P. Elomaa, M. Itkonen, H. Vrzakova, R. Bednarik, & A. Huotarinen, "Eye-Tracking Indicators of Workload in Surgery: A Systematic Review," *Journal of Investigative Surgery*, Vol. 35, Issue 6 (17 January 2022), p. 1340.

[52] TSB Air Transportation Safety Issue Investigation Report A15H0001, *Raising the bar on safety: Reducing the risks associated with air-taxi operations in Canada* (07 November 2019), at www.tsb.gc.ca/eng/rapports-reports/aviation/etudes-studies/a15h0001/a15h0001.html (last accessed on 29 April 2024).

> company. This mentorship program could also be extended to new captains within the company.[53]

Working under the supervision of an experienced crew member allows new crew members to develop a richer mental model, learn to apply their knowledge in real-life situations to make more efficient decisions, and increase their self-confidence.[54]

When novice captains are paired with experienced FOs, the captains can focus on their role as PIC and rely on the experienced FOs for support. In the same vein, an experienced captain who is familiar with his or her own tasks is in a better position to coach a new FO.

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53 Ibid., Section 4.2.2.2.2: How operators are managing these issues.

54 P.R. Messmer, S.G. Jones, and B.A. Taylor, "Enhancing knowledge and self-confidence of novice nurses: The 'Shadow-A-Nurse' ICU program," in *Nursing Education Perspectives*, Volume 25, Issue 3 (May-June 2004), p. 132.

2.0 ANALYSIS

2.1 General

There was no indication of airframe or engine failure during the occurrence flight before the aft fuselage strike. The flight crew members held the appropriate licences for the flight in accordance with existing regulations, and there were no indications that their performance was degraded due to medical or physiological factors such as fatigue. Consequently, the analysis will focus on the following issues:

- flight crew experience and pairing;
- stabilized approach criteria;
- execution of the approach and flare to landing; and
- company procedures and safety management system (SMS).

2.2 Flight crew pairing

The flight crew pairing for the occurrence flight met the regulatory requirements, given that both pilots had completed their training, consolidation period, line indoctrination, and line check. In effect, Perimeter Aviation LP (Perimeter Aviation) had provided the captain 195.5 hours of line indoctrination, and the first officer (FO) 73.9 hours, when only 20 hours are required. Although Perimeter Aviation's management team had an informal practice of not pairing new pilots together on the monthly schedule, the company did not have a process in place during the Systems Operations Control Centre's (SOCC) daily rescheduling to avoid pairing pilots with limited experience in their roles to the same flight.

The day of the occurrence marked the captain's 2nd flight day in the role of captain and on the occurrence aircraft type since his line check, and he had limited experience flying in the remote northern regions of Canada. The FO with whom he had been paired had a number of flight hours on single-engine aircraft but very limited multi-engine experience. He was on his 3rd flight day since his line check. Like the captain, he had not conducted many flights in this region of Canada, and his experience in multi-crew environments was limited, as was his experience on the DHC-8.

Owing to the fact that the FO was relatively new to the aircraft type and the multi-crew environment, he required more supervision and coaching from the captain than an experienced FO would have needed. However, the captain also had limited experience in his role. Because of this, performing his role as a pilot-in-command led to a higher workload compared to that of a more experienced captain, leaving him with fewer cognitive resources that could be used to observe and support the FO.

As highlighted in the Air Transportation Safety Issue Investigation Report A15H0001, some air taxi operators have implemented a "green-on-green" policy to limit crew pairings of pilots who, despite having completed all their training, have not yet gained enough operational experience to mitigate the risks associated with pilots with limited experience in their roles flying together. This strategy is especially effective during times of high pilot turnover, when a higher number of inexperienced pilots are available to be scheduled.

Perimeter Aviation's informal daily scheduling practice did not take into account pilot experience when pairing crew members together. Given the nature of Perimeter Aviation's operations, the different types of expertise required, and its recent high pilot turnover, this practice can reduce safety margins.

Finding as to risk

If an air operator does not factor a pilot's level of experience into a formal daily crew scheduling process, there is a risk of compromised safety margins due to the assignment of 2 pilots with limited experience in their roles to the same flight.

2.3 Stabilized approach criteria

Air operators are not required by regulation to provide criteria for a stabilized approach in their procedures. However, given the history of approach and landing accidents (ALAs) and numerous studies, reports, and recommendations, most air operators, including Perimeter Aviation, have adopted a stabilized approach philosophy and incorporated stabilized approach criteria into their standard operating procedures (SOPs). Air operators develop their own stabilized approach criteria and often do so with the assistance of published guidance from Transport Canada.

The exact details of these adopted criteria often differ from one air operator to the next. Perimeter Aviation's SOPs in effect at the time of the occurrence included a section that described the requirements of a stabilized approach. It stated that the power setting should be appropriate for the aircraft configuration and that it should not fall below the minimum power setting for the approach as defined by the aircraft's operating manual. An examination of de Havilland's *Dash 8 Series 300 Model 311/314/315 Operating Data* manual revealed that it does not contain recommended power settings or any reference to a minimum power setting for an approach.

After a review of Perimeter Aviation's *Flight Crew Training Manual* (FCTM), it was determined that the company's pilots were not trained in recognizing stabilized approach factors. The de Havilland operating manual, to which the SOPs refer, does not provide the pilot with any power setting guidance, and consequently, it is the pilot who must determine the best power setting during an approach.

During the final approach on the occurrence flight, the aircraft met Perimeter Aviation's stabilized approach criteria at the required altitude of 500 feet above airport elevation. However, when the aircraft was below 500 feet above airport elevation, the pilot flying (PF) increased the power lever setting from 10% torque to 57% torque and, moments later, reduced it to flight idle. The large increase in engine power greatly affected the descent profile, resulting in a substantial increase in aircraft lift, a decrease in the rate of descent, and an increase in airspeed; causing the approach to become unstable. Given the trend in the aircraft's airspeed and altitude, these large power variations would not have been required to intercept or maintain the appropriate approach path, and were likely a result of the pilot's relatively limited experience operating the aircraft type.

Findings as to causes and contributing factors

Below 500 feet above ground level and while trying to intercept and maintain the appropriate approach path, the PF varied the power setting between 57% and flight idle, likely owing to limited experience operating the aircraft type, and the result was an unstable approach.

Due to insufficient detail in the SOPs and the absence of awareness training on stabilized approach criteria, the pilots did not recognize that significant variations in the power setting had made the approach unstable, and they continued the approach.

2.4 Pitch control during the approach and landing

While the aircraft passed 0.2 nautical miles from the threshold, the FO, who was the PF, reduced the torque to flight idle while also decreasing the aircraft's pitch angle to positive 2°. Immediately afterward, with a pronounced pitch-up control input, the pilot increased the pitch angle in the flare. At the same time, the torque began to gradually increase from flight idle.

The aircraft's descent rate was 950 fpm when the main landing gear contacted the runway; the aircraft's pitch angle increased rapidly through 5.8°. A fraction of a second later, the pitch angle reached 7.24°. The aircraft's aft fuselage impacted the runway, approximately 350 feet from the threshold. At the moment of impact, the aircraft bounced to a height of approximately 1.5 feet while the pitch angle rapidly decreased to 2.2°.

Given the large and rapid increase in pitch, there was insufficient time for the captain, who was the pilot monitoring, to assist in the prevention of excessive pitch attitude, take control of the aircraft, or announce the pitch awareness calls to arrest the excessive descent rate.

It remains uncertain why the PF handled the aircraft in this manner, especially given that the SOPs caution pilots against it. Although the aircraft manufacturer had made a training video entitled "Dash 8-Q400 Pitch Awareness" and issued a service letter regarding Dash 8-Q400 pitch awareness training, this video was not used by Perimeter Aviation for its pilot training. However, some elements of the service letter, such as maximum pitch on landing, were incorporated in the SOPs.

Finding as to causes and contributing factors

The PF, who was relatively inexperienced on the DHC-8 and had received limited guidance on pitch awareness, made a pronounced pitch-up input during the flare. There was insufficient time for the pilot monitoring to arrest this action, and the aircraft's aft fuselage consequently contacted the runway, causing significant damage.

2.5 Using safety management systems to address unstable approaches

In response to TSB Recommendation A14-01, Transport Canada published a Civil Aviation Safety Alert titled *Using SMS to Address Hazards and Risks Associated with Unstable Approaches* in June 2014.

In the absence of flight data monitoring (FDM), the publication recommends that air operators complete a review of their SMS database to verify the rate of occurrence of unstable approaches in order to perform a proactive assessment of the hazard.

The TSB's investigation determined that from October 2021 to October 2022, Perimeter Aviation conducted approximately 34 000 aircraft movements, and of these, only 3 unstable approaches were reported to the company's SMS.

The occurrence flight crew reported the occurrence as required under the company's SMS. Perimeter Aviation's Flight Operations department investigated the event and populated the SMS report file, detailing the investigation root cause analysis, causal factors, and a corrective/mitigation plan. As part of the company's investigation, the department examined a similar report related to an aft fuselage strike, which identified unstable approach and landing as a factor. However, the Flight Operations department did not examine the recorded flight data from either the occurrence flight or the previously reported aft fuselage strike incident to determine whether the unstable approach was isolated to these 2 occurrences or whether it was a systemic issue. Additionally, because the company did not have an FDM program in place, no review of flight data had been conducted to determine the rate of incidence of unstable approaches within the company's fleet.

When the TSB conducted an examination of Perimeter Aviation's data from flight data recorders, it was discovered that 8.7% of the 246 recorded flights landed with pitch flare exceeding the air operator's limit during the landing flare.

Excessive pitch flare resulting in a successful landing is not a reportable item in accordance with Perimeter Aviation's SMS. Nonetheless, the data examined by the TSB demonstrate that hazards and risks are not always detected through reportable data.

Finding as to risk

If air operators rely solely on flight crews to report hazards and risks to the company's SMS and do not actively monitor flight operations through flight data-monitoring capabilities, unsafe practices may not be identified, increasing the risk that they will continue.

3.0 FINDINGS

3.1 Findings as to causes and contributing factors

These are conditions, acts or safety deficiencies that were found to have caused or contributed to this occurrence.

1. Below 500 feet above ground level and while trying to intercept and maintain the appropriate approach path, the pilot flying varied the power setting between 57% and flight idle, likely owing to limited experience operating the aircraft type, and the result was an unstable approach.

2. Due to insufficient detail in the standard operating procedures and the absence of awareness training on stabilized approach criteria, the pilots did not recognize that significant variations in the power setting had made the approach unstable, and they continued the approach.

3. The pilot flying, who was relatively inexperienced on the DHC-8 and had received limited guidance on pitch awareness, made a pronounced pitch-up input during the flare. There was insufficient time for the pilot monitoring to arrest this action, and the aircraft's aft fuselage consequently contacted the runway, causing significant damage.

3.2 Findings as to risk

These are conditions, unsafe acts or safety deficiencies that were found not to be a factor in this occurrence but could have adverse consequences in future occurrences.

1. If an air operator does not factor a pilot's level of experience into a formal daily crew scheduling process, there is a risk of compromised safety margins due to the assignment of 2 pilots with limited experience in their roles to the same flight.

2. If air operators rely solely on flight crews to report hazards and risks to the company's safety management system and do not actively monitor flight operations through flight data-monitoring capabilities, unsafe practices may not be identified, increasing the risk that they will continue.

4.0 SAFETY ACTION

4.1 Safety action taken

4.1.1 Perimeter Aviation LP

Following the occurrence, Perimeter Aviation LP took the following safety actions:

- incorporated the “Dash 8-Q400 Pitch Awareness” video in its initial and recurrent cockpit procedures training for the DHC-8-100 and DHC-8-300 series and made the video available for instructors to share;
- amended the DHC-8 standard operating procedures (SOPs) to revise its stabilized approach criteria to include target power settings, and added information and guidance regarding the flight management system’s “LPV APPR INHIBITED” error message;
- amended the SOPs for the DHC-8, SA227, and SA226 to include an instrument approach policy that requires flight crews to fly the instrument approach procedure for the intended runway, if one is available, regardless of weather conditions, to assist in ensuring a stabilized flight profile;
- developed flight operations quality assurance and line operations safety audit procedures;
- added this occurrence to the company’s crew resource management course;
- implemented a command and decision making course;
- amended DHC-8 initial simulator training to include excessive pitch recovery and black hole exercises;
- implemented a restricted crew status list;
- instituted a flight data monitoring program for its DHC-8 and SA227 AC fleet.

This report concludes the Transportation Safety Board of Canada’s investigation into this occurrence. The Board authorized the release of this report on 27 March 2024. It was officially released on 21 May 2024.

APPENDICES

Appendix A – Flight data plots

Figure A1. Summary of occurrence flight data (Source: TSB)

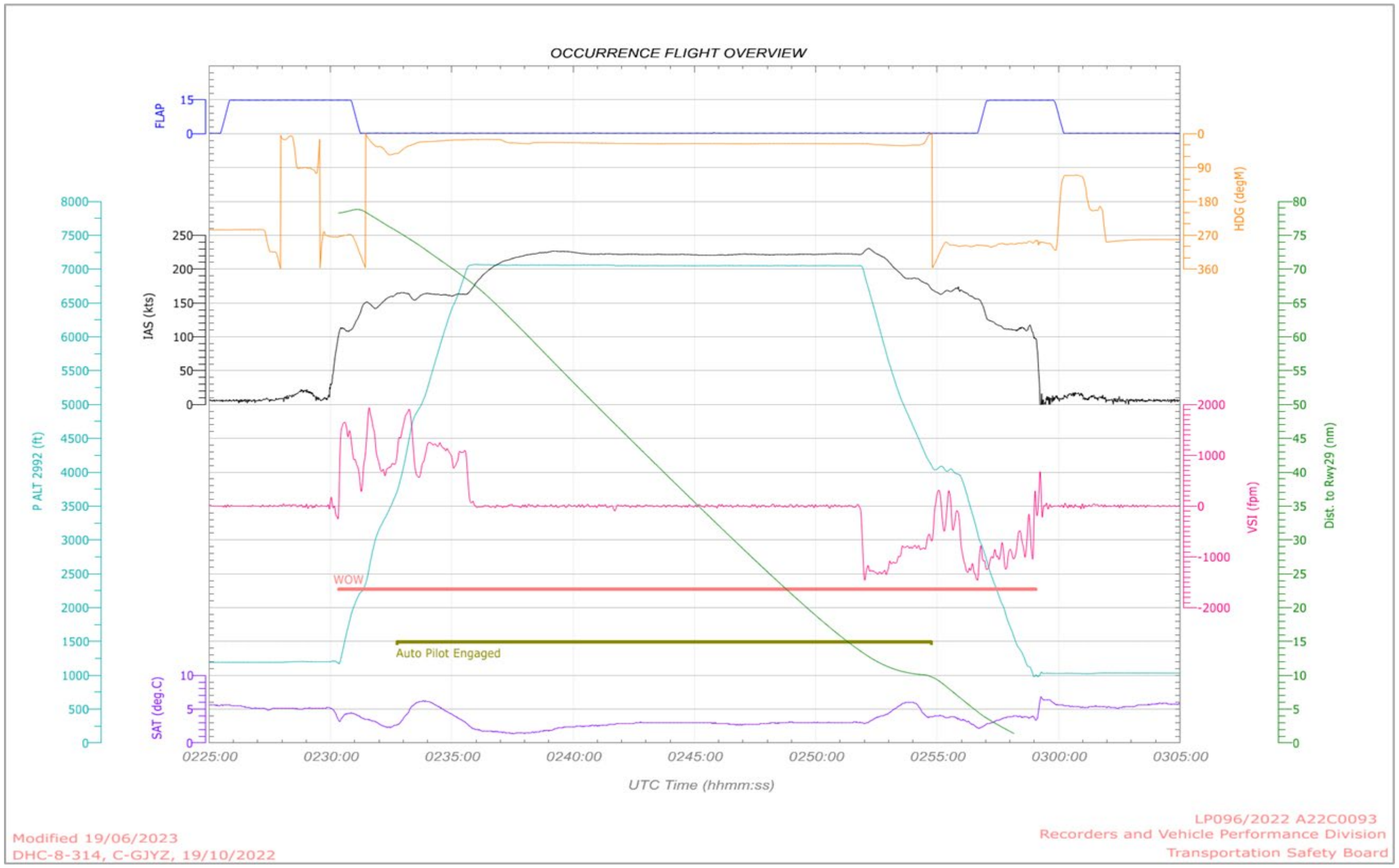

Figure A2. Approach data (Source: TSB)

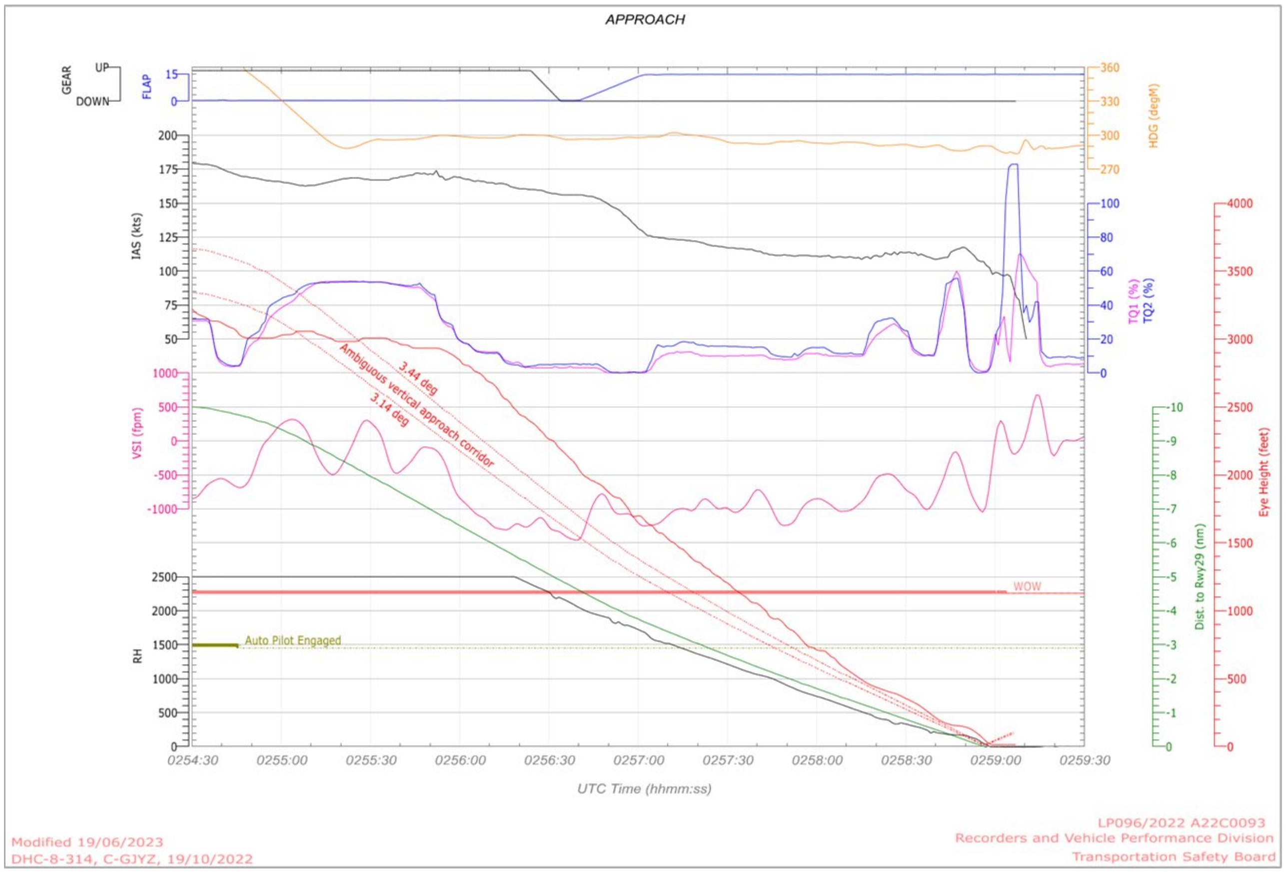

Figure A3. Final approach data (Source: TSB)

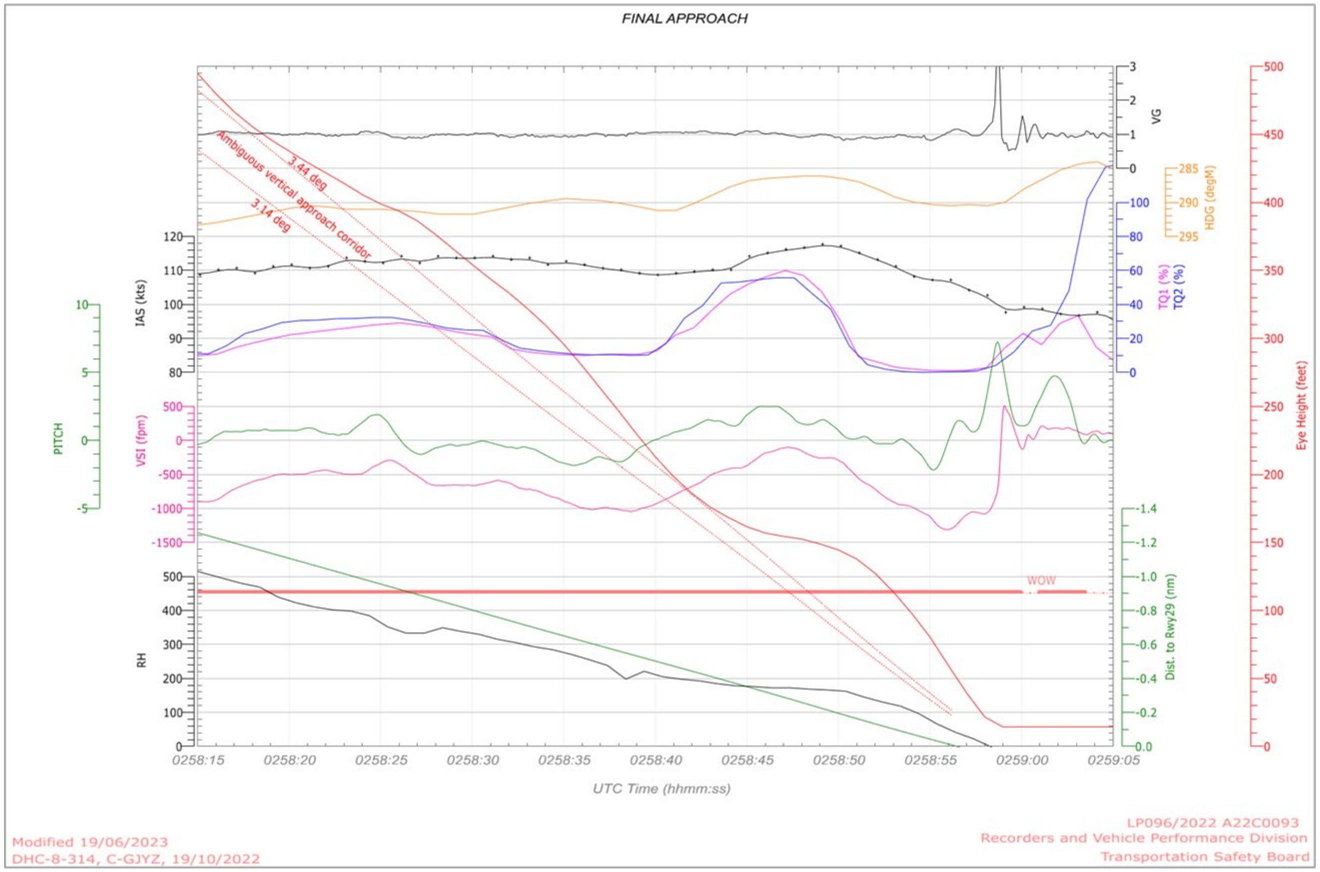

Figure A4. Landing data (Source: TSB)