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

AIR TRANSPORTATION SAFETY INVESTIGATION REPORT A20Q0013

HARD LANDING AND AFT FUSELAGE STRIKE

Air Inuit Ltd.
de Havilland DHC-8-314 (C-GXAI)
Schefferville Airport, Quebec
20 January 2020

Canada

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Citation

Transportation Safety Board of Canada, *Air Transportation Safety Investigation Report* A20Q0013 (released 04 May 2021).

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Air transportation safety investigation report A20Q0013

Cat. No. TU3-10/20-0013E-PDF
ISBN: 978-0-660-38505-1

This report is available on the website of the Transportation Safety Board of Canada at www.tsb.gc.ca

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Summary

On 20 January 2020, the de Havilland DHC-8-314 aircraft (registration C-GXAI, serial number 481), operated by Air Inuit Ltd., was conducting scheduled flight AIE820 from Québec/Jean Lesage Airport, Quebec, to Schefferville Airport, Quebec, with 3 crew members and 42 passengers on board. During landing, as the wheels touched down on Runway 35 at 1109 Eastern Standard Time, the aft fuselage struck the runway. After landing, the aircraft taxied to the terminal to disembark the passengers. No one was injured; however, the aircraft sustained major damage. The emergency locator transmitter did not activate.

1.0 FACTUAL INFORMATION

1.1 History of the flight

International Civil Aviation Organization (ICAO), Annex 13 to the *Convention on International Civil Aviation*[1] requires states conducting accident investigations to protect cockpit voice recordings. Canada complies with this requirement by making cockpit voice recordings privileged in the *Canadian Transportation Accident Investigation and Safety Board Act*. While the Transportation Safety Board of Canada (TSB) may make use of any on-board recording in the interests of transportation safety, it is not permitted to knowingly communicate any portion of an on-board recording that is unrelated to the causes or contributing factors of an accident or to the identification of safety deficiencies.

The reason for protecting cockpit voice recorder (CVR) material lies in the premise that these protections help ensure that this essential material is available for the benefit of safety investigations. The TSB has always met its obligations in this area and has restricted the use of CVR data in its reports. Unless the CVR material is required to both support a finding and identify a substantive safety deficiency, it will not be included in the TSB's report.

In this report, the TSB has made extensive use of the CVR recording. In each instance, the material has been carefully examined to ensure that the extracts used are related to the causes or contributing factors of this accident or to the identification of safety deficiencies.

On 20 January 2020, the 2 pilots and the flight attendant who composed the crew of the de Havilland DHC-8-314 (DH8C) operated by Air Inuit Ltd. (Air Inuit) arrived at Montréal/Pierre Elliott Trudeau Airport (CYUL), Quebec, for their work day, which began at 0600.[2] That day, they were scheduled to fly a series of 7 flights (Figure 1):

- Montréal to Québec
- Québec to Schefferville
- Schefferville to Kuujjuaq
- Kuujjuaq to Kangirsuk
- Kangirsuk to Quaqtaq
- Quaqtaq to Kangiqsujuaq
- Kangiqsujuaq to Salluit

The first flight was scheduled to depart from CYUL at 0700, and the arrival at Salluit, Quebec, was scheduled for 1735.

At 0706, the crew began the series of flights under call sign AIE820. The 1st flight from CYUL to the Québec/Jean Lesage Airport (CYQB), Quebec, took place without incident. The aircraft landed at CYQB at 0824.

[1] International Civil Aviation Organization (ICAO), Annex 13 to the *Convention on International Civil Aviation*, Aircraft Accident and Incident Investigation, 12th Edition (July 2020), paragraph 5.12.

[2] All times are in Eastern Standard Time (Coordinated Universal Time minus 5 hours).

Figure 1. Map showing the points of origin and destinations for AIE820's flight segments on the day of the occurrence flight (Source: Google Earth, with TSB annotations)

At 0902, the aircraft took off from CYQB bound for Schefferville Airport (CYKL), Quebec, with 42 passengers on board. The captain occupied the left seat and was the pilot monitoring (PM). The first officer occupied the right seat and was the pilot flying (PF).

At 0926, the aircraft reached its cruising altitude of flight level (FL) 230.[3] Approximately 1 hour later, still in cruising flight, the crew began preparations for approach and landing at CYKL. The crew obtained weather conditions from the automated weather observation system (AWOS). According to the AWOS report, at that time, visibility was 9 statute miles (SM) with a few clouds at 6000 feet above ground level (AGL) and winds were calm. The PF then gave an approach briefing for a visual approach to land on Runway 35. Based on the aircraft's weight, the crew calculated a landing reference speed (Vref)[4] of 99 knots indicated airspeed (KIAS).

At 1050, the PM contacted air traffic control (ATC) to request clearance for descent. Because radar coverage is not provided below FL 180 in this area, ATC first asked another aircraft departing from CYKL to provide its crossing altitude. Once the aircraft departing from CYKL

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[3] The flight level (FL) is the altitude expressed in hundreds of feet and indicated by a barometric altimeter set to 29.92 inches of mercury or 1013.2 millibars. FL 230 corresponds to an altitude of 23 000 feet above sea level.

[4] Bombardier Inc., *DHC-8 SERIES 300 Airplane Flight Manual*, Volume 1, revision 266– defines Vref as the approach speed at a height of 50 feet above the runway in the landing configuration.

was radar-identified, ATC cleared AIE820 for descent. At 1051, the PF began the descent from FL 230.

At approximately 1055, before entering uncontrolled airspace below FL 180, the PM broadcast AIE820's position on a frequency of 126.7 MHz. Meanwhile, the flight attendant had noticed that the descent had begun, and had begun preparing the cabin for landing. As the aircraft was descending through 9000 feet above sea level (ASL), the PM broadcast on CYKL's frequency (122.2 MHz) that AIE820 was on approach 24 nautical miles (NM) southwest of the airport.

At 1105, the aircraft levelled off at 5000 feet ASL and the PF asked the PM to enter the next altitude (the circuit altitude of 2800 feet ASL) in the altitude selector. At that point, haze was reducing visibility and the pilots could not see the aerodrome. The PM then activated the aircraft radio control of aerodrome lighting (ARCAL). The PF turned off the autopilot and, while searching for the airport, began a right turn to intercept the Runway 35 centreline. Still unable to see the runway, the PF asked the PM to enter a track simulating a line to the airport along the Runway 35 centreline into the flight management system (FMS). Approximately 20 seconds later, the pilots had the runway in sight.

As the aircraft passed through 3800 feet ASL at 1107:25, the PM began to broadcast a position report on CYKL's frequency but stopped when he realized that the descent checklist had not been started. Because the checklist includes the descent call, which alerts the flight attendant to prepare the cabin for landing, he then contacted the flight attendant, who confirmed that she had noticed the descent and that the cabin was secured for landing.

At 1107:58, while the aircraft was on the base leg[5] approximately 2.45 NM from the runway, the PF noticed that the aircraft was coming in fast and high (162 KIAS and 3100 feet ASL, that is, 480 feet above a nominal 3° slope). He then reduced the engine torque (power) and asked the PM to increase propeller speed to 1050 rpm to help slow down the aircraft. The PM set the propellers to 1050 rpm as the aircraft was turning onto its final approach course, passing through 1000 feet AGL. As the aircraft was turning left, the PF asked the PM to lower the landing gear. The aircraft passed the final approach course by approximately 400 feet to the northeast and then very briefly banked left up to 36°, which triggered a bank angle alert from the terrain awareness and warning system (TAWS).

At 1108:21, as the aircraft was passing through 750 feet AGL, still turning left, a second TAWS alert was triggered, this time by the rate of descent, which had momentarily reached 2500 fpm. The aircraft maintained a speed of 162 KIAS. The PF then corrected the bank angle and stabilized the rate of descent to approximately 1000 fpm, ending the turn to intercept the final approach course.

Once the aircraft was established on the final approach to Runway 35, the PM advised the PF on how to manage the height and speed. After analysis, the PM determined that the

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5 The base leg is the leg preceding final approach for a landing; it is normally perpendicular to the runway centreline.

approach and landing were feasible, even though the aircraft was flying above the nominal 3° slope at a high speed. The PM then performed the descent checklist while the PF continued to reduce speed as he proceeded with the approach.

At 1108:37, the aircraft descended through 500 feet AGL at a speed of 144 KIAS and decelerating, with flaps at 5°, landing gear extended, power at idle, and propellers set to a speed of 1050 rpm. At that point, the aircraft was 150 feet above the nominal 3° slope. The PF then asked the PM to set the flaps to 15° and perform the landing checklist, which the PM did, as well as sounding a chime twice to notify the flight attendant that landing was imminent.

At 1108:58, as the aircraft reached 200 feet AGL with a rate of descent of approximately 1000 fpm and a speed of 120 KIAS, with a 1.5° nose-up attitude, the PF asked the PM to set the flaps to 35° and the propeller speed to 1200 rpm, and to perform the final checklist. The PM performed the requested actions and completed the final check as the aircraft was passing through 100 feet AGL, at 1109:10.

At that point, the airspeed was 96 KIAS, below the Vref of 99 KIAS, and continuing to decrease rapidly. Power was at idle, the aircraft had a 1° nose-up attitude, and it began to descend rapidly. The PM called out the Vref speed, and immediately afterward, Vref minus 5.

At 1109:13, the aircraft passed through 50 feet AGL at a rate of descent of nearly 900 fpm and a speed of 94 KIAS, with a 2° nose-up attitude. The PM then told the PF to add power, which the PF did, while increasing the nose-up attitude to arrest the descent.

At 1109:16, the aircraft landed hard with a 9° nose-up attitude, during which the lower aft fuselage struck the runway. While taxiing on the runway, the crew noticed that the "Touched Runway" indicator had illuminated.

After landing, the aircraft taxied normally and parked in front of the terminal at 1111.

In accordance with the tail strike checklist, the crew performed an external inspection of the aircraft and contacted Air Inuit's maintenance department.

1.2 Injuries to persons

There were no injuries.

1.3 Damage to aircraft

The aft fuselage had friction damage, and the structure was dented. The skin, frame, structural stiffeners, and longerons in the lower part of the fuselage were damaged. The fuselage runway contact sensor was torn from its mount (Figure 2).

The flight data recorder indicated that, upon landing, the vertical acceleration recorded was 2.37 times the force of gravity (*g*). According to the aircraft manufacturer, a level 1 hard landing inspection was required before the aircraft could be returned to service.[6] This inspection was performed by Air Inuit's approved maintenance organization (AMO). A ferry flight was then conducted to bring the aircraft to the repair centre at the Trois-Rivières Airport, Quebec.

Figure 2. Rear view of another DH8C and view of the damage to C-GXAI (Source: TSB)

1.4 Other damage

Not applicable.

1.5 Personnel information

The flight crew was certified and qualified for the flight, in accordance with existing regulations.

The captain had 4.5 years of experience flying DH8Cs and DHC-8-100s (DH8As). He had been working as a pilot for Air Inuit since 2005. His semi-annual recurrent training and pilot proficiency check (PPC) had taken place in December 2019.

The first officer had been working as a pilot for Air Inuit since 2017. He had been assigned to DH8Cs and DH8As in the fall of 2019 and had completed initial training and passed his PPC at the end of November 2019.

The flight crew had been on continuous duty for approximately 5 hours at the time of the occurrence. The investigation found no indication that the captain's or the first officer's performance was degraded by fatigue or other physiological factors.

The flight attendant was trained under the operator's training program and was qualified for the flight, in accordance with existing regulations.

6 de Havilland, *de Havilland Dash 8 Series 300 Aircraft Maintenance Manual* (15 July 2015), section 05-50-11: Hard Landing Inspection, p. 1.

Table 1. Personnel information

	Captain	First officer
Pilot licence	Airline transport pilot licence (ATPL)	Commercial pilot licence (CPL)
Medical expiry date	01 June 2020	01 August 2020
Total flying hours	10 186	1055
Flight hours on type	5024	82.8
Flight hours on type in the 90 days before the occurrence	128.8	82.8
Hours on duty before the occurrence	5	5
Hours off duty before the work period	82	60

1.6 Aircraft information

C-GXAI is a DH8C, which is a version of the DH8A extended by 11.3 feet, increasing the maximum number of passengers from 37 to 50.

The propellers are 13 feet in diameter. As with other aircraft with wing-mounted engines, when power is increased, lift is increased by airflow over 26 feet of wing. Conversely, when power is reduced to a minimum, the propellers impede the airflow, and therefore the lift is reduced over 26 feet of wing.

The aircraft took off from CYQB with a weight of 42 698 pounds and landed at CYKL with an estimated weight of 39 849 pounds. The aircraft's weight and centre of gravity were within the manufacturer's prescribed limits.

Table 2. Aircraft information

Manufacturer	de Havilland Inc.
Type and model	DHC-8-314
Year of manufacture	1997
Serial number	481
Certificate of airworthiness issue date	07 November 2010
Total airframe time	39 314 hours
Engine type (number of engines)	Pratt & Whitney PW123B (2)
Propeller type (number of propellers)	Hamilton Standard 14SF-23 (2)
Maximum allowable take-off weight	43 000 pounds (19 505 kg)
Maximum allowable landing weight	42 000 pounds (19 051 kg)
Recommended fuel type(s)	Jet A, Jet A-1, JP5, JP8, Jet B, JP-4
Fuel type used	Jet A-1

1.6.1 Maintenance

C-GXAI is maintained by Air Inuit's AMO (number 0008-86), in accordance with a maintenance schedule approved by Transport Canada Civil Aviation (TCCA). Records indicate that the aircraft was certified and maintained in accordance with existing regulations and approved procedures, and no deficiencies were reported before the occurrence flight. Also, there was no indication of an airframe or engine failure or a system malfunction during the flight.

1.7 Meteorological information

Weather conditions at CYKL were favourable for a visual approach.

Aerodrome routine meteorological reports (METARs) for CYKL are issued by an AWOS. METARs and aerodrome special meteorological reports (SPECI) that are based on data from an automated system contain the qualifier AUTO.

The METAR AUTO issued at 1100 on 20 January 2020 for CYKL indicated

- winds variable at 5 knots;
- visibility 9 SM;
- a few clouds at 6500 feet AGL;
- temperature −22°C, dew point −27°C; and
- altimeter setting 29.55 inches of mercury.

A SPECI AUTO for CYKL was issued at 1146, 37 minutes after landing, indicating a reduction in visibility to 5 SM due to haze, and winds from 270° true (T) at 14 knots, gusting to 22 knots.

1.8 Aids to navigation

Not applicable.

1.9 Communications

Aircraft operating below 18 000 feet in the vicinity of CYKL are in uncontrolled airspace (Class G airspace).[7] In Class G airspace, pilots are responsible for broadcasting their intentions on frequency 126.7 MHz.

In addition, at aerodromes where the traffic volume and diversity justify it, a mandatory frequency area (MF area) is established.[8] At CYKL, the MF area includes airspace within a 15 NM radius of the airport, up to an altitude of 4800 feet ASL. In this MF area, pilots are required to provide a position report on frequency 122.2 MHz.

Position reports were provided during the occurrence flight; however, the last report was interrupted.

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[7] Transport Canada, TP 14371, *Transport Canada Aeronautical Information Manual* (TC AIM), RAC – Rules of the Air and Air Traffic Services (26 March 2020), section 2.8.7.

[8] Ibid., section 4.5.4.

1.10 Aerodrome information

Schefferville Airport is adjacent to the city of Schefferville, and has a single, paved runway (Runway 17/35), 5002 feet long and 150 feet wide. The airport's altitude is 1709 feet ASL. At the time of the accident, Runway 35, which was in use, was bare and dry.

1.11 Flight recorders

The aircraft was equipped with a flight data recorder (FDR) and a cockpit voice recorder (CVR). The 2 recorders were sent to the TSB Engineering Laboratory in Ottawa, Ontario, to extract the recorded data.

The FDR contained data for 144 flights, including the occurrence flight. An analysis of these data established the aircraft's speed, path, pitch angle, vertical acceleration at touchdown, bank angles, flap position, propeller rotation speed, engine power, TAWS alerts, and the PF's use of flight controls and the power levers.

The CVR, which contained good-quality audio recordings, had a rated recording time of 30 minutes, in compliance with *Canadian Aviation Regulations* (CARs) requirements in effect at the time this report was written.[9] The recording had begun at 1042:15 and had ended at 1112:21, 3 minutes and 5 seconds after landing.

After the occurrence, Air Inuit removed the FDR. The CVR was not secured at the time, but the data were still preserved because the aircraft remained powered down after being parked. It was not until the next day, when the TSB was advised of the occurrence, that the CVR was secured at the request of the TSB.

The *Transportation Safety Board Regulations* in effect at the time of the accident required that the TSB be provided information about an accident "as soon as possible and by the quickest means available"[10] and that "[e]very person having possession of or control over evidence relating to a transportation occurrence must keep and preserve the evidence unless the Board provides otherwise."[11]

1.12 Wreckage and impact information

The first marks made by the right main gear can be seen approximately 175 feet from the threshold of Runway 35, and the fuselage struck the runway immediately afterward (Figure 3).

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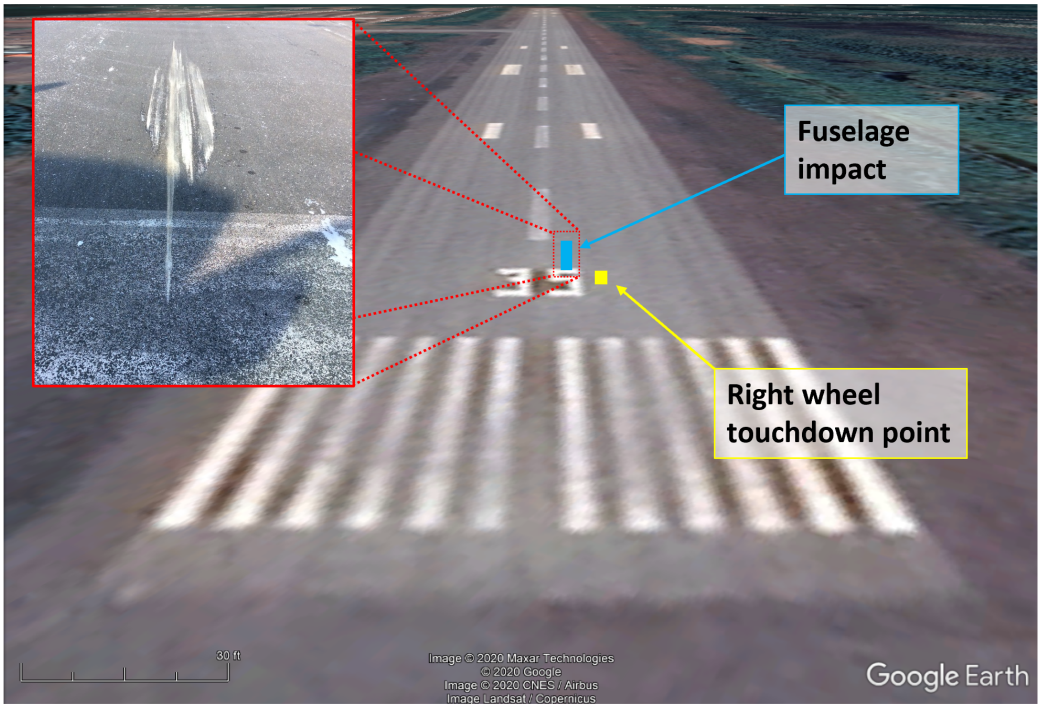
9 However, this 30-minute recording time does not comply with the 2 hours required by the ICAO since 01 January 2016. In May 2019, Transport Canada published modifications to the *Canadian Aviation Regulations* (CARs) so that Canadian regulations would reflect this standard. These changes will come into effect on 29 May 2023.

10 Transportation Safety Board of Canada, SOR/2014-37, *Transportation Safety Board Regulations*, subsection 2(3).

11 Ibid., subsection 8(1).

Figure 3. Wheel touchdown and fuselage impact points (Source of main image: Google Earth, with TSB annotations. Source of inset image: Schefferville Airport manager)



1.13 Medical and pathological information

Not applicable.

1.14 Fire

Not applicable.

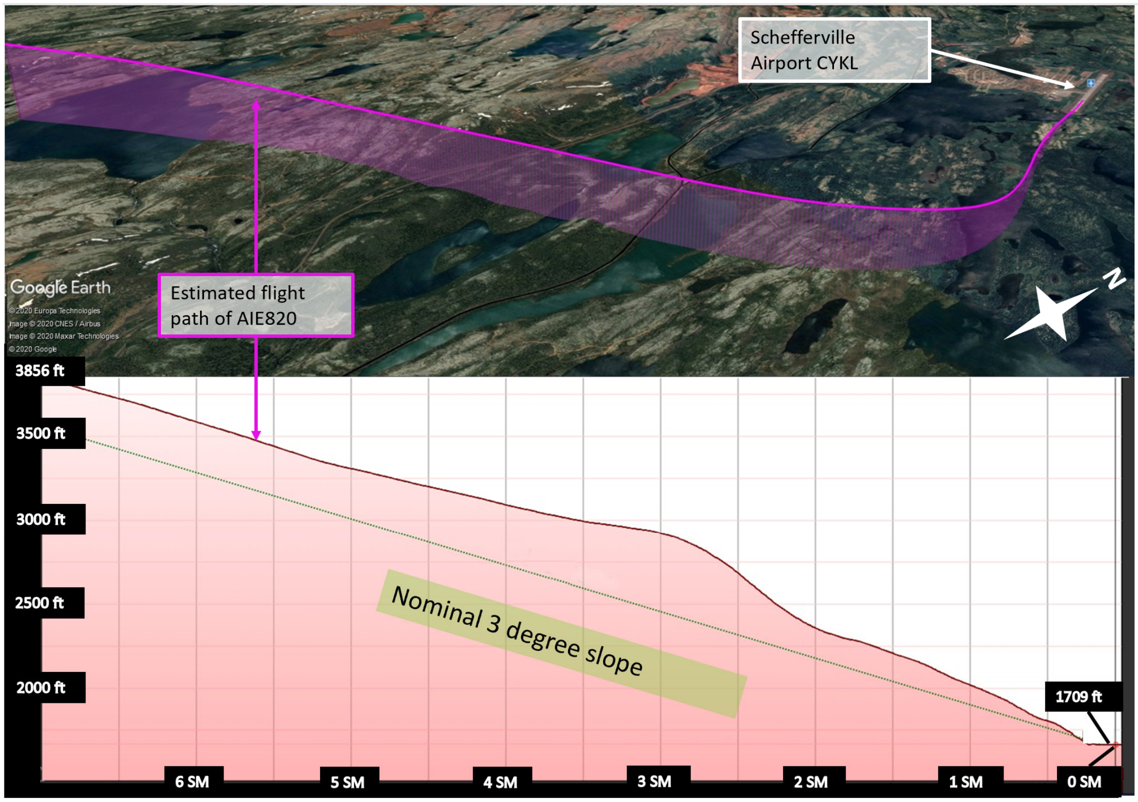
1.15 Survival aspects

Not applicable.

1.16 Tests and research

Because the FDR model used in the occurrence aircraft does not record the position from the global positioning system (GPS), the TSB Engineering Laboratory compared the data from the radio altimeter with the topography of the terrain to establish an estimated descent path. The laboratory created a visualization of the aircraft's vertical path in relation to the nominal 3° slope (Figure 4).

Figure 4. Estimated flight path of AIE820 (altitude above sea level, in feet, and remaining distance of the approach path, in statute miles) (Source: Google Earth, with TSB annotations)



1.16.1 Analysis of data from the flight data recorder

The TSB laboratory analyzed the data from 144 flights recorded on the occurrence aircraft's FDR to determine whether the occurrence flight was an exception to normal operations. This analysis, which focused primarily on the maximum speed reached while the aircraft was on approach, revealed that 23 of the 144 approaches conducted had a speed greater than 130 KIAS[12] at some point below 500 feet above aerodrome elevation (AAE). However, since the analysis did not consider the duration of these irregularities or the weather conditions when they occurred, some irregularities may have been very brief or due to moderate turbulence.[13]

1.16.2 TSB laboratory reports

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

- LP063/2020 – FDR download and analysis

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12 A speed of 130 KIAS was identified as the maximum speed below 500 feet above aerodrome elevation (AAE) based on the standard operating procedures (SOPs) approach speed of 120 KIAS with a deviation of +10 KIAS. Air Inuit Ltd., *Combined Standard Operating Procedures — Dash 8 Section 2, Amendment 14* (15 February 2019), section 2.34.17 "Stabilized Approach Factors," p. 2-139 and *Section 1, Amendment 7* (21 December 2009), section 1.4.3 "Standard Calls," p. 1-60.

13 Air Inuit Ltd., *Combined Standard Operating Procedures — Dash 8 Section 2, Amendment 14* (15 February 2019), section 2.34.18 "Target Speeds & Minimum Manoeuvring Speeds," p. 2-140.

- LP064/2020 – CVR audio recovery

1.17 Organizational and management information

1.17.1 Operator

Air Inuit is a regional air carrier based in Dorval, Quebec. It operates charter and scheduled flights to 22 destinations, primarily to Nunavik (northern Quebec).

The company operates 28 aircraft under CARs subparts 702 (Aerial Work), 703 (Air Taxi Operations), 704 (Commuter Operations), and 705 (Airline Operations). The occurrence flight was conducted under Subpart 705.

At the time of the occurrence, Air Inuit's fleet comprised 4 Boeing 737s, 2 Beechcraft 100s, 3 Beechcraft 300s, 7 de Havilland DHC-6s, 10 de Havilland DH8Cs, and 2 de Havilland DH8As.

1.17.1.1 Safety management system

Air Inuit has a safety management system (SMS) that integrates TCCA guidelines, as required by CARs Subpart 705. This SMS encompasses all company activities related to aircraft operations and associated equipment, as well as service-related activities.

1.17.1.2 Standard operating procedures

1.17.1.2.1 General

Standard operating procedures (SOPs), including standard callouts and checklists, are crucial sources of information that provide pilots with guidelines on the general use of the aircraft. They assist pilots with decision making and coordination among crew members. They provide pilots with proven solutions to various situations in normal or abnormal operations and in emergencies.

To provide airline operators with direction on SOPs in order to reduce the risk of accidents, ICAO released a regional safety advisory in which it stated that

> [m]any aviation safety organizations including the FAA [Federal Aviation Administration] have recently reaffirmed the importance of SOPs. For many years the National Transportation Safety Board (NTSB) has identified deficiencies in standard operating procedures as contributing causal factors in aviation accidents. Among the most commonly cited deficiencies involving flight crews has been their non-compliance with established procedures […].[14]

Furthermore, ICAO issued the following recommendations:

> 4. [Airline operators should] Develop training programs to provide pilots with rationale for SOPs, focusing on those with lower adherence rates.

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[14] International Civil Aviation Organization (ICAO), RASG-MID Safety Advisory – 07 (RSA-07), *Standard Operating Procedures Effectiveness and Adherence* (May 2016), p. 4.

5. Airlines/operators and regulators should ensure that their training/standardization and monitoring programs emphasize the importance of adherence to SOPs and identify the rationale behind those procedures.
6. Airlines/operators should implement Flight Operational Quality Assurance (FOQA) programs to identify systemic procedural deviations and unsafe trends.[15]

Section 4.2.3 of ICAO Annex 6 explains the requirement for an air operator to have an operations manual that includes the SOPs.[16] Attachment D of Annex 6 states that the regulatory organization must at least accept the SOPs after conducting a specific review or evaluation.[17]

The FAA released advisory circular (AC) 120-71B on 10 January 2017, which "provides guidance for the design, development, implementation, evaluation, and updating of standard operating procedures (SOP), and for pilot monitoring (PM) duties."[18] This circular states that:

> Standard operating procedures (SOP) are universally recognized as fundamental to safe aviation operations, yet accidents and incidents continue to occur as a direct result from, or related to, a failure by the flightcrew [*sic*] to follow SOPs, particularly during critical phases of flight.[19]

AC 120-71B also emphasizes that "SOPs should be clear, comprehensive, and readily available within the manuals used by flight deck crewmembers."[20]

FAA inspectors review operators' procedures to ensure that they comply with the regulations, are consistent with safe operating practices, and are based on sound rationale or demonstrated effectiveness.[21]

In its analysis of approach-and-landing accidents (ALAs), the Flight Safety Foundation (FSF) stated that "Crew Resource Management (CRM) is not effective without adherence to

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15 Ibid., p. 5.

16 International Civil Aviation Organization (ICAO), Annex 6 to the *Convention on International Civil Aviation*, 11th Edition (July 2018), Part 1 – International Commercial Air Transport – Aeroplanes, section 4.2.3 Operations manual.

17 Ibid., Attachment D: Air operator certification and validation, section 3.4: Provisions that require a technical evaluation.

18 Federal Aviation Administration (FAA), Advisory Circular (AC) 120-71B: Standard Operating Procedures and Pilot Monitoring Duties for Flight Deck Crewmembers (10 January 2017), cover page.

19 Ibid., p. 1-1.

20 Ibid.

21 Federal Aviation Administration (FAA), *Flight Standards Information Management System 8900.1 CHG 0* (12 April 2012), Volume 3: General Technical Administration manuals, Chapter 32, section 2, paragraph 3-3151.C.

SOPs."[22] Also, "SOPs are the reference for crew standardization and establish the working environment required for CRM."[23]

From the TCCA's standpoint, section 4.5 of the *Air Carrier Inspector Manual*[24] stipulates that inspectors reviewing SOPs must be familiar with the aircraft type and must ensure that procedures in the manuals do not contradict the aircraft flight manual or the company operations manual. Finally, like those of the FAA, TCCA inspectors must ensure that procedures comply with regulations[25] and are consistent with safe operating practices.

An official interpretation regarding SOP review was published in 2014 in TCCA's National Aviation Safety Information Management System (NASIMS).[26] This interpretation concluded that, since SOPs play an important role in operations, when inspectors review the SOPs, they must evaluate their quality, consistency, accuracy, conciseness, clarity, relevance, and content.

Furthermore, between 1994 and 2020, inconsistent or missing procedures were mentioned 39 times in the various findings in TSB aviation investigation reports.[27] The deficiencies identified were mainly related to a absence of precise guidelines and discrepancies in procedures.

1.17.1.2.2 Air Inuit standard operating procedures

TCCA reviewed Air Inuit's SOPs, verifying that the required subjects were included, and issued an acceptance letter on 18 February 2019. The SOPs relevant to this occurrence are indicated below.

Preparation for approach and descent

According to the SOPs, preparation for approach is carried out before beginning descent. In coordination with the PF, the PM obtains the weather conditions and configures the navigation radios and FMS for the planned approach. Next, the PF transfers controls to the PM to conduct the approach briefing. According to the SOPs:

> The Visual Briefing will include:

[22] Flight Safety Foundation, *Reducing the Risk of Runway Excursions: Report of the Runway Safety Initiative* (May 2019), Appendix II, p. 1.

[23] Ibid., p. 3.

[24] Transport Canada, TP 3783, *Air Carrier Inspector Manual,* 5th Edition, (March 2004, revised in December 2010), section 4.5.

[25] Transport Canada, SOR/96-433, *Canadian Aviation Regulations*, section 705.138.

[26] National Aviation Safety Information Management System, guideline 4011093 (approved 21 July 2014).

[27] TSB aviation investigation reports A94C0160, A96A0035, A97H0011, A98P0303, A98P0194, A98W0011, A99Q0005, A00Q0006, A00H0007, A00W0177, A01C0236, A02O0105, A04C0016, A04O0092, A04O0103, A04Q0199, A05A0059, A06C0062, A07C0001, A10Q0098, A11H002, A11P0149, A12C0005, A12Q0216, A13H0001, A13O0098, A14F0065, A15H0002, A15P0217, A17O0038, and A18Q0030.

- A revision of any transition or arrival instructions;
- The visual approach for the planned runway;
- Any known Threats;
- The applicable minimum altitudes and/or restrictions when appropriate; and,
- A briefing of the missed approach procedure.[28]

On the occurrence flight, the PF did the approach briefing and, as part of a threat and error management (TEM) process (see section 1.18.5.9 for further details on TEM), the crew determined that the air traffic in the vicinity of CYKL might be a threat. The pilots did not discuss the stabilized approach gate, but this was not required by the SOPs.

Stabilized approach criteria

According to paragraph 2.34.17 of the SOPs, under normal conditions in visual meteorological conditions (VMC), the aircraft shall be in a stabilized approach by the approach gate, which is at 500 feet AAE.[29] Given that this point is the altitude above aerodrome, the corresponding altitude ASL will be different for each aerodrome.

Stabilized approach components include

- Normal Sink Rate of 500-800 FPM;
- Reference Speed of 120 knots;
- Flaps set at;
    - Approach Flaps at 15°
    - Landing Flaps at 15° or 35° for normal two engine landing; and,
    - Landing Flaps at 15° for a single engine landing.
- Final approach speed maintained at 120 knots to 500 feet (AAE) then gradually reduced to the bugged approach speed to achieve V_{REF} at touchdown;
- The aircraft must be stabilized in the landing configuration by 500 feet.

[…]

NOTE[1]: The, **“Stabilized”** call shall be made when crossing 1,000 feet (AAE) in IMC [instrument meteorological conditions] or at 500 feet (AAE) when in VMC.

NOTE[2]: During a PMA [pilot-monitored approach], the final checklist is to be completed by the FAF [final approach fix], with the exception (if required) of the selection and confirmation of Flaps 35° (**“Flaps 35° to go”**).[30]

[28] Air Inuit Ltd., *Combined Standard Operating Procedures — Dash 8 Section 2, Amendment 14* (15 February 2019), paragraph 2.34.4 “Visual Briefing,” p. 2-126.

[29] Ibid., paragraph 2.34.17 “Stabilized Approach Factors,” p. 2-139.

[30] Ibid.

Furthermore, according to the SOP, the PM must call out an airspeed reading that deviates by more than −5 KIAS or +10 KIAS.[31]

No fault/no blame go-around policy

In its operations manual, Air Inuit has implemented a no fault/no blame policy for go-arounds conducted following an unstable approach. This section of the manual also includes stabilized approach criteria that must be met at 500 feet AAE in VMC:

> - the aircraft is on a correct flight path; and,
> - only small changes in heading and pitch are required to maintain the correct flight path; and,
> - the aircraft is in the landing configuration; and,
>
> […]
>
> - the airspeed is not more than VREF +20 and not less than VREF (see NOTE 1 below); and,
> - all briefings and checklists have been completed.
>
> **NOTE 1**: Abnormal conditions requiring deviations from the above elements of a Stabilized Approach require a briefing.[32]

The manual also states:

> Any indication that a desired flight parameter will not be achieved before the Approach Gate shall prompt immediate corrective action or, if after the Approach Gate, the decision to go around.[33]

This policy also appears in Air Inuit's SOPs.[34]

Approach checklists

According to the SOPs,[35] the landing checklist is normally completed by 1000 feet AAE in VMC. The PF will request the *final* checklist once the landing is assured. This request will be made by 500 feet AAE.

On the occurrence flight, the landing checklist was carried out below 500 feet AAE and the *final* checklist was requested when the aircraft was passing through 200 feet AAE.

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31 Air Inuit Ltd., *Combined Standard Operating Procedures — Dash 8 Section 1, Amendment 7* (21 December 2009), paragraph 1.4.3 "Standard Calls," p. 1-60.

32 Air Inuit Ltd., *Flight Operations Manual* (Amendment 9, 27 September 2019*)*, paragraph 3.18: No Fault/No Blame Go Around Policy, p. 104.

33 Ibid., p. 105.

34 Air Inuit Ltd., *Combined Standard Operating Procedures — Dash* 8, SOP Advisory #23 "Stabilized Approach and No Fault/No Blame Go Around Policy – Revised" (10 February 2016).

35 Air Inuit Ltd., *Combined Standard Operating Procedures — Dash 8 Section 2, Amendment 14* (15 February 2019), paragraphs 2.35.1 "Landing Check" and 2.35.2 "Final Check," pp. 2-141 to 2-144.

Normal landing procedure

The SOP section that describes normal landings states that, under certain circumstances, the flaps may be set for landing when the aircraft is below 500 feet AAE.[36] For example, flaps are set to 35° when landing is assured, which may be lower than 500 feet AAE for an instrument flight rules approach, and as low as 250 feet AAE. This might also happen in abnormal operations requiring a delay in the final landing flap selection, such as approach with an engine failure.

The SOPs also state that, once an aircraft is established on approach, it must not fly slower than the approach speed. As the aircraft approaches the runway threshold, speed must be reduced so that Vref is reached at touchdown.

This SOP section also provides pitch awareness calls, which must be spoken aloud.

Figure 5. Standard pitch awareness calls (Source: Air Inuit Ltd., *Combined Standard Operating Procedures — Dash 8 Section 2*, Amendment 14 [15 February 2019], paragraph 2.35.3, p. 2-144)

Pitch Awareness	PM	PF
5° Degrees Pitch	**"5° Degrees"**	**"Check"**
6° Degrees Pitch or above	**"6° Degrees"**	**"Correcting"**

The SOPs indicate that once the "6 Degrees" call is made, the pilot must avoid any further increase in pitch. The PF must adjust the power, pitch, and speed to correct the aircraft's attitude and reduce the rate of descent.

On the occurrence flight, the "5 Degrees" and "6 Degrees" calls were not made when the pitch changed from 2° to 9° in less than 2 seconds just before touchdown.

Visual approach procedure

The SOPs describe IFR approaches in detail, but they do not describe visual approaches. Only one flight profile gives an overview of a visual flight rule (VFR) circuit, indicating in boxes which standard calls should be made, and where(Figure 6).[37]

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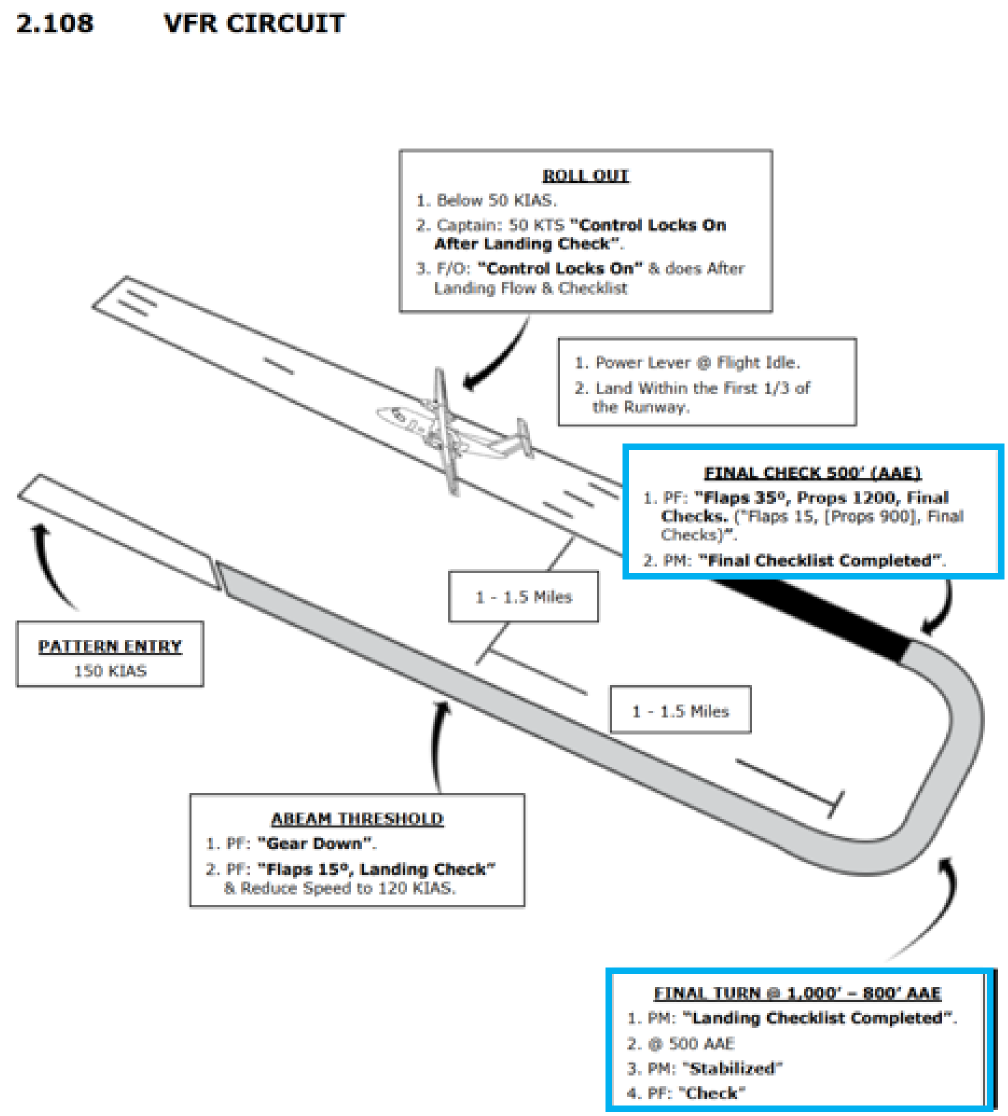
36 Ibid., paragraph 2.35.3 "Normal Landing," p. 2-144.

37 Ibid., paragraph 2.108 "VFR Circuit," p. 2-243.

Figure 6. Diagram of a VFR circuit (Source: Air Inuit Ltd., Combined Standard Operating Procedures — Dash 8 Section 2, Amendment 14 (15 February 2019), paragraph 2.108, p. 2-243, emphasis by the TSB)



1.17.1.2.3 Differences in stabilized approach guidelines

The investigation determined that there were differences between the operations manual and the SOPs (Table 3), as well as between the various sections of the SOPs (Table 4).

Table 3. Differences between the operations manual and the standard operating procedures

Operations manual	Standard operating procedures
Paragraph 3.18: airspeed between Vref and Vref + 20 KIAS at stabilized approach gate.	Section 2.34.17 (Stabilized Approach Factors): reference speed of 120 KIAS at stabilized approach gate, with a deviation tolerance of −5 KIAS and +10 KIAS.
Paragraph 3.18: rate of descent is not greater than 1000 fpm at stabilized approach gate.	Section 2.34.17 (Stabilized Approach Factors): normal sink rate of 500–800 fpm at stabilized approach gate.

Paragraph 3.18: all checklists must be completed by the stabilized approach gate.	Section 2.35.3 (Normal Landing): selecting flaps at 35°, which triggers the final check, is done when landing is assured, which may be when the aircraft is lower than the stabilized approach gate.
	Section 2.108 (VFR circuit diagram): “flaps 35°” is requested after the ”Stabilized” call at 500 feet AAE.

Table 1. Differences between standard operating procedures

Standard operating procedures	Standard operating procedures
Section 2.34.17 (Stabilized Approach Factors): the aircraft must be in the landing configuration by the stabilized approach gate.	Section 2.35.3 (Normal Landing): selecting flaps at 35°, which triggers the final check, is done when landing is assured, which may be when the aircraft is lower than the stabilized approach gate.
	Section 2.108 (VFR circuit diagram): “flaps 35°” is requested after the ”Stabilized” call at 500 feet AAE.
Section 2.34.17 (Stabilized Approach Factors): flaps must be set at 15° or 35° by the approach gate and the aircraft must be stabilized in the landing configuration by 500 feet AAE.	Section 2.35.3 (Normal Landing): selecting flaps at 35°, which triggers the final check, is done when landing is assured, which may be when the aircraft is lower than the approach gate.
	Section 2.108 (VFR circuit diagram): “flaps 35°” is requested after the ”Stabilized” call at 500 feet AAE.
Section 2.35.2 (Final Checklist): flaps at 35° is requested at no lower than 500 feet AAE.	Section 2.35.3 (Normal Landing): selecting flaps at 35°, which triggers the final check, is done when landing is assured, which may be when the aircraft is lower than the stabilized approach gate.
	Section 2.108 (VFR circuit diagram): “flaps 35°” is requested after the ”Stabilized” call at 500 feet AAE.

1.17.1.3 Coordination with flight attendant

The CARs require that, before each takeoff and landing, procedures be in place to ensure the safety of persons on board the aircraft. In the case of aircraft like the DH8C, the flight attendant must ensure that all passengers have fastened their safety belts, the back of each seat is in the upright position, and all chair tables and carry-on baggage are stowed.[38]

In the Flight Attendant Manual and the SOPs, Air Inuit implemented procedures to advise pilots of the cabin status before takeoffs and landings. Pilots must not begin takeoff until the green indicator light for the passenger announcement (PA) system is no longer illuminated in the cockpit.

The descent checklist states that, before landing, pilots must sound a chime to signal that the descent is about to begin. From that point on, the flight attendant must prepare the cabin for landing. If more time is needed to prepare the cabin, the flight attendant must notify the captain well in advance.[39]

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38 Transport Canada, SOR/96-433, *Canadian Aviation Regulations*, paragraphs 705.40(1)(b) and 705.40(1)(c).

39 Air Inuit Ltd., *Flight Attendant Manual — Section 2 Amendment 10* (12 July 2019), subsection 2.1.1, p. 2-5.

Approximately 10 NM before the destination, pilots must remember to sound the chime twice to notify the flight attendant that landing is imminent. The landing checklist includes a reminder of this notification. From that point on, the rules for critical phases of flight come into effect, and the cockpit is considered sterile.[40] The flight attendant must contact the pilots only in case of an emergency or a situation affecting flight safety.[41] As an example of an emergency requiring communication with pilots during a critical phase of flight, the manual mentions a visually confirmed engine fire or cabin fire. During training, these 2 emergencies are cited as the only situations that justify communication with the cockpit during a critical phase of flight. According to the training, once the call has been made that landing is imminent, the flight attendant will not advise the pilots that the cabin has not been secured.

In this occurrence, no descent notification was given. The investigation also determined that this omission was not unique to this flight, and there were instances in which the cabin was not prepared when the 10 NM notification was given. To deal with descent notification omissions, flight attendants developed a practice of noticing the descent so that they could prepare the cabin. The flight attendant in this occurrence noticed the descent and prepared the cabin.

1.17.2 Transport Canada Civil Aviation — Regulatory oversight

TCCA's surveillance program "verifies that enterprises are complying with regulatory requirements and that they have effective systems in place to ensure they comply with regulatory requirements on an on-going basis."[42] The program includes "assessments, program validation inspections (PVIs) and process inspections [PIs]."[43]

The assessments are used to verify whether an enterprise's SMS enables it to maintain compliance with regulatory requirements. PVIs provide system surveillance and an overall review of the enterprise; they use sampling methods to verify whether the enterprise can remain in compliance with regulatory requirements on an ongoing basis. PIs are inspections that focus on one or more specific processes. They enable the verification that the processes are meeting regulatory requirements and working properly. The frequency of these inspections depends on the type of operation, the turnover rates for the company's key personnel, the compliance history, and the nature of previous findings, amongst other things. In Air Inuit's case, an assessment was done in May 2015, according to TCCA's surveillance plan,. This assessment resulted in 5 findings related to SMS components. Four PIs that were not scheduled in the surveillance plan were then conducted. Two inspections of flight attendant ratings and training records were conducted in November 2016, and 2 in-

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40 Ibid., *Section 3 Amendment 10* (12 July 2019), subsection 3.18.1, p. 3-29.

41 Ibid.

42 Transport Canada, Advisory Circular (AC) SUR-004: Civil Aviation Surveillance Program (Issue 01: 19 November 2015), section 3.0.

43 Ibid.

flight inspections on the DH8C were conducted, in April 2016 and January 2018. These inspections did not result in any findings.

In May 2019, in accordance with TCCA's surveillance plan, a scheduled PI was conducted regarding flight dispatching and flight attendant procedures. During this inspection, 1 finding was noted with regard to procedural deviations by flight attendants, primarily in relation to passenger briefings.

After each inspection that resulted in findings, the company submitted corrective action plans, which were accepted by TCCA before the next inspection.

In addition, throughout the year, Air Inuit is involved in several certification activities, including the addition of aircraft and special authorizations on the certificate, SOP reviews, and approval of manuals, training programs, and pilot proficiency check scenarios. These certification activities usually include a verification of regulatory requirements. Consequently, apart from the activities in its surveillance program, TCCA also provides safety oversight through the certification activities.

TCCA inspectors occasionally receive training specific to an aircraft type. When inspectors take training provided by an operator, they assess the training quality and determine whether it meets CARs expectations. TCCA assessed some of Air Inuit's theoretical training, including theoretical training on the DH8C, in 2015, 2017, and 2020, and did not find any non-compliance.

1.18 Additional information

1.18.1 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[44] entitled "Dash 8 Q400 Pitch Awareness." 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 power rather than the increase of the pitch attitude near the ground.

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

This video was not part of Air Inuit's training program. However, the captain had recently watched this video. The first officer had not watched the video as part of his initial training.

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

After several incidents involving aft fuselage strikes, the manufacturer released a service letter on 11 September 2008.[45] This service letter was intended solely for DH8D 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 Figure 5).

The manufacturer also recommended managing the rate of descent below 200 feet AGL by managing the power. The letter also made reference to the training video and suggested that operators offer initial and recurrent training on pitch awareness.

Although the service letter was intended only for DH8D operators, and was therefore not sent to DH8C operators, Air Inuit included standard 5- and 6-degree pitch awareness calls in its SOPs, and stressed the importance of pitch awareness and managing the rate of descent using power.

1.18.2 Stabilized approaches

1.18.2.1 Description

As established in previous investigations conducted by the TSB[46] and by organizations in other countries, unstabilized approaches pose a high risk to aviation operations.

According to Civil Aviation Safety Alert (CASA) 2015-04, "Rushed 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." [47]

Based on the findings and conclusions of the Go-Around Safety Forum published on 26 June 2013, the FSF indicated in its final report on the *Go-Around Decision-Making and Execution Project* that "Failure 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."[48]

The report adds, "Go-arounds, although considered a normal flight maneuver, are rare."[49] 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

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

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

47 Transport Canada, Civil Aviation Safety Alerts (CASA), No. 2015-04: Stabilized Approach, 6 August 2015.

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

49 Ibid., section 3.3, p. 4.

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.[50]

1.18.2.2 Benefits of a stabilized approach

The safety benefits derived from a stabilized approach have been recognized by many organizations, including ICAO, the FAA, the European Aviation Safety Agency, and TCCA.[51] According to the FSF,[52] some of the benefits are

- increased flight crew situational awareness;
- more time and attention for monitoring ATC communications, weather conditions, and systems operation;
- more time for monitoring and backup by the PM;
- 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 Risks of an unstabilized approach

The FSF, following the recommendations of its Approach-and-Landing Accident Reduction (ALAR) Task Force, created and distributed an ALAR tool kit, which was intended to reduce the number of ALAs. In the tool kit, the FSF stated that the leading cause of ALAs was unstabilized approaches that continue to landing.

Unstabilized approaches require constant monitoring of flight parameters such as airspeed, approach angle, and visual references, as well as frequent adjustments to maintain appropriate flight parameters.

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

51 Transport Canada, Civil Aviation Safety Alerts (CASA), No. 2015-04: Stabilized Approach, 6 August 2015.

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

Of the 292 accidents recorded by the International Air Transport Association (IATA) from 2015 to 2019:[53]

- 57% occurred during the landing phase;
- 17% had an unstabilized approach as a causal factor; and
- 7% involved an aft fuselage strike.

Research conducted in 2013 indicated that 3% to 4% of all approaches are unstabilized, and 97% of these are continued to a landing.[54]

TSB aviation investigation A12Q0161, which examined a similar accident involving a DH8C that sustained a hard landing and aft fuselage strike in 2012, linked the unstabilized approach to situational awareness. In that occurrence, the workload associated with conducting an unstabilized approach reduced situational awareness. The PF did not notice the aircraft's energy deficit, nor did the PM anticipate or perceive the action of the PF, who reduced the power 4 seconds before landing. The attention of both pilots was focused outside the aircraft. Neither pilot could refocus attention inside the cockpit in time to understand the aircraft configuration and subsequently react to prevent the hard landing. Neither of the pilots in that occurrence had seen the manufacturer's training video.

In its investigation report on a controlled-flight-into-terrain accident in Resolute Bay, Nunavut, in 2011,[55] the TSB identified the need to reduce the incidence of unstabilized 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 , TC provided data from some CARs Subpart 705 operators and the results of internal process bulletin (IPB) 2016-01, showing that the rate of unstabilized approaches that continue to a landing had decreased significantly since 2014. Also, TCCA'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 Transport Canada'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 assessed as Fully Satisfactory.[56]

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53 International Air Transport Association, "Safety Report 2019," Issue 56 (April 2020).

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

55 TSB Aviation Investigation Report A11H0002.

56 Reassessment of the response to TSB Recommendation A14-01, at https://www.bst.gc.ca/fra/recommandations-recommendations/aviation/2014/rec-a1401.html.

1.18.3 Transport Canada safety alerts

In response to TSB Recommendation A14-01, TCCA published a CASA entitled "Using SMS to Address Hazards and Risks Associated with Unstable Approaches" (CASA No. 2014-03) in June 2014.

The purpose of the CASA was, in part:

> To request Canadian air operators operating under Subpart 705 of CARs that they use—on a voluntary basis—their existing Safety Management System (SMS) to address and mitigate hazards and risks associated with unstable approaches[.][57]

TCCA has designed a follow-up initiative to measure the effectiveness of CASA No. 2014-03. Specifically, the purpose of IPB 2016-01 is to examine an operator's assessment of unstabilized approaches using its SMS and, where applicable, review established mitigations and the extent, type, and frequency of interventions for unstabilized approaches.

On 06 August 2015, TCCA released CASA No. 2015-04, entitled "Stabilized Approach."[58] This CASA was intended for air operators certificated under subparts 702, 703, 704, and 705 of the CARs as well as private operators registered under Subpart 604. Its purpose was "to stress the importance of, and to outline the elements of a stabilized approach."[59]

In CASA No. 2015-04, TCCA recommended that stabilized approach procedures should "include the requirement for a 'Stable' or 'Unstable' call at the appropriate gate […]. Furthermore, the application of the stabilized approach concept should be supported by non-punitive go-around policies."[60]

In March 2016, TCCA conducted an assessment of the use of Air Inuit's SMS to deal with hazards and risks associated with unstable approaches. TCCA noted that Air Inuit had previously used its SMS to deal with unstable approach issues in 2011 and that risk mitigation measures had already been put in place, such as a "stable" approach callout in the SOPs and a no fault/no blame go-around policy for unstable approaches.

1.18.4 Training program

CARs subsection 705.124(1) requires that

> [e]very air operator shall establish and maintain a training program that is:
>
> **(a)** designed to ensure that each person who receives training acquires the competence to perform the person's assigned duties; and

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57 Transport Canada, Civil Aviation Safety Alert (CASA) No. 2014-03: Using SMS to Address Hazards and Risks Associated with Unstable Approaches (27 June 2014).

58 Transport Canada, Civil Aviation Safety Alerts (CASA) No. 2015-04: Issue no. 01: Stabilized approach (06 August 2015).

59 Ibid., Issue no. 02: Stabilized approach (05 August 2019).

60 Ibid., p. 4.

> **(b)** approved by the Minister in accordance with the *Commercial Air Service Standards* [...][61]

For level C and D training programs, the *Commercial Air Services Standards* (CASS) list the training elements to be covered, which include[62]

- use of airplane checklists;
- engine, airplane, and cargo fire on the ground and while airborne;
- system, equipment, and flight control failures;
- loss of pressurization and emergency descent;
- pilot incapacitation;
- all types of instrument approaches;
- a visual flight rules training program.

The purpose of a training program is to enable the trainees to acquire the skills needed to perform the duties they are assigned. These training programs use SOPs specific to each operator. By using the SOPs, the training establishes practices that mitigate possible ambiguities and contradictions among written procedures.

Recurrent training promotes the retention and ongoing development of acquired skills and is intended to correct, if necessary, any adaptations that do not comply with procedures. In recurrent training, either a level C or D program, a CARs Subpart 705 operator can decide whether to cover all training elements over a cycle that may extend up to 3 years. In its training program, Air Inuit used a 2-year cycle for recurrent training. The training program specified that all initial training elements would be covered within a 2-year cycle.

The captain received his initial training in 2015. He then took recurrent training every 6 months, completing 2 cycles of 2 years each. During these training cycles, the captain did not receive several required elements, including some elements of VFR flight training, and other elements concerning airplane and cargo fires on the ground and while airborne, loss of pressurization, and pilot incapacitation. The first officer had received all training elements as part of his initial training.

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[61] Transport Canada, SOR/96-433, *Canadian Aviation Regulations*, subsection 705.124(1).

[62] Transport Canada, *Commercial Air Services Standards* (CASS), section 725.124.

1.18.5 Human factors

1.18.5.1 Situational awareness

Situational awareness is "the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the near future."[63] There are 3 levels of situational awareness:[64]

- **Level 1 – Perception**: perceiving critical factors in the environment
- **Level 2 – Understanding**: understanding what those factors mean
- **Level 3 – Projection**: understanding how these factors will evolve over time

1.18.5.2 Perceived risk

The results of a study into pilots' experiences conducting unstabilized approaches and go-arounds were reported in the April 2013 issue of *Aero Safety World.*[65] More than 2000 pilots were asked to provide detailed accounts of recent experiences with approaches that were unstabilized below the stabilized approach altitude and that either resulted in a go-around or were continued to a landing.

The study found that pilots were more likely to continue with unstabilized approaches in VMC and in the absence of environmental factors that might increase operational complexity, such as wind shear, turbulence, and contaminated runways. The authors suggest that these factors increase the pilot's perception that an approach can be salvaged and reduce his perception of the risk.

1.18.5.3 Information processing

Pilots work in a complex environment that requires monitoring of multiple sources of information of different types. When pilots receive information about the environment that reflects what they are expecting, they tend to react quickly and accurately. However, when they receive information that is contrary to their expectations, their reaction is slower and may be inappropriate.[66]

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63 M.R. Endsley, "Design and evaluation for situation awareness enhancement," Proceedings of the Human Factors Society 32nd Annual Meeting, Santa Monica, CA (1988), p. 97.

64 M. Kardos, "Automation Information Sharing and Shared Situation Awareness," Defence Science And Technology Organisation, Salisbury, Australia, Systems Sciences Lab (2004), p. 3.

65 J.M. Smith, D.W. Jamieson, and W.F. Curtis, "Why do we forgo the go-around?," *Aero Safety World (*April 2013), at https://flightsafety.org/asw-article/why-do-we-forgo-the-go-around/ (last accessed on 31 August 2020).

66 M.R. Endsley, "Situation Awareness in Aviation Systems" in: J.A. Wise, V.D. Hopkin and D.J. Garland (eds.), *Handbook of Aviation Human Factors*, Second Edition (Boca Raton, FL: CRC Press, 2010), pp. 12-1 to 12-22.

1.18.5.4 Workload

Excessive workload is when the performance of a task demands more resources than are available,[67] and it can result in degraded performance.[68] An increased workload can be caused by various factors, such as a change in weather conditions, a mechanical failure, or errors due to inattention.

A snowballing effect occurs when the workload builds on itself and increases at an accelerating rate;[69] errors that are inconsequential in themselves may increase the workload, which in turn can lead to further errors.[70]

A substantial increase in workload can narrow the field of attention, increase stress, and reduce working memory capacity.[71]

1.18.5.5 Inattentional deafness

Inattentional deafness is an operator's failure to perceive auditory stimuli during periods of high cognitive load.[72,73,74] It is primarily observed when performing cognitive or visual tasks[75] where workload is heavy,[76] when the operator is engaged in a task, or when he is multi-tasking.[77] The high cognitive load required by the main task leaves few cognitive resources available for secondary tasks, such as perceiving an aural alarm. The remaining cognitive resources are insufficient to enable a mental picture of the alarm to be activated in

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67 C. Gonzalez, "Task workload and cognitive abilities in dynamic decision making," *Human Factors*, Vol. 47, Issue 1 (2005), p. 1

68 E. Svensson, M. Angelborg-Thanderez, L. Sjöberg and S. Olsson, "Information complexity-mental workload and performance in combat aircraft,"., *Ergonomics*, Vol. 40, Issue 3 (1997), p. 13.

69 B.A. Berman and R.K. Dismukes, "Pressing the approach," *Aviation Safety World* (2006), p. 28.

70 Ibid., p. 32.

71 Ibid., p. 32.

72 J.S. Macdonald and N. Lavie, "Visual perceptual load induces inattentional deafness," *Attention Perception Psychophysiology*, Volume 73, (2011), doi: 10.3758/s13414-011- 0144-4.

73 S. Koreimann, B. Gula and O. Vitouch, "Inattentional deafness in music," *Psychological Research*, Volume 78 (2014), doi: 10.1007/s00426-014-0552-x.

74 F. Dehais, M. Causse, F. Vachon, N. Régis, E. Menant and S. Tremblay, "Failure to detect critical auditory alerts in the cockpit: Evidence for inattentional deafness," *Human Factors*, Volume 56, Issue 4 (2014), p. 634.

75 C.P. Janssen, R.M. van der Heiden, S.F. Donker and J.L. Kenemans, "Measuring susceptibility to alerts while encountering mental workload," Proceedings of the 11th International Conference on Automotive User Interfaces and Interactive Vehicular Applications: Adjunct Proceedings (September 2019), p. 416.

76 F. Dehais, M. Causse, F. Vachon, N. Régis, E. Menant and S. Tremblay, "Failure to detect critical auditory alerts in the cockpit: Evidence for inattentional deafness," *Human Factors*, Volume 56, Issue 4 (2014), p. 650.

77 Ibid., p. 635.

memory.[78] Given that piloting is a multi-tasking activity that can involve a heavy workload, it is likely that the flight crew occasionally misses aural alarms.[79]

1.18.5.6 Prospective memory

Prospective memory refers to the function that enables a person to perform an intended action in the future.[80] It is a form of long-term-memory retrieval, in which the individual must remember an intended action at the appropriate time[81] without actively storing the intention in working memory.[82] The action is remembered using time-based or event-based cues from the environment.[83] The following are 2 examples of the use of prospective memory during the occurrence flight:

- When the aircraft is 10 NM from the destination (retrieval cue), the double chime must be sounded to let the flight attendant know that landing is imminent.
- When the aircraft passes through the stabilized approach gate at 1000 or 500 feet AAE (retrieval cue), the pilot must check the flight parameters to ensure that they meet the stabilized approach criteria.

Prospective memory is influenced by several factors, including the importance imparted to the task, regardless of whether the cue is time-based or event-based.[84] This is explained by the fact that the main task (the task currently being performed) and environmental monitoring (to identify the cue) are competing for the attentional resources available. If the task in prospective memory is deemed less important, fewer attentional resources will be assigned to it, reducing the chances of perceiving the retrieval cue when it appears.[85]

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78 M. Causse, J.P. Imbert, L. Giraudet, C. Jouffrais and S. Tremblay, "The role of cognitive and perceptual loads in inattentional deafness," *Frontiers in Human Neuroscience*, Volume 10 (2016), p. 2.

79 F. Dehais, M. Causse, F. Vachon, N. Régis, E. Menant and S. Tremblay, "Failure to detect critical auditory alerts in the cockpit: Evidence for inattentional deafness," *Human Factors*, Volume 56, Issue 4 (2014), p. 635.

80 P.W. Burgess, A. Quayle and C.D. Frith, "Brain regions involved in prospective memory as determined by positron emission tomography," *Neuropsychologia*, Volume 39, Issue 6 (2001), p. 1.

81 D.M. McBride and J.C. Cutting, *Cognitive psychology: Theory, process, and methodology* (SAGE Publications, 2017), p. 138.

82 P.W. Burgess, A. Quayle and C.D. Frith, "Brain regions involved in prospective memory as determined by positron emission tomography," *Neuropsychologia*, Volume 39, Issue 6 (2001), p. 1.

83 Ibid., p. 2.

84 M. Kligel, M. Martin, M. McDaniel and G. Einstein, "Importance effects on performance in event-based prospective memory tasks", *Memory,* Volume 12, Issue 5 (2004), p. 15.

85 Ibid., p. 5.

1.18.5.7 Decision making and bias

Pilot decision making is essential to flight safety. Decision making can be defined as the correspondence between information and response,[86] in 4 steps:

1. seeking information in the environment;
2. analyzing information based on context and knowledge;
3. choosing an action plan by comparing the analyzed information with other potential action plans in long-term memory;
4. metacognition, which is the ability to assess one's own decision and its limits.[87]

In the occurrence flight, decision making was affected by uncertainty, time pressure, and information overload.[88] In that context, simplifying information lessens the pilot's cognitive load. In a complex situation, humans have a tendency to rely on mental shortcuts (i.e., heuristics and cognitive biases) to assess the environment and make decisions. Although shortcuts are efficient most of the time, when they are used in conjunction with ambiguous information, they can lead to poor decisions that result in dangerous situations.

1.18.5.7.1 Confirmation bias

When pilots seek additional information about a situation, they may seek only additional information that confirms their initial hypothesis and to interpret ambiguous cues in a manner that suits their objective. This is referred to as confirmation bias, and is explained by the following facts:

- It is cognitively demanding to manage conflicting information.
- Changing a decision and making a new one requires more cognitive resources than sticking with a wrong decision.

1.18.5.7.2 Plan continuation bias

Plan continuation bias is described as "a deep-rooted tendency of individuals to continue their original plan of action even when changing circumstances require a new plan."[89] Plan

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86 C.D. Wickens and J.G. Hollands, *Engineering psychology and human performance*, 3rd Ed. (Psychology Press, 1999), p. 294.

87 Ibid., pp. 295–296.

88 G. Klein, "Naturalistic decision making," *Human Factors,* Volume 50, Issue 3 (2008), pp. 456–460.

89 B.A. Berman and R.K. Dismukes, "Pressing the approach," *Aviation Safety World* (2006), p. 28.

continuation bias may be the result of an incorrect assessment of the situation,[90,91] an incorrect anticipation of the risks,[92] or an overestimation of one's ability to deal with the situation.[93] A pilot may overestimate the skills of other flight crew members and their capability to manage the new situation. For example, a PM who has more experience than the PF may decide to stick with a plan based on their own ability to manage the situation, without considering that the PF may not be able to manage the same situation. In other words, when there is a change in conditions, the pilot may not perceive the new data, or may interpret it incorrectly, and may underestimate the risks associated with the new conditions.

1.18.5.8 Crew resource management

Crew resource management (CRM) is the effective use of all available resources—human, hardware, and information—to conduct flights safely and efficiently. CRM includes skills, abilities, attitudes, communication, situational awareness, problem solving, and teamwork. CRM is linked to the cognitive abilities and interpersonal skills required to manage a flight. These cognitive abilities include the mental processes needed to establish and maintain accurate situational awareness, solve problems, and make decisions. Interpersonal skills are linked to communications and conduct associated with teamwork.

1.18.5.9 Threat and error management

Modern CRM incorporates TEM. The 3 core elements of TEM are threats, errors, and undesired aircraft states. Every flight has hazards that the crew must manage. These hazards, referred to as threats, increase flight risks and may include environmental threats (adverse weather conditions, runway contamination, etc.) or operational threats (short runways, etc.). TEM stresses the principles of anticipation, recognition, and recovery[94] and is based on the proactive detection of threats that could reduce safety margins. Crews can establish countermeasures during the planning stage or during flight, modifying the plan according to circumstances.

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90 S. Shappell, C. Detwiler, K. Holcomb, C. Hackworth, A. Boquet and D.A. Wiegmann, "Human error and commercial aviation accidents: an analysis using the human factors analysis and classification system," *Human Factors*, Volume 49, Issue 2 (2007), p. 239.

91 E.K. Muthard and C.D. Wickens, "Change detection after preliminary flight decisions: Linking planning errors to biases in plan monitoring," Proceedings of the Human Factors and Ergonomics Society Annual Meeting (September 2002), p. 1.

92 B. Léonore, V. Claude, F. Sophie, L. Fanny and N. Claude, "The Effects of Success Related Pressure on Information Processing Strategies and Plan Continuation Error," Proceedings of the International Symposium on Aviation Psychology (2009), p. 6.

93 L. Bourgeon, C. Valot, A. Vacher and C. Navarro, "Study of perseveration behaviors in military aeronautical accidents and incidents: Analysis of Plan Continuation Errors," Proceedings of the Human Factors and Ergonomics Society Annual Meeting (September 2011), p. 4.

94 A. Merritt and J. Klinect, "Defensive Flying for Pilots: An Introduction to Threat and Error Management," *The University of Texas Human Factors Research Project: The LOSA Collaborative* (Austin, Texas: 2006).

Effective error management is associated with specific behaviours by the flight crew, the most common being vigilance, a propensity to ask questions or provide feedback, and assertiveness. Although threats exist and errors occur during most flight segments, they are rarely accompanied by serious consequences, because the crew is managing them effectively. Effective risk management in the cockpit is intrinsically linked to effective CRM.

TCCA has developed new CRM training standards, which came into effect on 28 July 2017,[95,96] with an original implementation deadline 18 months later (31 January 2019); this deadline was then postponed to autumn 2019. Under these new standards, air operators are required to provide contemporary CRM training to flight crews, flight attendants, dispatchers, flight followers, ground crew, and maintenance personnel, on an initial and annual basis.

Air Inuit had updated its CRM training program, which complied with the new TCCA standard, and, at the time of the occurrence, the new training program had been given to all affected personnel.

1.19 Useful or effective investigation techniques

Not applicable.

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95 Transport Canada, SOR/96-433, *Canadian Aviation Regulations*, Commercial Air Services Standards, Standard 725 : Airline Operations – Aeroplanes, paragraph 725.124(39).

96 Transport Canada, Advisory Circular (AC) 700-042: Crew Resource Management (CRM), 2nd edition (14 March 2020).

2.0 ANALYSIS

There was no indication of airframe or engine failure, or system malfunction, during the occurrence flight. Furthermore, aircraft performance was not a factor in the occurrence. The flight crew was certified and qualified for the flight in accordance with existing regulations, and there were no indications that the crew's performance was degraded due to physiological factors such as fatigue. Consequently, the analysis will focus on preparation for the approach, particularly the resources (procedures, training, regulations, guidelines, and experience) available to the crew, and the execution of the approach.

2.1 Preparation for the approach

2.1.1 Crew resource management

The concept of crew resource management (CRM) is based primarily on communication. Since July 2017, Transport Canada Civil Aviation (TCCA) has gradually implemented its new standard, which requires air operators to provide contemporary CRM training to all company personnel who interact with the flight crew.

The investigation established that, in Air Inuit operations on the de Havilland DHC-8-314 (DH8C), the flight attendant is sometimes not notified of the descent. Flight attendants have adapted in order to mitigate these omissions and have learned to be attentive to cues that the aircraft is descending for a landing, so that they can prepare the cabin for landing.

On the occurrence flight, the flight crew was concerned about an aircraft departing from the Schefferville Airport (CYKL), a threat the crew had identified. As a result, the descent checklist was forgotten and the flight attendant was not given any descent warning. The flight attendant noticed the descent and prepared the cabin. Although the absence of descent warning may appear to be minor, the absence of communication with the cabin at the beginning of the descent was linked to the omission of the descent checklist.

Finding as to causes and contributing factors

The pilots forgot to perform the descent checklist and realized this at an inopportune time, when the pilot monitoring (PM) was providing a position report.

2.1.2 Cabin procedures

The cabin must be secured before each takeoff and landing to minimize the risk of injury. To ensure this, Air Inuit has implemented procedures for communications between pilots and flight attendants. According to the procedures, the flight attendant must contact the pilots only if the cabin is not secured before landing.

Although the Flight Attendant Manual instructs flight attendants to communicate directly with the pilots in an emergency or a situation affecting flight safety, flight attendant training emphasizes that communications must be limited in critical phases of flight. Flight attendants are instructed that the only 2 situations in which they can call the cockpit during a critical phase of flight is when they have visually confirmed a fire in an engine or in the cabin. Consequently, if the cabin is not secured because the descent warning is not sounded or for any other reason, according to the interpretation of the procedure for critical phases of flight, once the imminent landing notification has been given, the flight attendant will not notifiy the pilots that the cabin is not secured.

An unsecured cabin is a situation that affects flight safety. A hard or short landing, hard braking, or a landing incident may cause injuries to passengers if heavy objects are not secured or safety belts are not fastened.

Finding as to risk

If a procedure is interpreted in a way that limits communications concerning cabin safety, there is a risk that pilots will not be informed that the cabin has not been secured and that passengers will receive injuries on landing, particularly if there is an abnormal landing.

2.1.3 Approach stability monitoring

Prospective memory is a form of long-term-memory retrieval in which the individual must remember an intended action at the appropriate time without actively storing the intention in working memory. The memory is triggered by cues in the environment.

Verifying stabilized approach criteria at the approach gate is a prospective memory task: a crew must remember that, when it reaches the stabilized approach gate, it must ensure that the aircraft meets all stabilized approach criteria. Therefore, the crew must able to monitor the environment to identify when the aircraft passes the stabilized approach gate (retrieval cue in memory). This stabilized approach gate is different for each aerodrome.

Given that performing the main task and monitoring for the cue are competing for the attentional resources available, if there is no mandatory reminder of the retrieval cue during approach preparation, fewer attentional resources may be assigned to it, reducing the chances of the cue being perceived when it appears.

According to the standard operating procedures (SOPs), under normal conditions in visual meteorological flight conditions, the aircraft must be on a stabilized approach by the approach gate (500 feet above aerodrome elevation) at the latest, and the pilot must call out "Stabilized." In the occurrence flight, no call was made.

Finding as to risk

If there is no reminder of the altitude of the stabilized approach gate for each approach, this stabilized approach gate may be missed, and an unstabilized approach may be continued, increasing the risk of an approach-and-landing accident.

2.1.4 Standard operating procedures

According to the company operations manual, the aircraft must be configured for a landing at 500 feet above aerodrome elevation (AAE) at the reference landing approach speed (Vref) (deviation tolerance of −0 and +20 knots indicated airspeed [KIAS]), and all checklists must be completed by 500 feet AAE for a visual flight rules (VFR) approach and 1000 feet AAE for an instrument flight rules (IFR) approach.

According to the SOPs, the aircraft must be stabilized in the landing configuration at 120 KIAS (deviation tolerance of −5 KIAS and +10 KIAS) by 500 feet AAE. The SOPs also indicate that, during an instrument approach, flaps are lowered to 35° and the final checklist is performed when landing is assured. This means that, when weather conditions are near the approach minima, flap selection and the final checklist are often done below 500 feet AAE, in some cases at 250 feet AAE. Therefore, an IFR approach may be continued below 500 feet AAE although the flaps have not been set to the landing position and the final checklist has not been completed. Consequently, it is not possible to comply with the operations manual policy while following the procedures in the SOPs.

These contradictions between the stabilized approach policy in the operations manual, the stabilized approach criteria in the SOPs, and the approach procedures in the SOPs create ambiguities that leave room for interpretation.

The occurrence flight was conducting a visual approach; however, the SOPs do not describe procedures for this type of approach. Only VFR circuits are illustrated, with the flaps set to 35° at 500 feet AAE. For IFR approaches, according to the SOPs, the flaps may be selected below 500 feet AAE. It is therefore reasonable to conclude that, when the runway is in sight on a visual approach, late flap selection may also be permitted.

Finding as to causes and contributing factors

Given the ambiguities and contradictions in the stabilized approach guidelines, the captain interpreted that he was allowed to continue the approach below 500 feet AAE although the flaps had not been set to 35° and the final checklist had not been completed.

The interpretation of the ambiguities and contradictions in the stabilized approach guidelines was not unique to the occurrence flight. An examination of the information extracted from the aircraft's flight data recorder (FDR) revealed that 15.9% of the approaches conducted (23 of 144) were at a speed that exceeded the limit of the stabilized approach criteria at some point below 500 feet AAE. Since the analysis did not take into account the duration of these irregularities or the weather conditions when they occurred, some of these irregularities may have been very brief or due to moderate turbulence.

Discrepancies in guidelines make decision making more complicated. In a context of heavy workload and time pressures, as was the case in the occurrence flight, the resources available for decision making are limited. In that case, pilots take fewer factors into consideration and assesses fewer action plans. If, in addition, procedures are complex and contain discrepancies, pilots will have a tendency to rely on mental shortcuts and risk selecting procedural elements that confirm their plan and ignoring others.

Between 1994 and 2020, inconsistent or missing procedures were mentioned 39 times in various finding in Transportation Safety Board (TSB) aviation investigation reports . In many cases, the procedures had been reviewed by TCCA and no irregularities had been identified. These inconsistent or missing procedures give pilots the option of interpreting certain situations, and, at times, their interpretations reduce safety margins.

According to the Inspectors Manual and the official interpretation given in 2014, TCCA was required to assess the quality, consistency, accuracy, conciseness, clarity, relevance, and content of Air Inuit's SOPs. This assessment is done during certification activities such as the review of proposed changes to SOPs and during surveillance activities such as in-flight inspections. In 2016, an assessment was carried out specifically in response to Civil Aviation Safety Alerts 2014-03 and 2015-04, concerning Air Inuit's stabilized approach policy and procedures. During these assessments, TCCA did not identify any specific issues with the operator's stabilized approach guidelines.

The *Canadian Aviation Regulations* (CARs) require that SOPs contain specific elements. As a result, some SOPs are accepted after verifying that they include those elements, without verifying their quality, consistency, accuracy, conciseness, clarity, relevance, and content.

Finding as to risk

If TCCA does not assess the quality, consistency, accuracy, conciseness, clarity, relevance, and content of SOPs,the procedures may be ineffective, increasing risks to flight operations.

2.1.5 Flight crew training

Although some procedures may be ambiguous or contradictory, if training covers those issues, then the practices in place will usually mitigate the risks linked to those ambiguities and contradictions. An air operator's flight crew training is complex because there are several training elements involved: initial training, which is intended to provide crew members with the knowledge and skills they need to do their job, and recurrent training, which is intended to correct adaptations that do not comply with procedures, as necessary.

In initial training, all training elements must be covered. The captain and first officer had covered all training elements in their initial training in 2015 and 2019, respectively.

In recurrent training for *Canadian Aviation Regulations* Subpart 705 operators, training elements may be covered over a cycle extending up to 3 years. Air Inuit used a 2-year cycle for its recurrent training. The first officer had not taken any recurrent training after initial training. The captain had been taking recurrent training cycles since 2016. The investigation determined that, during the last 2 training cycles, the captain had not received many of the required training elements, including airplane and cargo fires on the ground and while airborne, loss of pressurization, pilot incapacitation, and some elements of VFR flight training .

Finding as to risk

If required training elements are not included in recurrent training, there may be procedural deficiencies or deviations, increasing risks to flight operations.

2.1.5.1 Regulatory oversight of training

The scope of regulatory oversight activities carried out at Air Inuit in 2015, 2016, 2018, and 2019, did not include checking the training elements covered in a simulator, as noted in training records. During the May 2019 scheduled process inspection (PI), although 4 pilot training records were verified, those verifications only confirmed that all training sessions had been completed, determined their length, and ensured that they had not expired. TCCA program validation inspections (PVIs) and PIs do not verify the content of pilot training. In other words, the inspections do not verify whether the pilots have received, at a minimum, training on all the elements listed in the *Canadian Aviation Regulations*, such as VFR flight training, in this case. The investigation revealed that some elements of recurrent training had not been provided.

Finding as to risk

If TCCA's surveillance plan does not verify the content of crew training, deviations may not be identified and procedural deficiencies or deviations may not be corrected, increasing risks to flight operations.

2.1.5.2 Manufacturer-suggested training

Following a series of aft fuselage strikes, the aircraft manufacturer identified managing the rate of descent during landing as an issue. To counter a pilot's instinctive reaction to nose up the aircraft in order to slow down a descent that is too fast near the ground, further training and practice are needed to anchor the manoeuvre in procedural memory. To that end, the manufacturer produced a video entitled "Dash 8 Q400 Pitch Awareness."

This video mentions that, although the DH8C is shorter than the DH8D, when the gear oleos are compressed, the fuselage of the DH8C touches the ground at a pitch attitude similar to that of the DH8D. Therefore, the procedures and techniques shown in the video also apply to the DH8C series. To reduce a rate of descent that is too high when an aircraft is close to the ground, the manufacturer recommends that pilots resist the temptation to increase the pitch attitude, and instead increase power and keep the pitch at 6°.

In 2008, the manufacturer published a service letter on managing the DH8's energy; however, this letter was intended solely for DH8D operators and was not sent directly to DH8C operators. Nevertheless, Air Inuit had included the recommended standard pitch awareness calls for the DH8D in its SOPs for the DH8C.

Finding as to risk

If information that is essential to flight operations for a particular aircraft type are not distributed directly to the operators of that aircraft type, there is a risk that those operators will not have all the resources needed to develop procedures and training that will prevent incidents or accidents.

2.2 Approach execution

To understand why the approach was continued, the context must be examined, along with the crew's perception and understanding of the situation as they were making decisions, because situational awareness is an integral part of a pilot's decision-making process.

2.2.1 Plan continuation bias

The results of Flight Safety Foundation studies show that a pilot's level of risk perception depends as much on weather conditions as it does on flight parameters. For example, during visual approaches, pilots are more likely to continue an unstabilized approach because they perceive less risk in salvaging the approach.

On the occurrence flight, as the pilots were approaching CYKL, they had to slightly modify their plan because they did not see the airport when they expected to. Once they had the airport in sight, they returned to their initial plan of conducting a visual approach and decided to continue the approach, although the aircraft's height and speed were higher than planned. From that point on, the pilots focused primarily on their individual tasks and on information—airspeed, rate of descent, and altitude—that they deemed critical to completing this visual approach.

Specifically, the pilot flying (PF) was attempting to reduce the airspeed so that the aircraft could be configured for a landing. The PM was busy completing checklists, ensuring that the cabin was secured for a landing, and advising the PF on how to manage the airspeed. Furthermore, the PM interrupted his position report when he realized that the descent checklist had not been completed. The PM contacted the flight attendant to ensure that the cabin was secured.

Finding as to causes and contributing factors

Communicating with the flight attendant to confirm the cabin status and performing the descent checklist during final approach added to the pilots' workload, which was already heavy.

Faced with a heavy workload, pilots tend to use mental shortcuts and take fewer elements into consideration in decision making. They also tend to assess fewer scenarios and underestimate risks.

The decision to continue with the landing can be explained by a combination of confirmation bias and a plan continuation bias. The fact that the PF successfully completed a series of tasks may have reinforced the PM's impression that they had the situation under control. Since changing a plan requires more effort than sticking with the original plan, and since the captain had little time and few resources available for decision making, the PM and PF gave more weight to the signs that they had the situation under control than to the signs suggesting that they needed to change the plan. This confirmation bias anchored them in a plan continuation bias.

Finding as to causes and contributing factors

The combination of the visual conditions and the plan continuation bias prompted the pilots to continue managing height and speed deviations past the stabilized approach gate.

2.2.2 Managing workload during final approach

The crew felt the heavy workload but was attempting to manage the tasks to be completed. However, neither of the flight crew members heard the alert from the terrain awareness and warning system (TAWS) at 500 feet AAE, owing to inattentional deafness. A heavy workload leaves few attentional resources available to monitor the environment. Although the aural alert was loud enough to be heard, the pilots did not have sufficient cognitive resources available to enable a mental picture of the alarm to be activated in their memory, and therefore did not perceive the alert.

Air Inuit had a no fault/no blame go-around policy for unstable approaches. However, to facilitate a go-around decision, the crew must be able to identify an unstabilized approach by the stabilized approach gate. According to the SOPs, when the aircraft passed 500 feet AAE, the speed should have been 120 KIAS (with a deviation tolerance of −5 KIAS or +10 KIAS). Furthermore, all checklists, except the final checklist, should have been completed. An analysis of the FDR data determined that, when the aircraft passed the stabilized approach gate (500 feet AAE), its speed was approximately 144 KIAS and decelerating, the flaps had not yet been lowered to 15°, the descent checklist was being performed, and the final checklist had not yet been started.

Finding as to causes and contributing factors

When the aircraft passed 500 feet AAE, the pilots, who were dealing with a heavy workload, passed the stabilized approach gate without noticing it and continued the approach, which was de facto unstable.

The crew was actively managing the situation below 500 feet AAE. The PF succeeded in slowing down the aircraft to the desired speed (Vref), and the final checks were done at 100 feet AAE. Although the aircraft was fully configured and had intercepted the nominal 3° slope, the airspeed was dropping quickly below Vref and the aircraft was losing energy because power was still at idle.

Finding as to causes and contributing factors

At the time of the flare, the aircraft no longer had enough energy to stop the rate of descent solely by increasing the pitch attitude.

The PM noticed the low energy and asked the PF to increase power.

The PF increased power slightly and, at the same time, reacted instinctively with a pronounced pitch-up control input (2 seconds before impact). Similar to the occurrence in investigation report A12Q0161, in this occurrence the PF had not seen the video recommending that aircraft energy be managed by increasing power while limiting the pitch attitude.

The aircraft's pitch changed from 2° to 9° in less than 2 seconds, and the PM did not have enough time to prevent the hard landing and aft fuselage strike.

Finding as to causes and contributing factors

The instinctive reaction to increase the pitch attitude, combined with the hard landing, resulted in the aft fuselage striking the runway, causing major damage to the aircraft's structure.

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. The pilots forgot to perform the descent checklist and realized this at an inopportune time, when the pilot monitoring was providing a position report.

2. Given the ambiguities and contradictions in the stabilized approach guidelines, the captain interpreted that he was allowed to continue the approach below 500 feet above aerodrome elevation although the flaps had not been set to 35° and the final checklist had not been completed.

3. Communicating with the flight attendant to confirm the cabin status and performing the descent checklist during final approach added to the pilots' workload, which was already heavy.

4. The combination of the visual conditions and the plan continuation bias prompted the pilots to continue managing the height and speed deviations past the stabilized approach gate.

5. When the aircraft passed 500 feet above aerodrome elevation, the pilots, who were dealing with a heavy workload, passed the stabilized approach gate without noticing it and continued the approach, which was de facto unstable.

6. At the time of the flare, the aircraft no longer had enough energy to stop the rate of descent solely by increasing the pitch attitude.

7. The instinctive reaction to increase the pitch attitude, combined with the hard landing, resulted in the aft fuselage striking the runway, causing major damage to the aircraft's structure.

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 a procedure is interpreted in a way that limits communications concerning cabin safety, there is a risk that pilots will not be informed that the cabin has not been secured and that passengers will receive injuries on landing, particularly if there is an abnormal landing.

2. If there is no reminder of the altitude of the stabilized approach gate for each approach, this stabilized approach gate may be missed, and an unstabilized approach may be continued, increasing the risk of an approach-and-landing accident.

3. If Transport Canada Civil Aviation does not assess the quality, consistency, accuracy, conciseness, clarity, relevance, and content of standard operating procedures, the procedures may be ineffective, increasing risks to flight operations.

4. If required training elements are not included in recurrent training, there may be procedural deficiencies or deviations, increasing risks to flight operations.

5. If Transport Canada Civil Aviation's surveillance plan does not verify the content of crew training, deviations may not be identified and procedural deficiencies or deviations may not be corrected, increasing risks to flight operations.

6. If information that is essential to flight operations for a particular aircraft type are not distributed directly to the operators of that aircraft type, there is a risk that those operators will not have all the resources needed to develop procedures and training that will prevent incidents or accidents.

3.3 Other findings

These items could enhance safety, resolve an issue of controversy, or provide a data point for future safety studies.

1. Data from the cockpit voice recorder were not secured after the accident, and the accident was not reported to the TSB until the next day. Data from the cockpit voice recorder specific to the accident were nevertheless available to TSB investigators.

4.0 SAFETY ACTION

4.1 Safety action taken

4.1.1 Air Inuit

Air Inuit took the following safety actions:

- After the accident, an internal bulletin was issued to pilots regarding stabilized approaches and best practices for the pilot monitoring.
- The video entitled "Dash 8 Q400 Pitch Awareness" was included in all initial and recurrent training.
- The review of pitch awareness during preparation briefings for simulator training was improved.
- An interim amendment of the standard operating procedures, regarding stabilized approaches and low energy awareness, was issued through an internal bulletin.
- The Dash 8 standard operating procedures were revised to improve guidelines on several subjects, including visual approaches and identifying stabilized approach gates.
- The training program was revised to ensure that all training elements are covered within the 2-year cycle for recurrent training.

This report concludes the Transportation Safety Board of Canada's investigation into this occurrence. The Board authorized the release of this report on 07 April 2021. It was officially released on 04 May 2021.