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

AIR TRANSPORTATION SAFETY INVESTIGATION REPORT A18Q0030

RUNWAY OVERRUN ON LANDING

Strait Air (2000) Ltd.
Beechcraft King Air A100, C-GJXF
Havre St-Pierre Airport, Quebec
26 February 2018

Canada

ABOUT THIS INVESTIGATION REPORT

This report is the result of an investigation into a class 2 occurrence. For more information, see the Policy on Occurrence Classification at www.tsb.gc.ca

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

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Executive summary

On 26 February 2018, a Beechcraft King Air A100 (registration C-GJXF, serial number B-159) operated by Strait Air (2000) Ltd. was conducting charter flight NUK107 under instrument flight rules, from the Sept-Îles Airport, Quebec, to the Havre St-Pierre Airport, Quebec, with 2 crew members and 6 passengers on board. The aircraft conducted an approach to Runway 08, which was snow-covered, while visibility was reduced due to heavy snow showers, and landed approximately 3800 feet beyond the threshold, at approximately 700 feet from the end of the runway. It continued its landing roll beyond the runway until it came to rest in a snowbank, approximately 220 feet beyond the end of the runway. The accident occurred in daylight, at 1120 Eastern Standard Time. The emergency locator transmitter, transmitting on 406 MHz, did not activate following the occurrence. The aircraft sustained substantial damage. Four of the occupants received minor injuries.

On the day of the occurrence, C-GJXF, which was conducting a series of flights as NUK107, touched down at Sept-Îles (CYZV), Quebec, at 0836 and took off again at 1049, bound for Havre St-Pierre (CYGV), Quebec. While on the ground at CYZV, the captain checked the weather conditions for the following flights, while the first officer (FO) was completing tasks to prepare the aircraft.

When the captain checked the aerodrome routine meteorological report (METAR) for CYGV, the reported visibility was ¾ statute mile (SM). Although this visibility was less than the visibility published in the *Canada Air Pilot* (CAP) for the LOC/DME RWY 08 approach[1] at CYGV, it was at the approach ban limit for this flight. Although the pilot was allowed to conduct the flight under instrument flight rules, it was reasonable for him to expect to have to perform a go-around or to divert to the alternate airport given the weather conditions forecast for CYGV and the surrounding area.

Landing minima in Canada

In designing instrument approaches, the published minimum visibility represents the minimum visibility at which a pilot on approach at the decision height (DH) or the minimum descent altitude (MDA) should be able to establish and maintain the visual reference required up until landing.

International Civil Aviation Organization (ICAO)[2] standards and recommended practices stipulate that an instrument approach shall not be continued unless the reported visibility is at or above the specified minima. These minima are published on approach charts based on the approach type and lighting.

Various civil aviation authorities throughout the world (such as the U.S. Federal Aviation Administration [FAA] and the European Union Aviation Safety Agency [EASA]) have established that the authorized visibility minima are those specified and published for the approach. Therefore, to determine whether an approach is authorized, it is simply a matter of comparing the reported visibility with the visibility published on the approach chart. Consequently, air traffic control (ATC) will not clear an aircraft for approach if the reported visibility is less than what is published on the approach chart.

In Canada, visibilities published on approach charts are provided for information purposes only.

To determine whether an aircraft can legally land at an aerodrome in Canada, consideration must first be given to the operational restrictions that apply to the aerodrome in question to ensure that the aerodrome is suitable for the manoeuvre being executed.[3] One of the determining factors is the aerodrome's operating visibility, which is defined in the *Canada Air Pilot* (CAP 5) in the general pages pertaining to operating minima.[4] This operating visibility limit is published in the *Canada Flight Supplement* (CFS), specifically in the box reserved for runway information. If an aerodrome's operating visibility limit is not

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1 Localizer (LOC) approach on Runway 08 using distance measuring equipment (DME).

2 International Civil Aviation Organization, Annex 6 to the Convention on International Civil Aviation, Eleventh Edition (July 2018), *Operation of Aircraft,* Part I, Chapter 4.

3 Transport Canada, SOR/96-433, *Canadian Aviation Regulations,* paragraph 602.96(2)(*b*).

4 NAV CANADA, *Canada Air Pilot* (CAP), CAP 5: Quebec (in effect from 01 February to 29 March 2018), p. 16-18.

published in the CFS, it means that operations are not authorized when visibility is less than ½ statute mile (SM).

Next, the minimum visibility for an approach ban must be calculated to determine whether the approach can continue to the DH or the MDA. This minimum visibility is calculated based on the visibility published on the approach chart, and varies depending on the type of operations:

- ¾ of the published visibility for commercial operators;
- ½ of the published visibility for commercial operators who have Operations Specification 019 regarding reduced visibility;
- ¼ SM for private operators, regardless of the approach being conducted.

According to this calculation, the minimum visibility for an approach ban in Canada is less than the visibility published on the approach chart in every case. Consequently, it is likely that, once at the DH or MDA, pilots are not able to establish the required visual reference that will help them make a safe landing.

Between December 2006[5] and December 2019, 31 incidents occurred following approaches conducted below the MDA with few visual references. Of these 31 incidents, 17 occurred during a landing in weather conditions where visibility was below what is published on the approach chart.[6] Furthermore, this situation continues to occur today: 9 of the 17 incidents have occurred within the past 5 years.

In Canada, due to the complexity and variations in minima based on the type of operations, it is difficult for ATC to determine whether the planned approach is banned. It will clear an aircraft for approach regardless of the published minima, contrary to what is done elsewhere in the world. Therefore, it is up to the captain to interpret the approach ban, and it is the captain who decides whether or not to continue with the approach.

In this occurrence, based on his interpretation of numerous conditions and exceptions relating to the approach ban, the captain incorrectly believed that he was allowed to conduct the approach. The first officer was aware that weather conditions were below the approach minima published in the CAP, but he did not understand all of the details involved in the approach ban. He was therefore unable to challenge the captain's decision to conduct the approach, and the captain continued the approach beyond the final approach fix when the reported visibility was below the approach ban minima. The captain then proceeded with the landing sequence without seeing or knowing the length of the remaining runway ahead and unable to accurately assess the aircraft's position.

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5 Implementation date for landing minima regulations (CARs section 602.128) and approach ban regulations (CARs section 602.129).

6 After these 17 occurrences, the TSB published the following aviation investigation reports: A08W0237, A08O0333, A09Q0203, A12Q0216, A14A0067, A15O0015, A15H0002, A16A0041, and A18Q0030.

Given that it was difficult for the flight advisory service and the aerodrome operator to determine whether the approach was banned, they could not inform the pilots that the approach was banned under the existing conditions, despite the fact that visibility was one quarter of what was published on the approach chart.

Therefore, if Transport Canada (TC) does not simplify approach and landing operating minima, flight crews may proceed with an approach that is actually banned, thereby increasing the risk of approach-and-landing accidents (ALAs), including runway overruns.

Consequently, the Board recommends that

> the Department of Transport review and simplify operating minima for approaches and landings at Canadian aerodromes.
> **TSB Recommendation A20-01**

In this occurrence, the approach ban in effect in Canada did not prevent the captain from continuing with the approach in weather conditions that were one third of the authorized visibility minima and one quarter of the visibility published on the approach chart. During the approach, when the aircraft arrived at the MDA, it was up to the pilot alone to determine whether or not he had established the visual reference required to continue the descent and landing. Therefore, it is reasonable to conclude that the approach ban was ineffective in stopping this approach while visibility on the ground was below the minimum required for an approach ban, which contributed to the runway overrun.

As this occurrence demonstrates, if there is no mechanism to stop an approach that is in fact banned, then pilots may choose to continue their approach, which increases the risk of an ALA.

Consequently, the Board recommends that

> the Department of Transport introduce a mechanism to stop approaches and landings that are actually banned.
> **TSB Recommendation A20-02**

Transport Canada regulatory oversight of standard operating procedures

Since 2019, TC has been requiring that all commercial air operators provide contemporary crew resource management (CRM) training. However, even though TC performs regular inspections of operators, these inspections are generally limited to documentation of the systems put in place by the company. For example, in this occurrence, the standard operating procedures (SOPs) complied with *Canadian Aviation Regulations* (CARs) requirements from a formal standpoint, but their effectiveness was not evaluated by TC. In this context, it is impossible to assess the effectiveness of training, CRM, threat and error management (TEM), decision making, and the degree to which SOPs are applied or complied with and their effectiveness on board aircraft during operations.

SOPs are not only guidelines for the general use of aircraft; they are universally recognized as fundamental to safe aviation operations, creating a framework for the application of concepts such as CRM and TEM. The Flight Safety Foundation (FSF) and the FAA have released several recommendations pertaining to SOPs to reduce the risk of an ALA.

Between 1999 and 2019, SOPs were mentioned in 113 findings as to causes, contributing factors, and risks in TSB aviation investigation reports. The deficiencies identified were primarily associated with a lack of precise directives, differences in procedures, and deviations from procedures. In this occurrence, a deviation from SOPs at a critical moment of the flight was a key factor that contributed to the runway overrun.

The Board is concerned that if TC does not provide oversight of flight operations by assessing the effectiveness of CRM, TEM, decision making and SOPs, including the degree of application and compliance, these SOPs may not be effective, increasing the risk of an accident, particularly an ALA.

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1.0 FACTUAL INFORMATION

1.1 History of the flight

On 26 February 2018, the 2 pilots who comprised the flight crew of the Beechcraft King Air A100 (registration C-GJXF, serial number B-159) operated by Strait Air (2000) Ltd. (Strait Air) arrived at the Québec/Jean Lesage International Airport (CYQB), Quebec, to begin their work day, which started at 0600.[7] That day, they were scheduled to conduct a series of 7 charter flights[8] (Figure 1). Departure for the first flight from CYQB was scheduled for 0710, and the last flight to CYQB was scheduled to arrive at the end of the day, at 1800.

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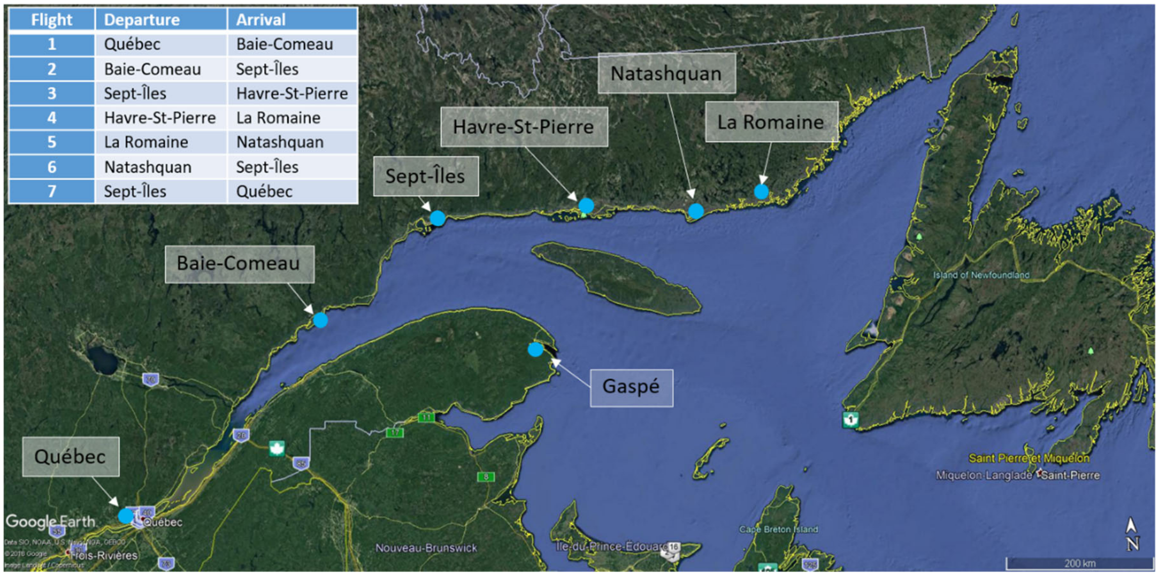
7 All times are Eastern Standard Time (Coordinated Universal Time minus 5 hours).

8 Flights subcontracted for Sky Jet M.G. Inc. (Air Liaison).

Figure 1. Flights operating as NUK107 on the occurrence date (Source: Google Earth, with TSB annotations)



At 0700, the flight crew began the series of flights operating as NUK107. The first flight, from CYQB to Baie-Comeau (CYBC), Quebec, and the next one, from CYBC to Sept-Îles (CYZV), Quebec, occurred without incident. The aircraft landed at CYZV at 0836.

The 3rd flight of the day, a departure from CYZV scheduled for 1000, was delayed by 46 minutes due to snow accumulation on the aircraft. The snow needed to be swept from the wings and the aircraft brought into a hangar to melt the remaining snow.

During this time, the captain was checking weather conditions for the next destinations. However, the various reports and forecasts were not printed, and the captain did not communicate these weather conditions to the first officer (FO). Given that visibility was reduced due to snow in the vicinity of Havre St-Pierre Airport (CYGY) and Natashquan Airport (CYNA), the captain changed the alternate airport indicated on the flight plan for the flight from CYZV to CYGV, Quebec, replacing Natashquan Airport (CYNA), Quebec, with Gaspé/Michel-Pouliot Airport (CYGP), Quebec. This information was not shared with the FO.

When the snow stopped, the aircraft was led to the terminal and refueled with 840 L of fuel. At 1049, proceeding with the series of flights, the aircraft took off from CYZV bound for CYGV, with 6 passengers on board. The captain was in the left seat and the FO was in the right seat. For the first 2 flights, the pilots were alternating roles between the pilot flying (PF) and the pilot [translation] "not flying, who is monitoring the flight parameters"[9] (PM). For this 3rd flight, the captain had the PF role.

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9 Strait Air (2000) Ltd., *Standard Operating Procedures — King Air A-100*, (25 September 2014), section 1.5, p. 1.2.

At 1059, the aircraft reached cruise flight at 11 000 feet above sea level (ASL). At 1108, 9 minutes after levelling off at 11 000 feet ASL, the crew began the descent and contacted Madeleine Radio[10] on the mandatory frequency (MF) to report that they planned to arrive at CYGV at 1118, which was 10 minutes later.

The flight crew obtained the weather conditions from the automated weather observation system (AWOS). At that point, the AWOS report indicated visibility of ¼ statute mile (SM) in heavy snow, and a vertical visibility of 400 feet.

At the flight crew's request, Madeleine Radio provided a runway condition report, which indicated that the centre of the runway was cleared to a width of 80 feet, but there were traces of dry snow, the Canadian runway friction index (CRFI[11]) was 0.38[12] and the remainder of the runway was covered in 30-inch snowdrifts. Madeleine Radio also informed the flight crew that snow removal trucks were operating on the runway.

At 1113, the aircraft crossed intermediate approach fix TARSI for the LOC/DME RWY 08 approach[13] (Appendix A), 14 nautical miles (NM) from the occurrence runway, while it was at 4500 feet ASL and on the optimal glide slope of 3°.

At 1116, when the crew informed Madeleine Radio that it was at 10 NM, on final approach, Madeleine Radio reported that a vehicle was still on Runway 08. One minute later, it reported that all of the vehicles were clear of the runway. The captain then activated the aircraft radio control of aerodrome lighting (ARCAL).

The flight crew set the flaps to 30% for the approach, dropped the landing gear and completed the pre-landing checklist. Speed was stabilized at 120 knots. All the crew had left to do was to set the flaps to the landing position and the propellers to the MAX RPM position, and reduce speed to the landing reference speed (V_{ref}) of 100 knots once landing was assured.

At 1118, the crew indicated that it was at final approach fix (FAF) ALKOV, 4 NM from the runway threshold. The aircraft was on an optimal glide slope of 3°, at 1430 feet ASL. Approximately 1 minute later, the PM made calls, in accordance with standard operating procedures (SOP), at 100 feet above the published minimum descent altitude (MDA) (which is 400 feet ASL or 286 feet above ground level [AGL]), then at the MDA. At the MDA, which the aircraft attained 0.74 NM (0.85 SM) from the threshold of Runway 08, the PM also told the PF that he had no visual contact. A few seconds later, still lacking visual contact, the PM

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10 Madeleine Radio is the Îles de la Madeleine flight service station.

11 The Canadian runway friction index (CRFI) is defined as "the average of the runway friction as measured by a mechanical or electronic decelerometer and reported through the Aircraft Movement Surface Condition Report (AMSCR)." (Source: NAV CANADA, TERMINAV terminology database, at http://www1.navcanada.ca/logiterm/addon/terminav/termino.php [last accessed 04 May 2020]).

12 The coefficient varies from 1 to 0. A coefficient of 1 corresponds to a vehicle's theoretical maximum decelerating capability on a dry surface, and a value of 0 indicates a low braking coefficient of friction.

13 Localizer (LOC) approach on Runway 08 with distance measuring equipment (DME).

asked the PF whether they should execute a go-around. The PF (and captain) then stated that he had visual contact and continued the descent below MDA in manual mode.

At 0.4 NM from the runway threshold, at approximately 125 feet AGL, the PM still could not see the runway lights and did not see the threshold of Runway 08 when they crossed it a few seconds later. After passing the precision approach path indicator (PAPI), the crew could not see anything for a brief moment. The crew then spotted a small section of paved runway approximately 20 feet long and 4 feet wide, slightly to the right of the aircraft's path. The PF aligned the aircraft with this visible portion of the runway, still unable to see the remainder of the runway or the runway lights.

At 1120, the aircraft crossed the threshold of Runway 08, flew over it for 20 seconds, and landed approximately 3800 feet beyond the threshold, 700 feet from the end of the runway. It bounced slightly and veered off the runway approximately 3 seconds later. The aircraft continued its roll beyond the runway until it came to rest in a snowbank, approximately 220 feet beyond the end of the runway.

At 1121, the captain informed Madeleine Radio that an overrun had occurred, and stated that assistance was not required. A few moments later, the FO began evacuating the passengers using the main door, at the rear of the aircraft.

By the time airport staff arrived at the scene, the passengers and crew had evacuated the aircraft. Airport staff assisted in transporting the crew and passengers to the terminal.

1.2 Injuries to persons

Table 1. Injuries to persons

Injuries	Crew	Passengers	Total in the aircraft	Others
Fatal	0	0	0	0
Serious	0	0	0	0
Minor	1	3	4	0
None	1	3	4	0
TOTAL	2	6	8	0

1.3 Damage to aircraft

The force of the impact with the snowbank caused the propellers to halt abruptly and the blades to bend backward. It also caused substantial damage to the left landing gear and wings (Figure 2).

Figure 2. Wreckage of the occurrence Beechcraft King Air A100 (Source: TSB)

1.4 Other damage

None.

1.5 Personnel information

Table 2. Personnel information

	Captain	First officer
Pilot licence	Airline transport pilot licence (ATPL)	Commercial pilot licence (CPL)
Medical expiry date	01 June 2018	01 September 2018
Pilot proficiency check (PPC) or pilot competency check (PCC) expiry date	01 April 2019	01 November 2018
Total flying hours	4288	395
Flight hours on type	2712	169
Flight hours on type in the last 90 days	76	54
Hours on duty prior to the occurrence	5.33	5.33
Hours off duty prior to the work period	24	72

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

The captain had 2 years of experience as captain of a Beechcraft King Air A100 when he joined Strait Air in July 2015. In July 2017, he was appointed chief pilot.

The FO had obtained his instrument flight rating on multi-engine aircraft in July 2017 and had completed FO training on the Beechcraft King Air A100 with Strait Air in September 2017.

The flight crew had been on continuous duty for approximately 5 hours and 20 minutes at the time of the occurrence. The investigation found no evidence that the captain's or FO's performance were diminished by fatigue or physiological factors.

1.6 Aircraft information

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. There was also no evidence to indicate airframe or engine failure or system malfunction before the overrun.

The aircraft was equipped with a Garmin 155XL global positioning system (GPS), mounted on the instrument panel, and a Honeywell 965-1198-005 enhanced ground proximity warning system (EGPWS). Both systems were removed from the wreckage and sent to the TSB Engineering Laboratory in Ottawa, Ontario, for data extraction. The investigation did not find any malfunctions in the aircraft's navigation equipment. The aircraft was fitted with a Bendix M-4C autopilot. There was no indication in the records that this system was unserviceable.

Table 3. Aircraft information

Manufacturer	Beech Aircraft Corporation
Type, model and registration	King Air A100, C-GJXF
Year of manufacture	1973
Serial number	B159
Certificate of airworthiness/flight permit issue date	10 December 1996
Total airframe time	19 559.1
Engine type (number of engines)	Pratt & Whitney PT6A-36 (2)
Propeller/Rotor type (number of propellers)	Hartzell HC-B4TN (2)
Maximum allowable takeoff weight	11 500 lb
Recommended fuel type(s)	Jet A, Jet A-1, Jet B
Fuel type used	Jet A-1

1.6.1 Weight and centre of gravity

According to flight documents, the aircraft's weight and centre of gravity were within the prescribed limits. The takeoff weight from CYZV was 11 454 pounds (the maximum allowable was 11 500 pounds) and the estimated landing weight at CYGV was 11 179 pounds (the maximum allowable was 11 210 pounds).

1.6.2 Landing distance

Data available in the aircraft flight manual (AFM)[14] assisted in calculating landing distances on a dry runway, and in determining the recommended distances for runways contaminated with snow, with a CRFI of 0.38 (Table 4). CRFI-recommended landing distances are published in the *Transport Canada Aeronautical Information Manual* (TC AIM).[15] They are available to a minimum CRFI of 0.18 (Appendix B).

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14 Beech Aircraft Corporation, *FAA Approved Airplane Flight Manual for the Beechcraft King Air A100* (amended February 2000).

15 Transport Canada, TP 14371, *Transport Canada Aeronautical Information Manual* (TC AIM), AIR – Airmanship (12 October 2017), section 1.6.6, tables 1 and 2.

Table 4. Landing distances (in feet). (Source: TSB calculations based on the aircraft flight manual)

Flaps	Dry runway		Contaminated runway (CRFI 0.38)	
	Obstacle 50 feet	Ground run	Obstacle 50 feet	Ground run
100%	2100	950	2900	1750
30%	2650	1250	3700	2250
0%	2900	1350	4050	2500

* All distances are calculated (rounded off to the nearest 50 feet) using distances on a dry runway, corrected for a landing reference speed of 100 knots and reverse thrust.

A precise calculation of landing performances was not carried out and, according to Strait Air SOPs[16], it is not required when the takeoff distance available is less than 4000 feet.

1.7 Meteorological information

The graphic area forecast issued at 0641 and valid beginning at 0700, indicated the presence of 2 low-pressure systems to the north and south of CYZV, which were moving in an easterly direction (Appendix C). Weather forecasts for the area east of CYZV while the occurrence flight was being conducted were:

- cloud cover at 3000 feet, with peaks at 14 000 feet;
- visibility 1 to 3 SM;
- light snow; and
- occasional altocumulus castellanus (ACC)[17] clouds with peaks at 14 000 feet reducing visibility to ⅜ SM, moderate snow showers and blowing snow, obscured ceiling associated with a vertical visibility of 300 to 600 feet AGL.

Aerodrome forecasts (TAFs) provide a description of the most likely weather conditions for aviation operations within a 5 NM radius around an aerodrome. The TAF for CYGV, issued on 26 February at 0830 and valid from 0900 to 2100 (Appendix D), was the following:

- winds 160° true (T) at 10 knots, gusting to 20 knots;
- prevailing visibility ¾ SM;
- light snow;
- obscured ceiling associated with a vertical visibility of 800 feet AGL.

According to the TAF, between 0900 and 1700, the prevailing visibility would temporarily be 3 SM in light snow, with scattered clouds at 800 feet and cloud cover at 1500 feet.

16 Strait Air (2000) Ltd., *Procédures d'utilisation normalisées — King Air A-100* (25 September 2014), section 2.11, p. 2.6.

17 "ALTOCUMULUS CASTELLANUS (ACC) – This is similar to altocumulus but with pronounced turrets building upward. It implies considerable instability in the cloud layer and may develop into cumulonimbus." (Source: Transport Canada, TP 9352, *Air Command Weather Manual*, Chapter 8: The Formation of Cloud and Precipitation, p. 8-19.)

Aerodrome routine meteorological reports (METARs) for CYGV are collected by AWOS. METARs and aerodrome special meteorological reports (SPECIs) based on data from an automatic system contain the qualifier AUTO.

The METAR AUTO for CYGV, issued at 1000 on 26 February 2018 (Appendix D) was:

- winds 170°T at 8 knots
- prevailing visibility 2½ SM
- light snow
- cloud cover at 900 feet AGL
- temperature −3 °C, dew point −3 °C
- altimeter setting 29.86 inches of mercury (inHg)

The METAR AUTO had a remark indicating variable visibility between 1¾ and 2½ SM (Appendix D).

Subsequently, before the departure from CYZV, 3 SPECI AUTO reports were issued at 1019, 1034, and 1043, indicating a significant reduction in visibility to ¾ SM in light snow (Appendix D). The captain was aware of these conditions.

When the aircraft took off from CYZV at 1049, snow showers at CYGV were intensifying and visibility was decreasing. The METAR AUTO for CYGV, issued at 1100, was:

- winds 190°T at 7 knots
- prevailing visibility ⅜ SM
- moderate snow
- cloud cover at 500 feet AGL
- temperature −3 °C, dew point −3 °C
- altimeter setting 29.84 inHg

Nine minutes later, at 1109, a SPECI AUTO was issued, indicating that visibility was reduced to ¼ SM in heavy snow, and an obscured ceiling associated with a vertical visibility of 400 feet. The crew obtained this SPECI AUTO by listening to the broadcast on the AWOS frequency during descent.

Forty minutes after the accident, the METAR AUTO for CYGV, issued at 1200, was:

- winds 160°T at 4 knots
- prevailing visibility ¼ SM
- heavy snow
- obscured ceiling associated with a vertical visibility of 600 feet
- temperature −2 °C, dew point −2 °C
- altimeter setting 29.81 inHg

1.8 Aids to navigation

The occurrence aircraft conducted the LOC/DME instrument approach for Runway 08 at CYGV. The CYGV LOC and DME were serviceable during the aircraft's approach and no NOTAMs were issued concerning their serviceability.

1.8.1 Instrument procedures

The crew was using the LOC/DME RWY 08 approach chart published in the general pages of the *Canada Air Pilot* (CAP) (Appendix A). In Canada, these approaches are designed based on criteria stated in *Criteria for the Development of Instrument Procedures* (TP 308/GPH 209), co-produced by Transport Canada (TC) and the Department of National Defence.

1.8.1.1 Visibility published in the *Canada Air Pilot*

When the LOC/DME RWY 08 approach chart was designed, the published minimum visibility was 1 SM (5280 feet), based on the aircraft's height above the runway at the MDA while flying the optimal glide slope of 3°. In all likelihood, this visibility should enable pilots to see the visual references required to proceed with the approach. However, in Canada, these visibilities are provided for information purposes only:

> Subject to the Approach Ban, published landing visibilities associated with all instrument approach procedures are advisory. Their values are indicative of visibilities which, if prevailing at the time of approach, should result in the required visual reference being established and maintained to landing. Subject to the Approach Ban, they are not limiting and are intended to be used by pilots to judge the probability of a successful landing when compared against available visibility reports at the aerodrome to which an instrument approach is being carried out.[18]

1.8.1.2 Operational approach and landing minima

The CAP states that

> CAR [*Canadian Aviation Regulations* section] 602 specifies take-offs for all Canadian aircraft as being governed by visibility only, approach restrictions by RVR [runway visual range] values only, and landings by published DH [decision height]/MDAs [minimum descent altitude] only[19] [Appendix E].

International Civil Aviation Organization (ICAO)[20] standards and recommended practices stipulate that an instrument approach shall not be continued unless the reported visibility is at or above the specified minima. This minima is published on approach charts based on the approach type and lighting.

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[18] NAV CANADA, *Canada Air Pilot* (CAP), CAP GEN (effective 01 February 2018), p. 26.

[19] Ibid., p. 15.

[20] International Civil Aviation Organization, Annex 6 to the Convention on International Civil Aviation, Eleventh Edition (July 2018), *Operation of Aircraft,* Part I, Chapter 4.

Unlike various civil aviation authorities throughout the world (such as the U. S. Federal Aviation Administration [FAA] and the European Union Aviation Safety Agency [EASA]), for which minimum visibility is that specified and published for the approach, Canada has chosen to define minimum visibility as a calculation that applies to all approaches, but varies depending on the type of operations. This calculation is applied to the published visibility (which is not limiting, but rather provided for information purposes only) for the approach based on the type of operation. In the case of an approach ban, minimum visibility is:

- ¾ of the published visibility for commercial operators;
- ½ of the published visibility for commercial operators who have Operations Specification 019 regarding reduced visibility;
- ¼ SM for private operators, regardless of the approach being executed.

The series of flights operating as NUK107 were conducted under commercial operations without Operations Specification 019. They needed to comply with a minimum visibility of ¾ of the 1 SM published in the CAP for the LOC/DME RWY 08 approach for CYGV. Therefore, the flight's approach ban would have been ¾ SM visibility on the day of the accident. However, the captain incorrectly believed that the visibility broadcast by the AWOS was not limiting in the context of the approach ban for CYGV. The FO was aware that weather conditions were below the approach minima published in the CAP, but he did not understand all of the details involved in the approach ban for this flight conducted under commercial operations without Operations Specification 019.

1.8.1.3 Required visual reference

Once it has been established that an approach is authorized based on approach ban criteria, an aircraft may descend below the MDA during the approach, provided that the pilot has at least one of the possible required visual references in sight and maintains it in sight (Appendix E).

CARs subsection 101.01(1) defines ''required visual reference'' as follows:

> [I]n respect of an aircraft on an approach to a runway, [it] means that portion of the approach area of the runway or those visual aids that, when viewed by the pilot of the aircraft, enable the pilot to make an assessment of the aircraft position and rate of change of position, in order to continue the approach and complete a landing.[21]

To clarify this CARs definition, the CAP states:

> The visual references required by the pilot in order to continue the approach [below the MDA] to a safe landing should include one of the following references for the intended runway and should be distinctly visible and identifiable to the pilot:
>
> - the runway or runway markings;
> - the runway threshold or threshold markings;
> - the TDZ [touchdown zone] or TDZ markings;

21 Transport Canada, SOR/96-433, *Canadian Aviation Regulations*, subsection 101.01(1).

- the approach lights;
- the approach slope indicator;
- the runway identification lights (RILS);
- the threshold and runway end lights;
- the touchdown zone lights (TDZL);
- the parallel runway edge lights; or
- the runway centreline lights.[22]

When pilots cannot establish or maintain the required visual reference, they must conduct a missed approach. The decision to begin a missed approach procedure is one of the last defences to mitigate the risk of an approach- or landing-related accident.

Between December 2006[23] and December 2019, 31 incidents occurred following approaches conducted below the MDA with few visual references. Seventeen of these 31 incidents occurred during a landing in weather conditions where visibility was below what is published on the approach chart.[24]

Furthermore, this type of incident has been persisting, with 9 of the 17 incidents occurring within the past 5 years.

1.9 Communications

Aircraft departing from CYZV contact the Sept-Îles flight service station radio on the MF. After takeoff, communications are transferred to the Montréal area control centre (ACC). Then when the aircraft is 60 NM east of CYZV (in other words, when it has left controlled airspace), the Montréal ACC clears the aircraft to switch to the appropriate frequency. At that point, the aircraft enters uncontrolled airspace in the Lower North Shore ATF (aerodrome traffic frequency) corridor (Figure 3). Pilots are then responsible for reporting their intentions on frequency 123.5 MHz in the ATF corridor, and for providing mandatory position reports for IFR arrivals in the CYGV MF zone, on frequency 122.0 MHz (Appendix F).

During the occurrence flight, calls were made on the CYGV MF; however, no calls were made on the Lower North Shore ATF corridor frequency.

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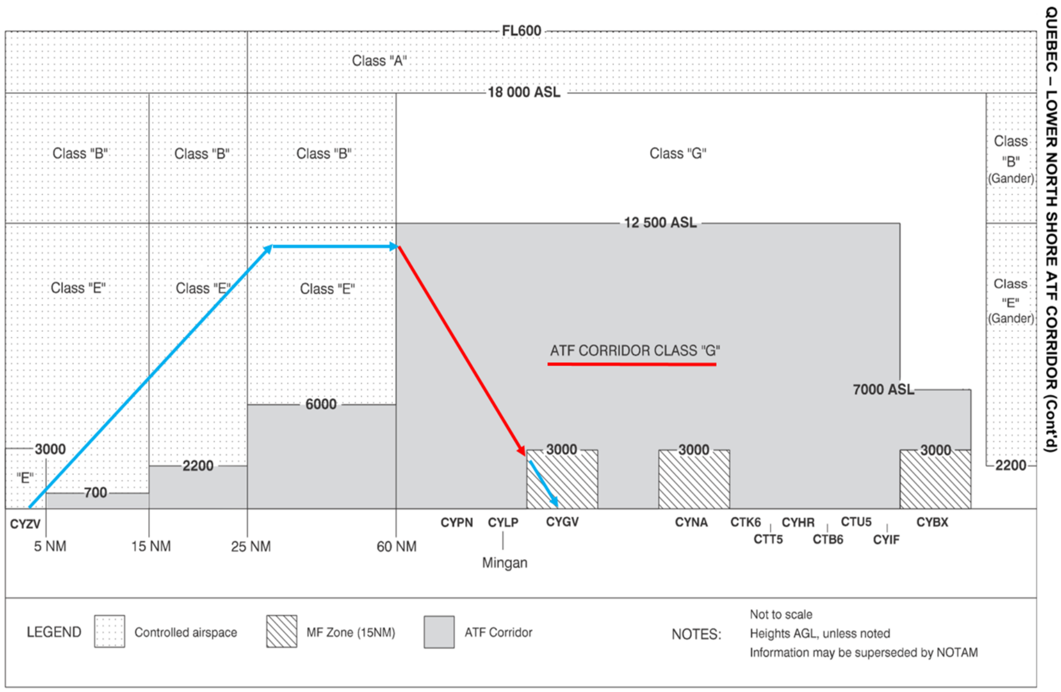
[22] NAV CANADA, *Canada Air Pilot* (CAP), CAP GEN (effective 01 February 2018), p. 26.

[23] Implementation date for landing minima regulations (CARs section 602.128) and approach ban regulations (CARs section 602.129).

[24] After these 17 occurrences, the TSB published the following aviation investigation reports: A08W0237, A08O0333, A09Q0203, A12Q0216, A14A0067, A15O0015, A15H0002, A16A0041 and A18Q0030.

Figure 3. Aircraft's path between the Sept-Îles and Havre St-Pierre airports: the absence of communications in the aerodrome traffic frequency corridor is shown in red (Source: NAV CANADA, Canada Flight Supplement, effective 01 February 2018 to 29 March 2018, Planning section, p. C98, with TSB annotations)



1.10 Aerodrome information

Located approximately 3 NM north of the town of Havre-Saint-Pierre, CYGV belongs to TC, which is responsible for its management, operations and development. To accomplish this, a contract is awarded to a company that ensures the administration, operations and daily maintenance of the airport.

CYGV is certified in accordance with the requirements stated in CARs Subpart 302 and those stated in the 4th edition of TP 312 – *Aerodrome Standards and Recommended Practices*,[25] which were incorporated through a cross-reference in CARs. CYGV is available 24/7, for day and night VFR and IFR operations. However, no hangars are available to park an aircraft. As the airport certificate holder, TC has implemented a safety management system (SMS) to satisfy the requirements of CARs Subpart 107.

1.10.1 Hours of operation

According to the technical specifications of the operating agreement for CYGV, the airport manager or his/her replacement has daily responsibility for operations. Maintenance operations, including snow removal, are done during normal business hours, 0730 to 1630, Monday through Friday. Outside these hours, the runway is maintained on request.

25 Version in effect when the aerodrome received certification.

1.10.2 Runway 08/26

CYGV has a single paved runway (Runway 08/26), which is 4498 feet long and 100 feet wide. The airport's altitude is 125 feet ASL, and the threshold of Runway 08 is at 110 feet ASL (Appendix G). Runway 08 has a 0.33% ascending grade. Runway 08 was active at the time of the accident.

1.10.2.1 Touchdown zone

The TC AIM[26] defines a TDZ as "the first 3 000 ft of the runway or the first third of the runway, whichever is less, measured from the threshold in the direction of landing." Therefore, the TDZ for Runway 08 (which is 4498 feet long) is the first 1500 feet.

1.10.2.2 Lighting

Runway 08/26 is equipped with the following lighting:

- white variable-intensity runway edge lights, located along the edges, spaced 60 m apart, for the entire length of the runway;
- threshold and runway end lights, which appear red in the direction of takeoff and green in the direction of approach and landing.

In accordance with the standard stipulated in the 4th edition of TP 312, the lights were mounted at a maximum height of 35 cm.[27]

1.10.2.2.1 Aircraft radio control of aerodrome lighting

Runway 08/26 has type K ARCAL, which allows pilots to turn on aerodrome lights and adjust their intensity with the exclusion of obstruction lights. The TC AIM states:

> Activation of the system is via the aircraft VHF [very high frequency] transmitter and is effected by depressing the push-to-talk button on the microphone a given number of times within a specified number of seconds. Each activation will start a timer to illuminate the lights for a period of approximately 15 min.[28]

Lighting intensity can be adjusted by clicking the microphone button 7, 5 or 3 times within 5 seconds to obtain high (100%), medium (30%) or low (10%) intensity, respectively. Given that the pilot can restart the ARCAL timing cycle by repeating the keying sequence, it is recommended that the pilot perform this step at the beginning of the approach, even if the lights are already on, to ensure a full 15-minute cycle for the approach.

At 1116:49, the ARCAL was activated by the pilot, who clicked the microphone button 7 times on frequency 122.0 MHz, when the aircraft was on final approach. At 1117:44,

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26 Transport Canada, TP 14371, *Transport Canada Aeronautical Information Manual* (TC AIM), GEN – General (12 October 2017), section 5.1.

27 Transport Canada, TP 312, *Aerodrome Standards and Recommended Practices*, 4th Edition (March 1993), section 5.3.10.15.

28 Transport Canada, TP 14371, *Transport Canada Aeronautical Information Manual* (TC AIM), AGA – Aerodromes (12 October 2017), section 7.18.

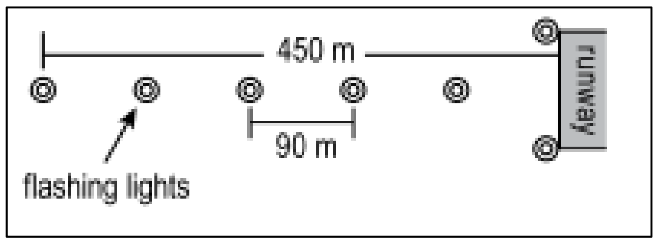
6 very rapid clicks were heard on the frequency, followed by 2 clicks a few seconds later, precisely 6 seconds after the first 6 clicks. The second series of clicks lowered the lighting intensity to medium.

1.10.2.2.2 Omnidirectional approach lighting system

Runway 08 also has an omnidirectional approach lighting system (ODALS). An ODALS consists of 7omnidirectional, variable-intensity, sequenced flashing lights. Two lights are positioned 12 m to the left and right of the threshold; they flash in unison. There are also 5 lights on the extended centreline commencing 90 m from the threshold and spaced 90 m apart over a total distance of 450 m. They flash sequentially toward the threshold[29] (Figure 4).

Given the presence of a sensitive environmental area, a lake that is home to endangered species, the 5 lights on the extended centreline of the Runway 08 ODALS at CYGV extend over a distance of 419.8 m rather than 450 m, pursuant to an exemption from regulatory requirements issued by TC.[30]

Figure 4. Omnidirectional approach lighting system (Source: Transport Canada, Transport Canada Aeronautical Information Manual, AGA – Aerodromes [12 October 2017], section 7.5.1)



The ODALS was serviceable at the time of the occurrence, and was turned on automatically when the pilot activated the ARCAL.

1.10.2.2.3 Precision approach path indicator

Runway 08 has a P1 PAPI. A PAPI consists of 4 light units, spaced equally apart, typically situated on the left side of the runway, in the form of a wing bar. When an aircraft is on the approach slope, the 2 units nearest the runway show red and the 2 units farthest away show white.[31] The P1 PAPI is designed for aircraft with an eye-to-wheel height[32] extending up to 10 feet (Figure 5). The PAPI was serviceable at the time of the occurrence; it was turned on automatically when the pilot activated the ARCAL.

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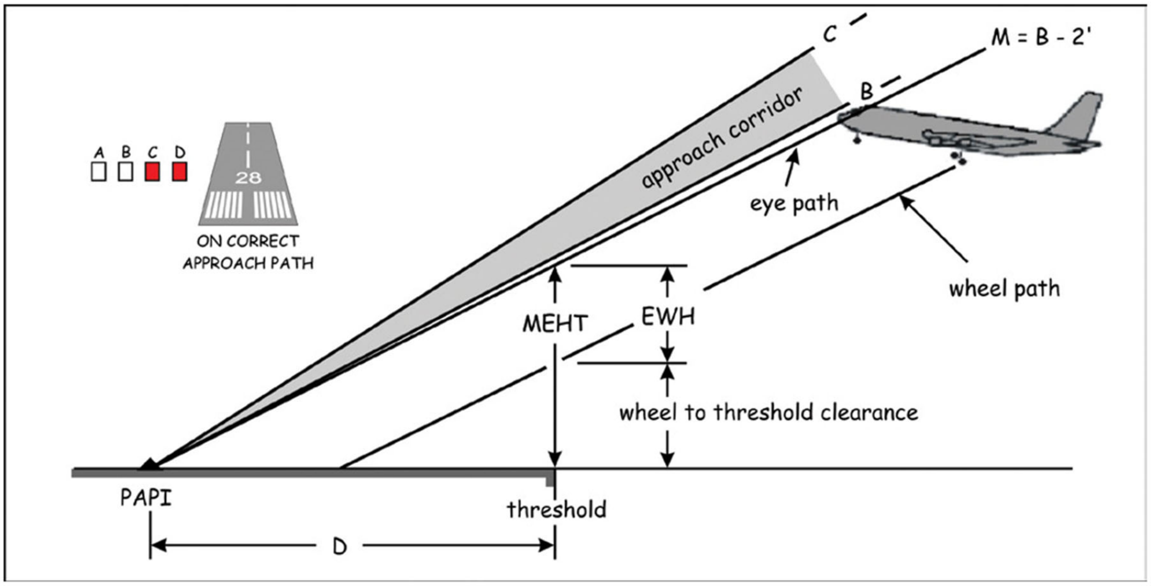
29 Transport Canada, TP 14371, *Transport Canada Aeronautical Information Manual* (TC AIM), AGA – Aerodromes 12 October 2017), section 7.5.1.

30 Transport Canada, *Exemption from the application of section 5.3.5.2 of AERODROME STANDARDS AND RECOMMENDED PRACTICES (TP312F, 4th edition) established under subparagraphs 302.07(1)(a)(i) and (ii) of the* Canadian Aviation Regulations (20 December 2012).

31 Transport Canada, TP 14371, *Transport Canada Aeronautical Information Manual* (TC AIM), AGA – Aerodromes (12 October 2017), section 7.6.3.

32 Eye-to-wheel height (EWH) is the ''vertical distance from a pilot's eyes to the lowest portion of the aircraft in the landing attitude. This distance ranges from less than 4 ft up to 45 ft for some wide-bodied aircraft.'' (Source: NAV CANADA, TERMINAV terminology database, at http://www1.navcanada.ca/logiterm/addon/terminav/termino.php [last accessed 04 May 2020]).

Figure 5. Precision approach path indicator: pilot eye path to wheel path (Source: Transport Canada, Transport Canada Aeronautical Information Manual, AGA – Aerodromes [12 October 2017], section 7.6.4.3)



1.10.2.3 Runway end safety area

Runway 08/26 at CYGV satisfies the criteria stipulated in the 4th edition of TP 312, because it has a 60 m strip before the threshold and beyond the runway end.[33]

1.10.2.3.1 Grandfathering at airports

The 5th edition of TP 312, published in September 2015, defines design standards applicable to airport, particularly with respect to the location and characteristics of runway end safety areas (RESA). In order for an airport such as CYGV, which has a runway longer than 1200 m, to be able to comply with standards, a RESA must have a minimum length of 150 m.[34]

However, pursuant to CARs section 302.07, commonly referred to as the "grandfather clause", CYGV is not required to comply with the 150 m RESA standards stated in the 5th edition of TP 312, unless repairs or modifications are carried out, in which case the most recent standards must be applied.

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33 Transport Canada, TP 312, *Aerodrome Standards and Recommended Practices*, 4th edition (March 1993), Chapter 3, section 3.1.6.2.

34 Transport Canada, TP 312, *Aerodrome Standards and Recommended Practices,* 5th edition (15 September 2015), Chapter 3, section 3.2.

1.10.3 Aerodrome operating visibility

Before taking off from, landing at, or otherwise operating an aircraft at an aerodrome, the pilot-in-command (PIC) of the aircraft must be satisfied that the aerodrome is suitable for the intended operation. The PIC must ensure that the operating visibility meets the limit for which the aerodrome is certified (Appendix E).[35] If the aerodrome is certified for operations at a visibility less than ½ SM (RVR 600), this limit is published in the *Canada Flight Supplement* (CFS), and on the aerodrome chart published in the CAP. If an aerodrome's operating visibility limit is not published in the CFS, it means that operations are not authorized when visibility is less than ½ SM. The certified minimum operating visibility for Runway 08 at CYGV is ¼ SM (Appendix G).

When an aerodrome does not have an air traffic control (ATC) tower, the operating visibility for this aerodrome is determined in accordance with the following criteria, in this order[36,37]:

- RVR for the runway of intended use;
- ground visibility (METAR); and
- visibility as determined by the pilot.

Given that the runways at CYGV are not equipped to measure RVR, the ground visibility measured by AWOS and reported in the METAR (Appendix E) constitutes CYGV's operating visibility. At airports where an ATC tower is in service, an exception is made so that the visibility observed by the tower can be used when the visibility reported by AWOS is not representative of actual conditions. However, given that CYGV does not have an ATC tower, this exception does not apply.

As C-GJXF was landing, visibility was at the minimum operating visibility for Runway 08.

1.10.4 Snow clearing plan

Requirements for winter maintenance operations at certified aerodromes can be found in TP 312. The policies, standards, guidelines and responsibilities for winter maintenance operations at CYGV can be found in the airport's snow clearing plan.[38]

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35 Transport Canada, Advisory Circular AC 602-002, *Aerodrome Operating Visibility*, Issue no. 2 (30 June 2011), subsections 4.2(1) and 4.2(2).

36 NAV CANADA, *Canada Air Pilot* (CAP), CAP GEN (effective 01 February 2018), p. 16.

37 Transport Canada, Advisory Circular AC 602-002, *Aerodrome Operating Visibility*, Issue No. 2 (30 June 2011), subsection 4.2(2).

38 Transport Canada, *Plan de déneigement – Aéroport de Havre-St-Pierre*, modification #6 (November 2017).

1.10.4.1 Runway closures

According to the Havre St-Pierre Airport snow clearing plan, the airport manager [translation]

> is responsible for directing, managing and arranging snow removal and de-icing operations. Only the airport manager or his or her authorized representative has the authority to close the airport or any portion of the movement areas for snow removal operations, repairs or any other operational requirement.[39]

Furthermore, the following criteria can be used to assess whether a runway closure is required [translation]:

> - CRFI less than 0.15;
> - snowdrifts higher than 18 inches along the cleared parts of the runway;
> - between the cleared part and the runway lights, snowdrifts higher than 30 inches (for dry snow) or 24 inches (for wet snow);
> - portion of runway usable by aircraft is less than 100 feet wide;
> - impossible to drive on the runway to perform a surface condition report due to difficult weather conditions;
> - visibility of the runway lights is obstructed for an observer standing in the centre of the runway.[40]

However, a runway closure is not mandatory if these criteria are exceeded.

1.10.4.2 Aircraft movement surface condition report

On 26 February 2018, the first aircraft movement surface condition report (AMSCR) of the day, issued at 0632, indicated that the entire surface of Runway 08/26 at CYGV was covered with 1 inch of snow.

A grader and a snowplow-sweeper began snow clearing operations at approximately 0700, with their top priority being to clear the runway over a width of 80 feet and the entire length of the runway.

A second AMSCR was issued at 0729. Given that the snow showers were becoming heavier, snow clearing operations were ongoing.

A 3rd AMSCR was issued at 0929, indicating the following runway conditions:

- centre of the runway cleared over a width of 80 feet, but covered with a trace of dry snow;
- presence of 30-inch snowdrifts on the remaining width of the runway;
- CRFI 0.38, temperature −4 °C.

The CRFI is calculated by taking the average of measurements recorded by a vehicle equipped with a decelerometer, operating approximately 10 m from the centre of the

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39 Ibid., p. 10.

40 Ibid., p. 13.

runway, braking at regular intervals along the runway. The readings are printed out, and the average of the readings is the reported CRFI. According to the information gathered, the average of the readings taken at 1005 was 0.36, which was below the CRFI indicated in the last AMSCR. This drop in the coefficient meant an increase of less than 50 feet in the recommended landing distance for C-GJXF. However, this difference did not contribute to the overrun.

While the aircraft was inbound for CYGV, the grader and snowplow-sweeper passed one last time over the entire length of the runway. They left the runway approximately 3 minutes before the aircraft landed.

1.10.5 Emergency response plan

According to the CYGV emergency response plan (ERP) [translation]:

> The purpose of the ERP is to provide the airport operator and staff, response units and community agencies involved with procedures to be followed in the event of an emergency.[41]

When an aircraft accident occurs at the airport, various checklists are used by the agencies involved. One of the first things to do is call 911 to request fire protection services and ambulances as needed. In this occurrence, emergency services were not contacted at the time of the accident because the captain indicated that he did not require assistance.

1.11 Flight recorders

1.11.1 Flight data recorder

The aircraft was not equipped with a flight data recorder, nor was it required by regulation.[42]

1.11.2 Cockpit voice recorder

The regulations in force at the time of the occurrence required this type of aircraft to be equipped with a cockpit voice recorder (CVR)[43] when the flight crew consisted of 2 pilots. However, the enforcement of these regulations was challenged by 3 air-taxi service operators in Quebec, and on 17 October 2005 a ruling by the Federal Court of Appeal on 17 October 2005 found in favour of the operators.[44] As a result, they were allowed to voluntarily operate their King Air aircraft with 2 pilots instead of just one, without having to install a CVR on the aircraft. In light of this ruling, Strait Air had not installed a CVR on the occurrence aircraft.

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41 Transport Canada, *Plan de mesures d'urgence – Aéroport de Havre-Saint-Pierre*, Version 2 (28 July 2017), section 1.3, p. 11.

42 Transport Canada, SOR/96-433, *Canadian Aviation Regulations,* subsection 605.33(1).

43 Ibid., subsection 605.33(2).

44 TSB Aviation Investigation Report A10Q0162.

1.12 Wreckage and impact information

The aircraft ended its landing roll in a snowbank approximately 220 feet beyond the end of Runway 08 (figures 2 and 6). There was a ditch approximately 50 feet past this point.

When they arrived on the scene, TSB investigators noted that the flaps were raised, the fuel system was cut and the electrical system was off. The pitch of both propellers was practically zero (0°), and all of the propeller blades were bent backwards. The landing gear collapsed and bent backwards, and the engine air inlets were blocked by compacted snow.

Figure 6. Position of the wreckage at the end of the runway (Source: TSB, photo taken 2 days after the accident)

1.12.1 Data on the global positioning system and the enhanced ground proximity warning system

The TSB Engineering Laboratory found that the 155XL GPS on board the aircraft was a model that did not record data. However, the EGPWS 965-1198-005 with which the aircraft was also equipped records an aircraft's position at takeoff, as well as additional data when an alert is triggered by this system. An examination of recorded data enabled investigators to determine the aircraft's position at takeoff from CYZV and to determine that no alerts were recorded during the flight.

1.13 Medical and pathological information

A review of TC medical information did not reveal any physiological conditions that could have hindered the flight crew's performance.

1.14 Fire

Not applicable.

1.15 Survival aspects

Despite the substantial damages to the landing gear and the wing structure caused by the impact with the snowbank, the deceleration forces did not jeopardize occupant survivability.[45] However, half of the occupants received minor injuries.

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[45] "A survival accident is one in which the forces transmitted to the occupant through the seat and restraint system do not exceed the limits of human tolerance to abrupt accelerations and in which the structure in the occupant's immediate environment remains substantially intact to the extent that a livable volume is provided throughout the crash sequence." (Source: United States National Transportation Safety Board, Safety Report, NTSB/SR-83/01, *General Aviation Crashworthiness Project, Phase One*, 27 June 1983, p. 3.)

Airport staff went to provide assistance to the aircraft occupants and the ERP was activated. The aircraft came to rest in a snowbank and there were no signs of a risk of fire. The occupants were evacuated using the main door and airport staff helped transport them to the terminal. Subsequently, 6 of the 8 occupants were taken to the hospital by ambulance to have their condition assessed.

1.15.1 Passenger safety briefing

According to the CARs,[46] "The pilot-in-command shall ensure that passengers are given a safety briefing in accordance with the *Commercial Air Service Standards.*"[47] This briefing must specify how and why to fasten, unfasten, and tighten safety belts or shoulder harnesses. In addition, the pilot-in-command "shall direct all of the persons on board the aircraft to fasten safety belts,"[48] including during takeoff and landing.

These regulatory requirements are included in the company operations manual[49] and are described in the chapter on SOP normal procedures.[50] The procedures apply after passenger boarding, while climbing, before descent, or when passing through transition altitude, depending on the cruising altitude. According to these procedures, a full safety briefing is done after passenger boarding, and the briefing before landing is more of a reminder, asking passengers to ensure that their safety belt is properly fastened. Finally, the aircraft checklist requires confirmation at each phase of flight that the necessary checks have been done.

In this occurrence, although a safety briefing was given before takeoff, no briefing was given before landing, and one of the passengers did not fasten her safety belt before landing. When the aircraft hit the snowbank past the end of the runway, the occupants who had their safety belts fastened were secured in their seats. However, the passenger whose safety belt was not fastened received minor injuries when she was thrown forward and landed on her knees in front of her seat, pressed against the seat in front of her.

1.15.2 Shoulder harnesses

The pilot seats on the aircraft were equipped with shoulder harnesses. The passenger seats were equipped only with a safety belt, in compliance with regulations in effect.

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[46] Transport Canada, SOR/96-433, *Canadian Aviation Regulations,* section 703.39.

[47] CARs standard 723.39.

[48] Transport Canada, SOR/96-433, *Canadian Aviation Regulations,* section 605.25.

[49] Strait Air (2000) Ltd., *Operations Manual – Aeroplanes: Air Taxi – Day/ME Night IFR* (10 May 2016), section 3.27, p. 3-21.

[50] Strait Air (2000) Ltd., *Procédures d'utilisation normalisées — King Air A-100* (25 September 2014), sections 3.3, 3.11, and 3.15.

It is a well-known fact that the use of a 3- or 4-point restraint system (safety belt and shoulder harness) ensures a more equal distribution of the impact forces and reduces the severity of injuries to the upper body and head.[51] Furthermore, passengers using a restraint system have better chances of survival in the event of an impact. On the occurrence flight, a passenger who had his safety belt fastened received minor injuries when his upper body hit a fixed portion of the aircraft.

The TSB has found that the risk of serious injury or death is higher for occupants of small aircraft who are not wearing an upper body restraint.[52] Studies on the protection of occupants in small aircraft during accidents, conducted by the United States[53] and Canada,[54] indicate that the probability of surviving impact forces is considerably higher when an upper body restraint is used.

In 2010, the FAA conducted a study into 649 accidents that occurred between 2004 and 2009, of which 97 involved serious or fatal injuries. The FAA determined that better protection would have helped to avoid 40% of the lost lives, and that simply fitting passenger seats with a shoulder harness would have saved close to 20% of the lost lives.

In 1970, Beechcraft published Service Instruction 0937, ''Notice of Availability of Shoulder Restraint Belts for Passengers''. This notice advised owners of certain models of Beechcraft aircraft, including the A100, of the availability of seat assemblies or shoulder harness kits to restrain a passenger's upper body. The aircraft manufacturer strongly recommended the installation of these upgrades to enhance passenger safety.

Based on the serial number of the occurrence aircraft, in order to comply with Service Instruction 0937, the owner should have procured the complete seat assemblies given the incompatibility with the shoulder harness kits.

1.15.3 Emergency locator transmitter

The aircraft was equipped with an ARTEX ME406 emergency locator transmitter (part number 453-6603, serial number 188-02703), able to transmit on 121.5 MHz and 406 MHz. According to the manufacturer's manual,[55] the deceleration forces needed for automatic activation are 2.3*g*. The emergency locator transmitter was not damaged, and the

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51 US National Transportation Safety Board, Safety Report, NTSB/SR-85/01, *General Aviation Crashworthiness Project, Phase Two – Impact severity and potential injury prevention in General Aviation accidents* (15 March 1985).

52 TSB Aviation Safety Study SA9401, *A safety study of survivability in seaplane accidents* (1994).

53 Federal Aviation Administration, Aviation Safety, Alaskan Region, *Fatal and Serious Injury Accidents in Alaska, A Retrospective of the years 2004 through 2009 with Special Emphasis on Post Crash Survival* (December 2010).

54 *Small Aircraft Crashworthiness*, volume 1, TP 8655E (prepared by Sypher: Mueller International Inc., July 1987), p. 46; Canadian Aviation Safety Board, *Study of the Influence of Shoulder Harnesses in Aviation Safety* (1987).

55 Artex, *ME406 Series, Emergency Locator Transmitter,* first edition (30 June 2005), version V (19 March 2015).

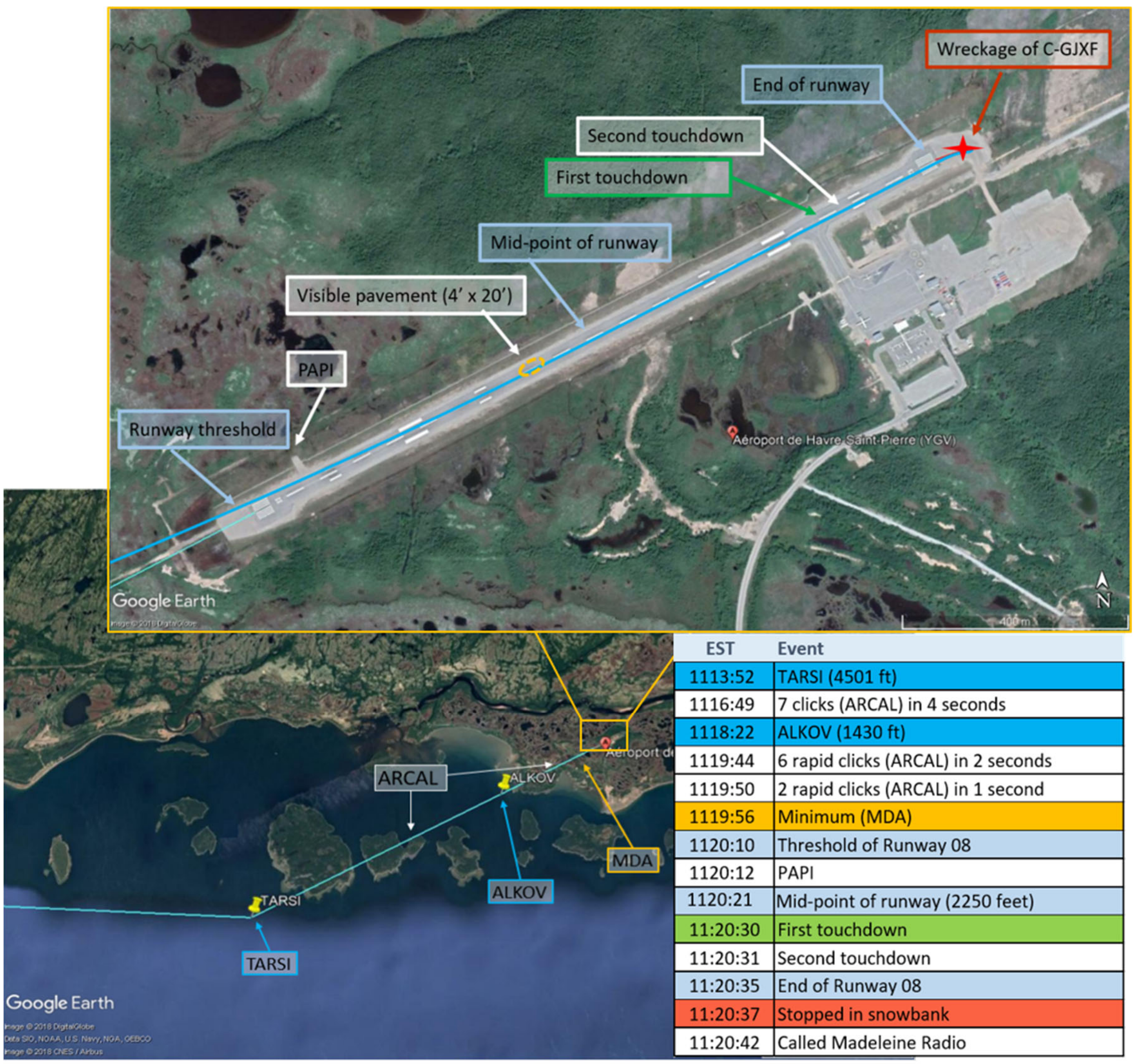
deceleration forces at the time of impact with the snowbank were not sufficient to activate it automatically.

1.16 Tests and research

1.16.1 Approach and landing path

Given the lack of GPS data, the aircraft's approach and landing path was calculated using radar data, recordings of conversations with ATC, observation of the touchdown point, and testimonies. These calculations assisted in determining the aircraft's position and speed during approach, the moment when the aircraft crossed the runway threshold and the length of time the aircraft was flying over the runway before touching down (Figure 7).

Figure 7. Approach path of the aircraft on final and over the runway (Source: Google Earth, with TSB annotations)



EST	Event
1113:52	TARSI (4501 ft)
1116:49	7 clicks (ARCAL) in 4 seconds
1118:22	ALKOV (1430 ft)
1119:44	6 rapid clicks (ARCAL) in 2 seconds
1119:50	2 rapid clicks (ARCAL) in 1 second
1119:56	Minimum (MDA)
1120:10	Threshold of Runway 08
1120:12	PAPI
1120:21	Mid-point of runway (2250 feet)
11:20:30	First touchdown
11:20:31	Second touchdown
11:20:35	End of Runway 08
11:20:37	Stopped in snowbank
11:20:42	Called Madeleine Radio

1.16.2 TSB laboratory reports

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

- LP080/2018 – NVM Recovery – GPS & EGPWS

1.17 Organizational and management information

1.17.1 Operator

At the time of the occurrence, Strait Air held an air operator certificate.[56] The company's activities are governed by CARs subparts 702, *Aerial Work,* and 703, *Air Taxi Operations*. The flights operated as NUK107 were conducted in compliance with CARs Subpart 703. Air taxi operators generally have less means of providing operational support than airlines, who have specific policies and procedures, as well as dispatchers who plan flights. Furthermore, airline flights are generally conducted to and from larger airports where support is available in the air and on the ground.

Strait Air's head office and a base were located at CYQB. It also had a second base at CYZV. At the time of the incident, the company was operating a fleet of 3 Beechcraft King Air A100s and 3 Piper Navajos.

1.17.1.1 Safety management

Air-taxi operators such as Strait Air have an obligation to manage the risks associated with their air operations. At minimum, risk management consists of:

- recognizing and reporting hazards;
- identifying and choosing measures to mitigate these hazards;
- assigning responsibility for managing these measures; and
- measuring and monitoring the effectiveness of measures and established control methods.[57]

According to regulations in force, Strait Air was not required to implement an official safety management system (SMS) and did not implement one.

1.17.1.2 Operations specifications

Pursuant to CARs Subpart 703, Strait Air had operations specifications for the use of the Beechcraft King Air A100 in air taxi operations. However, Strait Air did not have Operations Specification 019 regarding reduced visibility, which applies to instrument approach bans.

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56 Strait Air ceased operations on 30 June 2019.

57 A. J. Stolzer, C. D. Halford and J. J. Goglia (2008), *Safety Management Systems in Aviation*, Aldershot: Ashgate (2008), p. 157, as cited in TSB Aviation Investigation Report A17Q0050.

1.17.1.3 Contamination of critical surfaces on aircraft

According to the Strait Air Operations Manual,[58] "where any frost, ice and/or snow is found to be adhering to any lifting or control surface, the contamination will be removed completely before any flight is attempted." Given that it did not have a ground icing operations program in place, Strait Air was not authorized to use various anti-icing fluids on the ground to protect its aircraft before takeoff in icing precipitation.

1.17.1.4 Standard operating procedures

1.17.1.4.1 General

SOPs, including standard calls and checklists, are vital sources of information that provide pilots with guidelines for general use of the aircraft. They assist pilots with decision making and coordination between crew members. They provide pilots with appropriate solutions for various situations under normal or abnormal operations, and for emergency situations.

To provide air operators with SOP guidelines, with the goal of reducing the risk of accidents, ICAO published a regional safety briefing in which it stated:

> Many aviation safety organizations, including the FAA, 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.[59]

Furthermore, ICAO made the following recommendations:

> - Airline operators should develop training programs to provide pilots with rationale for SOPs, focusing on those with lower adherence rates.
> - 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.
> - Airlines/operators should implement Flight Operational Quality Assurance (FOQA) programs to identify systemic procedural deviations and unsafe trends.[60]

58 Strait Air 2000 Ltd., *Operations Manual – Aeroplanes: Air Taxi – Day/ME Night IFR* (10 May 2016), section 3.3.4, p. 3-3.

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

60 Ibid., p. 5.

For its part, the FAA published Advisory Circular (AC) 120-71B on 10 January 2017 to provide guidance for "the design, development, implementation, evaluation and updating of SOPs, and for pilot monitoring (PM) duties."[61] This circular reports that

> SOPs 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 flight crew to follow SOPs, particularly during critical phases of flight.[62]

Between 1999 and 2019, SOPs were mentioned in 113 findings as to causes, contributing factors and risks in TSB aviation investigation reports. The deficiencies identified were primarily associated with a lack of precise directives, differences in procedures and a failure to follow procedures.

AC 120-71B also states that "effective crew coordination and crew performance depend on the crew's having a shared mental model of each task. That mental model, in turn, is founded on SOPs."[63] Once established, the SOPs "must be applied with consistency and uniformity throughout the operation."[64]

Finally, 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 SOPs."[65] Furthermore, "SOPs are the reference for crew standardization and establish the working environment required for CRM."[66]

1.17.1.4.2 Strait Air standard operating procedures

In June 2015, TC reviewed Strait Air's SOPs and concluded that they complied with section 723.107 of the CARs *Commercial Air Services Standard*. The SOPs relevant to the occurrence are indicated below.

Coordination between crew members

Strait Air SOPs include information for flight crew members on coordination and the procedure to follow in the event of deviation [translation].

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

62 Ibid., p. 1.1.

63 Ibid.

64 Ibid.

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

66 Ibid., p. 3.

> Coordination between crew members is of the utmost importance. Crew coordination under normal or emergency situations is discussed throughout this manual. Failure to comply with standard operating procedures should be brought to the attention of the crew members as quickly as possible.[67]

Communications

Strait Air SOPs also include guidelines for communications between crew members: [translation]

> Communication in the cockpit is essential to avoid confusion and maintain a high safety level. Any disturbing or unusual incident must be communicated explicitly to the other flight crew member (FCM) (e.g.: dizziness, difficulty controlling the aircraft, abnormal instrument reading). If there is any doubt that the message has been properly understood, it is important to persevere until the situation is clear between the two FCMs.
>
> Every time that a FCM makes a change, he/she must advise the other FCM. This includes, but is not limited to, the following items: changes in speed, navigational aid keying, deviation from the flight plan, change in the position of a switch or lever (e.g.: de-icing system, etc.).[68]

Strait Air communications SOPs also indicate the phraseology to be used for standard calls and guide the crew members in identifying any state of incapacity in the other crew member: [translation]

> Standard calls are used to minimize ambiguities between FCMs during certain phases of flight. These calls are normally made by the pilot not flying (PM) and always followed by a response from the other FCM to confirm that the information has been properly understood. If the PM forgets to make the call, the pilot flying (PF) makes it and the PM responds.
>
> If the call is repeated a second time without a response, the pilot must consider a possible state of incapacity and apply the appropriate procedure.[69,70]

Pre-flight inspection

The captain is responsible for flight planning and, according to the SOPs, he must also inform the FO of [translation] "the content of all flight plans and itineraries, as well as expected weather."[71] The FO performs the pre-flight inspection of the aircraft, and oversees passenger boarding and briefing. In the case of the occurrence flight, the FO was not involved in the flight planning.

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67 Strait Air (2000) Ltd., *Procédures d'utilisation normalisées — King Air A-100* (25 September 2014), section 1.2, p. 1.1.

68 Ibid., section 2.8, p. 2.3.

69 Ibid., section 2.8.1, p. 2.4.

70 The appropriate procedure consists of taking over the controls.

71 Strait Air (2000) Ltd., *Procédures d'utilisation normalisées — King Air A-100* (25 September 2014), section 2.1, p. 2.1.

Preparation for approach and descent

Normally, preparation for approach is done before starting the descent. In coordination with the PF, the PM obtains the weather conditions, configures the navigation radios for the approach being used, and hands the PF the CAP open to the page with the approach being used. At that point, the PF transfers control to the PM in order to provide the approach briefing. The approach briefing stated in the Strait Air SOPs includes a review of the approach chart and missed approach procedure, but does not include establishing the minimum visibility for an approach ban or discuss the touchdown point or the need to conduct a go-around if this point is passed.

In this occurrence, while preparing for approach, the captain and FO did not discuss the high probability of needing to conduct a go-around.

The "Descent & Approach Check" is performed before beginning descent, or while passing through transition altitude. The final item on the checklist is the passenger briefing, which consists of reminding the passengers to ensure that their safety belt is properly fastened (see 1.15.1).

The "Approach Check" is performed when the aircraft is passing through 10 000 feet.

Instrument approach

During an instrument approach, the pre-landing checklist should be completed before reaching the final approach fix, making the standard calls indicated in Figure 8.

Figure 8. Pre-landing standard calls for an instrument approach (Source: Strait Air (2000) Ltd., Procédures d'utilisation normalisées — King Air A-100 [25 September 2014], section 3.18, p. 3.40)

PV	PM
1. *FLAPS APPROACH*	2. *SPEED CHECKED, FLAPS APPROACH* 3. *SÉLECTIONÉ, INDIQUÉ*
4. *GEAR DOWN* 6. *CONFIRMÉ* 7. *BEFORE LANDING CHECK*	5. *SPEED CHECKED, GEAR DOWN, 3 VERTES* 8. *BEFORE LANDING CHECK COMPLÉTÉ*

The pre-landing checklist is completed after setting the flaps to the approach position (F30%) and after confirming that the landing gear is in the down and locked position (Figure 9).

According to the SOPs, final approach is executed with the flaps in the approach position (F30%) and at a speed of 120 knots until the PF confirms the landing and requests that the propellers and flaps be set to the landing configuration (F100%). According to the SOPs, [translation] “for a short landing, or on a gravel, snow-covered or ice-covered surface, it is highly recommended that the ‘HIGH IDLE’ position and ‘MAX RPM’ be used.”[72]

Figure 9. Pre-landing checklist (Source: Strait Air (2000) Ltd., Procédures d’utilisation normalisées — King Air A-100 [25 September 2014], section 3.18, p. 3.41)

Before Landing CHECK (C/R) :	
1-Flaps	AS REQ’D
2-Gear	DOWN 3 GREEN
3-Ice Vanes	AS REQ’D
4-Landing & Taxi lights	ON
5-Prop Sync	OFF
6-Condition & Prop Levers	AS REQ’D
7-Yaw Damper	OFF
8-GPS Integrity 0.3	CHECKED

These items are completed later by the PM, once the PF confirms the decision to land by making the standard calls “CHECK, LANDING, FLAPS FULL, MAX RPM.” However, there is no other final checklist before landing to ensure that these last items have been completed.

During approach, the PM monitors the entire flight. The tasks consists of reporting any abnormal indications to the PF, informing the PF once there is visual contact with the ground and making the standard call “MINIMUM CONTACT” or “NO CONTACT”, depending on the required visual reference that the PM does or does not have in sight (see 1.8.1.3). The PF flies the aircraft, complying with approach limits, and after the PM makes the standard calls, has only 2 choices: make the call “LANDING” or “GO AROUND.”[73]

Minimum descent altitude (MDA) and landing

When the aircraft reaches the MDA and the PM establishes the required visual reference (see 1.8.1.3), the PM makes the corresponding standard calls (Figure 10). At that point, the PF confirms the landing and requests landing configuration.[74]

Figure 10. Standard calls for an instrument approach with confirmed landing (Source: Strait Air (2000) Ltd., *Procédures d’utilisation normalisées — King Air A-100* [25 September 2014], section 3.18, p. 3.44)[75]

PV	PNV
	1. MINIMUM, LUMIÈRES D’APPROCHES À 12H00
2. CHECK, LANDING 3. FLAPS FULL, MAX RPM	
	4. SPEED CHECK, FLAPS FULL, MAX RPM. 5. V Ref + ________Kts

Next, the PM confirms that the radio call on final has been made or that landing clearance has been received. Also, while decelerating from 120 knots to the V_{ref}, which is 100 knots, the PM advises the PF every 5 knots of the actual speed in relation to the V_{ref}.

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72 Ibid., section 3.18, p. 3.41.

73 Ibid., section 3.17, p. 3.37.

74 Ibid., section 3.21, p. 3.44.

75 Strait Air uses both “PM” and “PNV” interchangeably in their procedures. This report uses “PM” throughout..

Minimum landing altitude and go-around

According to the SOPs, a go-around is a manoeuvre that is possible at any time. However, during an instrument approach, it is generally executed at the MDA. When the aircraft reaches the MDA, if the PM does not have the required visual reference in sight (see 1.8.1.3), he/she makes the corresponding standard call. The PF then responds by making the standard calls and executes a go-around (Figure 11).[76]

Figure 11. Standard calls for an instrument approach with go-around (Source: Strait Air (2000) Ltd., *Procédures d'utilisation normalisées — King Air A-100* [25 September 2014], section 3.18, p. 3.43)

PV	PNV
Manœuvre l'avion pour respecter les limites de l'approche	*Surveille l'ensemble du vol et effectue les appels standards*
2. CHECK	1. 100' AVANT 3. MINIMUM, PAS DE CONTACT
4. GO AROUND 5. MAX POWER FLAPS APPROACH	6. MAX POWER SET, FLAPS APPROACH
8. GEAR UP	7. POSITIVE RATE

1.17.1.4.3 Procedures followed in this occurrence

Given that the occurrence aircraft did not have a CVR, it was impossible to accurately ascertain compliance with SOPs. According to information gathered, when the aircraft reached the MDA, the PM made the standard calls "MINIMUM, PAS DE CONTACT" (NO CONTACT) (Figure 11, item 3). The PF did not respond immediately. The PM then asked the PF if he was going to execute a go-around, and at that point the PF (and captain) said that he had visual contact and proceeded with the descent below the MDA. However, the PF did not make the standard landing confirmation calls (Figure 10, items 2 and 3), which indicate to the PM that the aircraft must be configured for a landing. So, the PM did not receive the instruction to complete the rest of his duties (Figure 10, items 4 and 5), and the aircraft proceeded with the descent with the flaps in approach position (F30%) at a speed of 120 knots.

1.17.2 Transport Canada Civil Aviation — Regulatory oversight

Transport Canada Civil Aviation's (TCCA) surveillance program "verifies that enterprises are complying with regulatory requirements and that they have effective systems in place to

76 Strait Air (2000) Ltd., *Procédures d'utilisation normalisées — King Air A-100* (25 September 2014), section 3.20, p. 3.43.

ensure they comply with regulatory requirements on an on-going basis."[77] The program includes "assessments, program validation inspections (PVIs) and process inspections."[78]

PVIs provide for system surveillance and an overall review of the company using sampling methods to verify whether the company is able to comply with regulatory requirements on an ongoing basis. Process inspections (PIs) are inspections that focus on one or more specific processes. They verify whether the processes comply with regulatory requirements and work properly. The frequency of these inspections depends on factors such as the type of operations, turnover of key company employees, compliance history and nature of the findings. In the case of Strait Air, following the 2013 PVI, TCCA chose to conduct inspections at one-year intervals:

- in October 2013, a PVI resulting in 19 findings;
- in October 2014, a PVI resulting in 7 findings;
- in November 2015, a PVI resulting in 6 findings;
- in December 2016, a PVI resulting in 6 findings;
- in December 2017, a PI resulting in 8 findings.

Due to the nature of certain systemic non-compliances linked to the operational control system and the quality assurance program, TCAC continued to conduct inspections annually.

Following each of the inspections resulting in findings, the company submitted corrective action plans, which were accepted by TCCA before the next inspection.

TCCA's inspection program includes flight inspections to "assess the operator's compliance with regulations and standards and the relevancy of its operating procedures."[79] Flight inspections provide an opportunity to assess an air operator's operations, the results of training programs, operating procedures, policies, equipment and facilities. Inspection reports include an assessment of compliance with SOPs, coordination between flight crew members and situational awareness. A flight inspection was not conducted for Strait Air.

1.18 Additional information

1.18.1 Runway overruns

Based on the findings and conclusions of the Go-Around Safety Forum released on 26 June 2013, the FSF stated in the final *Go-Around Decision Making and Execution Project*

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77 Transport Canada, Advisory Circular (AC) SUR-004, *Civil Aviation Surveillance Program*, Issue no. 01 (19 November 2015), section 3.0.

78 Ibid.

79 Transport Canada, TP 3783, *Air Carrier Inspection Manual* , 5th edition (March 2004, revised in December 2010), section 3.

report that "failure to conduct a go-around is the number one risk factor in ALAs and the number one cause of runway excursions."[80]

This report also states that "[g]o-arounds, although considered a normal flight manoeuver, are rare."[81] Go-around procedures are covered in initial and recurrent flight training. During training, pilots are prepared for this manoeuvre and they conduct it in a controlled environment. The altitude at which a decision is made to conduct a go-around is a determining factor for the difficulties associated with this manoeuvre. If a go-around is necessary, the PF must take immediate action. When the aircraft is descending and is near the ground, this decision becomes critical due to the loss of altitude between the time the pilot begins the go-around and the time the aircraft begins to climb.

The Go-Around Safety Forum found that professional pilots flying short-haul carriers conduct a go-around on average only once or twice a year. The fact that pilots do not often perform this manoeuvre may be a factor dissuading them from doing so. .

The Strait Air approach briefing includes the missed approach procedure, the airport environment (runway length and width, surface contamination), and the runway landing distance, if necessary. However, it does not require the flight crew to address the touchdown zone (TDZ) or the need to conduct a go-around if the aircraft flies past this zone. The SOPs provide a few examples of a go-around, but there is no mention of flying past the TDZ. It is therefore up to pilots to assess the situation and take action accordingly based on their knowledge and experience.

1.18.1.1 Factors contributing to the runway overrun

On 17 September 2014, the FAA published Advisory Circular (AC) 91-79A to provide "ways for pilots and airplane operators to identify, understand, and mitigate risks associated with runway overruns during the landing phase of flight."[82] This AC, which is to be used in developing risk mitigation standard operating procedures (SOPs), states that:

> […] the following hazards increase the risk of a runway overrun:
>
> - effect of excess airspeed over the runway threshold; […]
> - landing beyond the touchdown point; […]
> - a wet or contaminated runway.[83]

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

81 Ibid.

82 Federal Aviation Administration, Advisory Circular (AC) 91-79A, *Mitigating the Risks of a Runway Overrun Upon Landing* (17 September 2014).

83 Ibid.

The advisory circular also states that "specific SOPs are a primary risk mitigation tool" and that at a minimum they should focus on the hazards listed above. It is imperative that the flight crew execute SOPs faithfully. An effective training program offered by air operators on the reduction of runway overruns also "provides [flight crews with] academic knowledge and skill to increase the pilot's awareness of the factors that can cause a runway overrun."[84]

For its part, the FSF analyzed runway overrun data collected over 14 years and concluded that runway overruns were usually caused by at least one of the following factors: weather conditions, aircraft performance, landing technique, and flight crew decision making.[85]

The FSF then recommended the following measures to mitigate these factors:

- implementation of specific policies prohibiting landing beyond the touchdown zone
- inclusion of standard calls for the runway remaining based on runway lighting, runway-distance-to-go markers or other known runway markers
- implementation of procedures for managing adverse runway conditions
- implementation of training policies on flare[86] techniques
- compliance with SOPs

According to the FSF, the approach speed and technique used to conduct a flare before touchdown have a major impact on the landing distance:

> A 10 percent increase in final approach speed results in a 20 percent increase in landing distance. This assumes a normal flare and touchdown (i.e., not allowing the aircraft to float and bleed excess airspeed).[87]

If this approximate ratio of 10%/20% is used to calculate the increase in the landing distance for an aircraft configured with the flaps in approach position (F30%) and flying at a speed of 120 knots rather than 100 knots (i.e., at a speed 20% greater), the increase in landing distance is 40% at a height of 50 feet from the runway threshold. If the estimated distances in Table 4 are used, with the flaps set at 30%, an aircraft flying at 120 knots would need 3710 feet of dry runway, and 5180 feet for a runway with a CRFI of 0.38, in order to land safely.

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84 Ibid.

85 Flight Safety Foundation, *Reducing the Risk of Runway Excursions: Report of the Runway Safety Initiative* (May 2009), pp. 157–160.

86 A (landing) flare, "in a fixed wing aircraft, is the transition phase between the final approach and the touchdown on the landing surface. This sub-phase of flight normally involves a simultaneous increase in aircraft pitch attitude and a reduction in engine power/thrust, the combination of which results in a decrease in both rate of descent and airspeed." (Source: SKYbrary, "Landing Flare", at https://www.skybrary.aero/index.php/Landing_Flare [last accessed 04 May 2020]).

87 Flight Safety Foundation, *Reducing the Risk of Runway Excursions: Report of the Runway Safety Initiative* (May 2009), p. 168.

1.18.2 Decision making and situational awareness

Decision making is a cognitive process used to choose a plan of action from several possibilities. The process involves identifying issues and threats and assessing options, taking into account the associated risks. Decision making is done in a dynamic environment, and consists of 4 steps: gathering information; processing information; making decisions; and acting on decisions. Decision making may be biased if the information gathering step is not done properly and if the information gathered is inaccurate. Furthermore, information processing is influenced by organizational and individual factors, operational circumstances and the experience of the person processing the information. Communication between the pilots of a flight crew is vital. Pilots must communicate available information to have the same understanding of the situation and be able to make the best decision.[88]

Situational awareness is key to pilot decision making. Situational awareness is the perception of the elements in the environment, the comprehension of their meaning and the projection of their status in the future.[89] In a dynamic environment, situational awareness requires extracting information from the environment, integrating this information with relevant internal knowledge to create a coherent mental picture of the current situation, and using this picture to anticipate future events.[90] Shared situational awareness[91, 92] between the pilots of a flight crew depends on the extent to which the respective situational awareness of each pilot is similar. Flight crew members who have a shared situational awareness can anticipate and coordinate their actions and therefore act with cohesion and efficiency.

1.18.2.1 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

88 Transport Canada, TP 13897, *Pilot Decision Making — PDM*, at https://www.tc.gc.ca/eng/civilaviation/publications/tp13897-menu-1889.htm (last accessed 04 May 2020).

89 M. R. Endsley, "Design and Evaluation for Situation Awareness Enhancement" in *Proceedings of the Human Factors Society: 32nd Annual Meeting* (Santa Monica, California: 1988), pp. 97–101.

90 SKYbrary, "Situational Awareness", at https://www.skybrary.aero/index.php/Situational_Awareness (last accessed 04 May 2020).

91 M. R. Endsley, "Toward a Theory of Situation Awareness in Dynamic Systems", *Human Factors*, vol. 37, no. 1 (1995), pp. 32–64.

92 E. Salas, C. Prince, D.P. Baker, and L. Shrestha, "Situation awareness in team performance: Implications for measurement and training", *Human Factors*, vol. 37, no. 1 (1995), pp. 123–136.

they receive information that is contrary to their expectations, their reaction is slower and may be inappropriate.[93]

It has been established that several biases, including the following, have an impact on the way that information is interpreted and heeded in complex environments:

- In the case of expectation bias, when someone expects a certain situation, he or she is less likely to notice cues indicating that the situation is not quite what it seems. Expectation bias is worsened when crew are required to integrate new information that arrives piecemeal over time in incomplete, sometimes ambiguous, fragments.[94]
- Plan continuation bias, a form of confirmation 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."[95] Once a plan has been established and put into action, it becomes more difficult to recognize stimuli or conditions in the environment that may be cues for change, than it is when no plan has been established. In order for a pilot to recognize that a change of plan is needed, and react in time, he or she must perceive the condition or stimulus as important enough to warrant immediate action. Plan continuation bias becomes even stronger when a task (e.g., a landing) is on the verge of being completed.
- People have a limited capacity to focus their attention and process information. Consequently, people may fall into the trap of "attentional narrowing" or tunnelling. They focus on certain cues in the environment, which they attempt to process, intentionally or unintentionally, diverting their attention from other cues or tasks. For example, overloaded pilots may focus on certain indicators, to the detriment of others.[96]

Workload depends on the number of tasks to be completed within a certain period of time. If the number of tasks to be completed increases, or if the time available decreases, the workload rises. Consequently, to reduce the workload, either the number of tasks to be completed needs to decrease, or the time available to complete them needs to increase. Task saturation occurs when the number of tasks to be completed within a certain period exceeds pilots' capacity to complete them, and some tasks are put aside or delayed.

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93 M. R. Endsley, "Situation Awareness in Aviation Systems" in *Handbook of Aviation Human Factors,* Second edition (Boca Raton, Florida: CRC Press, 2010) pp. 12-1 to 12-22.

94 B. A. Berman and R. K. Dismukes, "Pressing the Approach", *Aviation Safety World* (December 2006), p. 31.

95 Ibid., p. 28.

96 J. A. Wise, V. D. Hopkin, and D. J. Garland, *Handbook of Aviation Human Factors,* 2nd edition (CRC Press, 19 April 2016), Chapter 12: Situation Awareness in Aviation Systems.

1.18.2.2 Crew resource management

CRM is the effective use of all available resources – human, hardware and information – to conduct flights safely and efficiently.[97] 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.

On 07 January 2007, a Beech A100 King Air operated by Transwest Air (TW350) crashed following a go-around executed during the flare. The 4 occupants survived the impact and successfully evacuated the aircraft. The captain succumbed to his injuries before the arrival of emergency services. The aircraft was seriously damaged by the shock and destroyed in the fire that broke out after impact. During the investigation (TSB Aviation Investigation Report A07C0001), the TSB found that CRM issues had contributed to the accident. Furthermore, the investigation found that some operators are highly unlikely to provide CRM training if it is not required by regulation. Given the inherent risks associated with a lack of modern CRM training for the crew members of an air taxi or commuter operations, in 2009, the TSB recommended that:

> The Department of Transport requires commercial air operators to provide contemporary crew resource management (CRM) training for *Canadian Aviation Regulations* (CARs) subpart 703 air taxi and CARs subpart 704 commuter pilots.
>
> **TSB Recommendation A09-02**

In its last response to this recommendation in December 2017, TC indicated that it had developed new standards for CRM training for commercial air operators subject to CARs subparts 702, 703, 704, and 705. These new training standards went into effect on 31 January 2019 and the affected air operators were required to implement them by 30 September 2019.[98] These standards require that air carriers provide initial and annual

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[97] Transport Canada, *Development and Implementation of an Advanced Qualification Program (AQP),* at https://www.tc.gc.ca/eng/civilaviation/standards/commerce-aqp-chapter7-menu-196.htm (last accessed 04 May 2020).

[98] Transport Canada, Exemption NCR-003-2019, *Exemption from subsections 722.76(24), 723.98(33) – Aeroplanes, 723.98(25) – Helicopters, 724.115(38) – Aeroplanes, 724.115(28) – Helicopters and 725.124(39) of the* Commercial Air Service Standards *made pursuant to subsection 702.76(1), subparagraph 702.76(2)(d)(vi), subsection 703.98(1), paragraph 703.98(2)(d), subsection 704.115(1), paragraph 704.115(2)(e), subsection 705.124(1) and paragraph 705.124(2)(e) of the* Canadian Aviation Regulations (31 January 2019), at https://www.tc.gc.ca/CivilAviation/regserv/Affairs/exemptions/docs/en/3174.htm (last accessed 04 May 2020).

refresher training on modern CRM to flight crews, flight attendants, airline dispatchers, flight monitoring personnel, ground crews and maintenance personnel.

The TSB is of the opinion that the regulation measures taken by TC will considerably reduce the risks associated with the safety deficiency defined in recommendation A09-02 once the new CRM standards are in effect. Consequently, the TSB considers the response to Recommendation A09-02 to be Fully Satisfactory.[99]

At the time of the accident, Strait Air, like other operators subject to CARs subparts 702, 703 and 704, was not required to provide CRM training to its flight crews, and did not provide such training.

1.18.2.3 Threat and error management

Modern CRM incorporates threat and error management (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 emphasizes the principles of anticipation, recognition and recovery[100] and is based on the proactive detection of threats that could reduce safety margins. Crews can establish counter measures during the planning stage or during flight, modifying the plan according to circumstances.

Effective error management is associated with specific behaviours by the flight crew, the most common being vigilance, an invitation 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.

TSB air transportation safety issue investigation report A15H0001 found that the 2 main underlying factors contributing to air-taxi accidents[101] were the acceptance of unsafe practices and the inadequate management of operational hazards.

1.18.2.4 Authority gradient

Authority gradient refers to the decision-making hierarchy between the captain and the FO. This relationship is characterized by several factors, including experience and rank within the organization. A strong authority gradient may be a barrier to the decisional dynamic of a flight crew and may discourage the FO from expressing disagreement, depending on their

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[99] Transportation Safety Board of Canada, Recommendation A09-02, Reassessment of the response from Transport Canada to Aviation Safety Recommendation A09-02 regarding crew resource management training (February 2018), at http://www.bst-tsb.gc.ca/eng/recommandations-recommendations/aviation/2009/rec-a0902.html (last accessed 04 May 2020).

[100] 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).

[101] This investigation reviewed a total of 167 TSB aviation investigation reports published from 2000 to 2014.

age, seniority, culture, respect for authority, overall experience, and experience with this type of aircraft.

In the case of the crew for the occurrence flight, the captain was the company's chief pilot, with 4288 flight hours accumulated at the time of the accident. The FO had accumulated 395 flight hours. Also, the captain had trained the FO when he began working for Strait Air. The captain and co-pilot had frequently been paired up for previous flights. The investigation did not find any authority gradient issues between them during previous flights.

1.18.2.5 Escalation of assertiveness by first officers

An example of a CRM communication tool is the Probing, Alerting, Challenging and Emergency Warning (PACE) model.[102] The PACE model provides pilots, especially FOs, with a series of communication strategies designed to allow for a natural escalation of assertiveness, depending on the circumstances at the time. Escalation can be progressive or immediate depending on the threat level identified.

The PACE model starts with the use of probing and unambiguous questions when safety is not in jeopardy and there is time to ask questions. This step is done to improve the crew's understanding of the situation and to help align mental models in a non-threatening way.

The next step in the process is to alert the other pilot that there is a concern. At this stage, the individual voices a specific concern to make sure that the other person understands the concern. Unambiguous and direct language is essential for an effective alert.

The third step in the escalating process is a challenging statement. This statement unambiguously presents the other person with a clear description of the consequences associated with continuing on a particular course of action, and provides an alternative course of action.

The final step is emergency intervention, with the PM taking control of the aircraft in dangerous situations or when time is critical.

While the PACE model provides a series of communication strategies that range from non-threatening to very directive, the individual does not have to start at the beginning of the model if the situation dictates otherwise. The underlying principle behind this model is to ensure that all parties understand the situation and that everyone is thinking in a similar manner regarding the proposed course of action.

In effect, the model allows the organization to give the FO the responsibility to not only take control, but also to take command of the aircraft from the captain when necessary.

Ideally, the model should be supported by company philosophy, addressed in an organization's policy, and implemented by procedures customized to the operator's needs.

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102 R. O. Besco, "To Intervene or Not To Intervene? The Co-Pilot's Catch 22," in the Proceedings of the 25th International Seminar of the International Society of Air Safety Investigators, 27, 5, pages 94-101.

Practical training sessions are necessary to reinforce the philosophical, policy-related, and procedural concepts and phraseology through their application in realistic operating scenarios.

At the time of the accident, Strait Air, like many other similar operators, had not provided its flight crews with an assertiveness tool; however, it was not required by regulations.

1.18.3 TSB Watchlist

The TSB Watchlist identifies the key safety issues that need to be addressed to make Canada’s transportation system even safer.

1.18.3.1 Runway overruns

Runway overruns are an issue on the 2018 Watchlist, and have been on the Watchlist since 2010.

Despite the millions of successful movements on Canadian runways each year, runway overrun accidents sometimes occur during landings or rejected takeoffs. A total of 135 runway overrun accidents and incidents were recorded in Canada between 2005 and the beginning of October 2018. In fact, since 2013, an average of 9 overrun accidents and incidents occur annually. These can result in aircraft damage, injuries, and even loss of life—and the consequences can be particularly serious when there is no adequate RESA or suitable arresting system.

There is currently no requirement in Canada for runways to meet international standards and recommended RESA practices.

Many Canadian airports do not yet meet the TC RESA guideline of 150 m, and most large airports do not meet the ICAO recommended practice of 300 m RESAs for runways longer than 1200 m.[103] As a result, the terrain beyond the end of many runways in Canada could contribute to aircraft damage and injuries to passengers and crew in the event of an accident.

1.19 Useful or effective investigation techniques

Not applicable.

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[103] International Civil Aviation Organization, Annex 14 to the Convention on International Civil Aviation, Vol. 1 *Aerodrome Design and Operations*, Eighth Edition (July 2018).

2.0 ANALYSIS

There was no evidence 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 pilots' performance was in some way degraded due to physiological factors such as fatigue. Consequently, the analysis will focus on flight planning, the conduct of the flight, and occupant survivability. Finally, the analysis will examine human factors associated with runway overruns.

2.1 Flight planning

On the day of the occurrence, C-GJXF, which was conducting a series of flights as NUK107, touched down at Sept-Îles (CYZV), Quebec, at 0836 and took off again at 1049, bound for Havre St-Pierre (CYGV), Quebec. While on the ground at CYZV, the captain checked the weather conditions for the following flights, while the first officer (FO) was completing tasks to prepare the aircraft.

2.1.1 Weather conditions during flight planning

Given that visibility was reduced due to snow showers in the area, the captain changed the alternate airport from the Natashquan Airport (CYNA), Quebec, to the Michel-Pouliot Gaspé Airport (CYGP), Quebec.

When the captain checked the aerodrome routine meteorological report (METAR) for CYGV, the reported visibility was ¾ statute mile (SM). Although this visibility was less than the visibility published in the *Canada Air Pilot* (CAP) for the LOC/DME RWY 08 approach[104] at CYGV, it was at the approach ban limit for this flight. Although the pilot was allowed to conduct the flight under instrument flight rules, it was reasonable for him to expect to have to perform a go-around or to divert to the alternate airport given the weather conditions forecast for CYGV and the surrounding area.

2.1.2 Recommended landing distance on contaminated surface

Based on the weight of the aircraft, which was close to the maximum authorized landing weight (see 1.6.1), and runway conditions with a Canadian runway friction index (CRFI) of 0.38, the recommended landing distance at a height of 50 feet while crossing the runway threshold was 2900 feet (Table 4). The aircraft had approximately 1600 additional feet of runway because Runway 08 at CYGV is 4498 feet long. Based on an expected approach speed of 100 knots at the runway threshold, it would take the aircraft approximately 9 seconds to cover the additional 1600 feet of runway. Therefore, after crossing the threshold, the pilot flying (PF) had approximately 9 additional seconds available to touch down on Runway 08 at CYGV.

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[104] Localizer (LOC) approach on Runway 08 using distance measuring equipment (DME).

The captain had checked the weather conditions before taking off from CYZV. Given his experience, he knew the aircraft's landing performance and did not expect any particular problems in landing at CYGV. Therefore, no specific landing performance calculations were done.

In their initial communication with Madeleine Radio, the flight crew received the weather conditions once again. They were identical to those obtained by the captain before departing from CYZV.

2.2 Conduct of the flight

The aircraft departed from CYZV 46 minutes late, but the takeoff, climb, and cruise flight were conducted with no particular issues.

2.2.1 Preparation for approach

Generally, preparation for approach is done in cruise flight, once the flight crew has received the most recent weather conditions and has determined the active runway. Of the 31 minutes of this short flight, the aircraft was in cruise flight for only 9 minutes. The crew's workload was heavy during this short flight owing to the numerous calls required on different frequencies and the need to monitor weather information on the automated weather observation system (AWOS) before beginning approach and landing preparations, in addition to the tasks required during approach and landing.

According to standard operating procedures (SOPs), when preparing for approach, the PF must review the approach procedure and the missed-approach procedure. Given that the runway conditions and AWOS weather conditions were obtained during descent, it is likely that preparations for approach were not completed before beginning the descent.

2.2.2 Weather conditions before landing

At 1100, which was 11 minutes after takeoff from CYZV, weather conditions had deteriorated at CYGV, and visibility was ⅜ SM in moderate snow. At 1109, visibility was further reduced to ¼ SM in heavy snow. At 1110, the pilot not flying, who was monitoring the aircraft's flight parameters (the PM), heard the most recent weather conditions for CYGV on the AWOS frequency. The PM then informed the PF of the weather conditions, including the fact that visibility was ¼ SM in heavy snow. Visibility remained ¼ SM until 1200, which was 40 minutes after the aircraft landed at CYGV.

2.2.2.1 Instrument approach design

When the LOC/DME RWY 08 approach for CYGV was designed, the minimum published visibility was 1 SM. This is the minimum visibility at which an approaching pilot at the minimum descent altitude (MDA) should be able to establish and maintain the visual reference required up until landing. In Canada, this visibility is only published in the CAP for information purposes; it is not an approach limit. An approach limit is based on rules applicable to approach bans, which vary depending on the type of operations (see 1.8.1.2

and 2.2.2.2). In every case, the approach limit is below the minimum visibility established during approach design. Consequently, it is likely that, once at the MDA, pilots are not able to establish the required visual reference, which will help them make a safe landing.

2.2.2.2 Approach ban and aerodrome operating visibility

In places other than Canada, approaches are banned if the reported visibility is less than the applicable visibility on the approach chart. Consequently, air traffic control will not clear an aircraft for approach if weather conditions are below the published limits on the approach chart. However, in Canada, the decision whether or not to comply with an approach ban lies entirely with the captain. Although Transport Canada (TC) can take enforcement action later, when a captain conducts an approach, there is nothing to prevent him or her from proceeding with the approach and landing below the minima.

In Canada, several rules and conditions associated with and exceptions to approach bans are published in the *Canadian Aviation Regulations* (CARs) and in the “Operating Minima” section of the CAP. The visibility level resulting in an approach ban is different for private operators, commercial operators, and commercial operators with Operating Specification 019. Therefore, based on the visibility published in the CAP for the approach being used, a different ratio is applied to obtain the ban limit for a specific flight.

Every aerodrome establishes an operating visibility limit that applies to ground manoeuvres and takeoffs and has nothing to do with approach bans. This limit is not published in the same location as the published visibility for the approach—it is published in the runway section of the *Canada Flight Supplement* (CFS). If an aerodrome’s operating visibility limit is not published in the CFS, this means that operations are not authorized when visibility is less than ½ SM. To determine whether the approach is permitted, the approach chart (in the CAP) and the approach ban criteria (CAP-GEN) must be consulted, then the runway section in the CFS must be consulted to determine whether ground manoeuvres are authorized when visibility is less than ½ SM. Finally, in some cases, although the approach may be authorized for certain operators according to approach ban conditions when visibility is less than ½ SM, the aerodrome operating visibility may not permit ground manoeuvres.

CYGV’s published operating visibility is ¼ SM and the visibility published in the CAP for the LOC/DME RWY 08 approach is 1 SM. However, the minimum visibility for approach ban purposes is ¼ SM for private operators and ¾ SM for commercial operators like Strait Air, but ½ SM for commercial operators with Operating Specification 019. Therefore, it is reasonable to conclude that visibility limits for operations at Canadian airports are not clear, and that the numerous conditions and exceptions increase the risk of misinterpretation by flight crews. If TC does not simplify approach and landing operating minima, flight crews may proceed with an approach that is actually banned, thereby increasing the risk of approach-and-landing accidents (ALAs), including runway overruns.

Neither air traffic control, flight advisory services, nor the aerodrome operator know with certainty the type of operations being carried out by an approaching aircraft, and they do not know whether the operator has Operating Specification 019. It is therefore impossible for them to determine which approach ban visibility limits apply to an aircraft executing an instrument approach, and to notify pilots that the approach is banned under conditions at that time. Therefore, it is up to the captain to interpret the approach ban, and it is the captain who decides whether or not to continue with the approach. Consequently, pilots may decide not to consider approach ban limits and may proceed with an approach with no immediate restriction, which increases the risk of an ALA.

Given that the occurrence flight was a commercial flight without Operating Specification 019, the approach ban was set to ¾ of the 1 SM visibility published in the CAP for the LOC/DME RWY 08 approach at CYGV. Therefore, the minimum visibility for approach ban purposes was ¾ SM for this flight. The aircraft was not authorized to proceed with the approach beyond inbound final approach fix (FAF) ALKOV because the reported visibility at CYGV was ¼ SM. However, during the flight, the captain incorrectly believed that the exception to the aerodrome operating visibility, with regard to the visibility reported by AWOS, could apply to the approach ban. He therefore believed that the AWOS visibility was not limiting for this approach. Consequently, the captain continued the approach beyond the FAF when the reported visibility was below the approach ban minima, which contributed to the ALA, which in this case was a runway overrun.

The PM was aware that weather conditions were below the approach minima published in the CAP. However, he did not have a clear understanding of all of the details pertaining to an approach ban for this commercial flight conducted without Operating Specification 019. Uncertain of the application of the approach ban, he did not question the captain's decision to continue the approach. This failure to fully understand the visibility limits applicable to this approach was not discussed or resolved before landing.

Given that the ban did not prevent the approach and landing even though visibility was far below the approach ban applicable for this flight (¼ SM rather than ¾ SM), it is reasonable to conclude that Canada's current approach ban is not an effective defence against approaches and landings in visibility below the minima.

Between December 2006[105] and December 2019, 31 incidents occurred following approaches conducted below the MDA with few visual references. Of these 31 incidents, 17 occurred during a landing in weather conditions where visibility was *below* what is published on the approach chart.[106]

Furthermore, this situation continues to occur today: 9 of the 17 incidents have occurred within the past 5 years.

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105 Implementation date for landing minima regulations (CARs section 602.128) and approach ban regulations (CARs section 602.129).

106 After these 17 occurrences, the TSB published the following air transportation safety investigation reports: A08W0237, A08O0333, A09Q0203, A12Q0216, A14A0067, A15O0015, A15H0002, A16A0041, and A18Q0030.

2.2.3 Approach

After intercepting the final approach path, the crew turned on all airport lighting (runway lights, omnidirectional approach lighting system [ODALS] and precision approach path indicators [PAPI]) at high intensity using the aircraft radio control of aerodrome lighting. However, when the aircraft was approaching the MDA, a series of 6 rapid clicks were heard on the frequency, decreasing the airport lighting to medium intensity (30%).

The pre-landing checklist was completed before FAF ALKOV; however, at that time, in accordance with Strait Air SOPs, the flaps and propellers were not yet configured for a landing. According to the SOPs, an aircraft must be configured for a landing when a decision is made to land the aircraft which, in this case, was at the MDA.

2.2.3.1 Required visual reference – continuing the descent below the minimum descent altitude

The SOPs also state that when an aircraft reaches the MDA, the PM must make precise calls based on what he or she can see. The PF must respond to the precise calls in a manner that depends on the situation: request a go-around and begin the manoeuvre, or confirm landing and request full flaps and propellers at low pitch in preparation for the landing. After completing these actions, the PM confirms the target speed. The reference speed was 100 knots for this flight. The PF can only continue the descent below the MDA if he or she has the required visual reference in sight and can only land if he or she can maintain the visual reference in sight until landing.

When the aircraft reached the MDA, the PM did not have visual contact and made the standard call "MINIMUM, NO CONTACT" in accordance with the SOPs. At that point, the aircraft was on the optimal glide slope of 3°, 0.85 SM from the threshold of Runway 08, and the reported ground visibility was ¼ SM. Although, from his perspective, the PF may have seen *one* of the possible visual references required to continue the approach, a few seconds later, the PM still did not have visual contact and asked the PF if he was going to conduct a go-around. At that point, the PF (and captain) advised that he had visual contact and continued the descent below the MDA, without making the SOP calls confirming a landing and requesting the aircraft landing configuration.

The flaps remained in the approach position (30%) and the aircraft's speed never reduced to the reference speed of 100 knots, which increased the landing distance by more than 25%, to a total of approximately 3700 feet (Table 4).

At that point, the PM's mental focus was on the need to conduct a go-around, while the PF was focused on continuing the approach and landing. Therefore, the flight crew no longer had shared situational awareness, and the PM was uncertain of the PF's intentions, other than the intention to continue the approach. Consequently, if flight crew members do not have shared situational awareness, they cannot anticipate or coordinate their actions, which increases the risk of an ALA. As the approach continued, the pilots were unable to effectively communicate what each of them was perceiving, understanding and expecting with regard to the aircraft's position for the approach to land.

2.2.4 Landing

2.2.4.1 Required visual reference – continuing to a landing

During this occurrence, the flight crew could have had ODALS, runway lights and PAPI lights as visual aids. Although PAPI is *one o*f the possible visual references required to continue the approach below the MDA, in its definition of a required visual reference, CARs requires that the pilot have a sufficient number of visual references to "make an assessment of the aircraft position and rate of change of position, in order to continue the approach and complete a landing."[107] Otherwise, the pilot must execute a missed approach.

In reality, it is unlikely that a flight crew who can see only the PAPI would be able to land safely because the lights are on the left, offset from the runway. In that case, the crew should have at least one other visual reference associated with the runway once past the PAPI.

In this occurrence, after crossing the PAPI, the flight crew could no longer see the runway or the runway lights for a brief moment. The crew then saw a small section of paved runway approximately 20 feet long and 4 feet wide, slightly to the right of the aircraft's path. Although the crew still could not see any runway lights, and the PF still could not see the rest of the runway, he pointed the aircraft in the direction of this paved section.

The crew only had a few visual references with which to accurately determine the aircraft's position in relation to the start and end of the runway. Therefore, the difficult manoeuvre of aligning the aircraft over the runway was made even more difficult by the visibility, which was reduced to ¼ SM due to strong snow showers, as well as the snow-covered surrounding terrain, the completely snow-covered runway and the lighting set to medium intensity (30%).

Furthermore, as the PF was pointing the aircraft in the direction of the visible paved portion of runway, his workload was very heavy. He was focusing his attention on performing the manoeuvre and was concentrating on certain indicators, to the detriment of others. His situational awareness dropped quickly, and he lost track of time and was no longer thinking about the aircraft's configuration (see 2.4.3.2.2).

Given that cognitive bias, the tendency to stick with a plan, becomes even stronger when a task is on the verge of being completed, it becomes increasingly difficult for a pilot to change plans and execute a go-around. Consequently, if pilots continue their approach below the MDA with only one visual reference, they risk continuing their landing without having established the additional visual references required to land safely. The issue of continuing an approach below the MDA with few visual references has come up several times in TSB aviation investigation reports.

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[107] Transport Canada, SOR/96-433, *Canadian Aviation Regulations*, subsection 101.01(1).

2.2.5 Runway overrun

During the alignment manoeuvre, the aircraft passed by the small visible paved portion and found itself at the mid-point of the runway, where there was only 2250 feet left to touch down (figure 7, section 1.16.1). At that point, an overrun was likely, because the recommended landing roll distance was an estimated 2250 feet with the flaps at F30% and a CRFI of 0.38.

During approach, runway lighting was reduced to medium intensity, which was 30% of maximum strength, thereby reducing the probability of seeing the visual references required to conduct the landing on the runway. Also, the low visibility combined with the runway condition and the snow-covered terrain did not provide enough visual contrast for the pilots to be able to detect the runway surface. Despite this, the captain proceeded with the landing sequence, without seeing or knowing the length of the remaining runway ahead and unable to accurately assess the aircraft's position. Consequently, the aircraft landed approximately 3800 feet past the threshold, 700 feet from the end of the runway, and stopped its landing roll in a snowbank, 220 feet beyond the runway.

2.3 Occupant survivability

2.3.1 Passenger pre-landing safety briefing

During this short flight, one of the passengers unfastened her safety belt after takeoff and forgot to refasten it before landing. She received minor injuries. It is always preferable for passengers to keep their safety belt fastened during flight, to reduce the risk of injury if turbulence is encountered. SOPs require that a safety briefing be provided to the passengers before descent. However, due to the short period of time in cruise flight and the heavy workload during descent, this briefing was not given. Consequently, if a safety briefing is not provided to passengers before landing to remind them to fasten their safety belt, some of them may not fasten their safety belt before landing, which increases the risk of injury in the event of an accident.

2.3.2 Shoulder harness

Studies conducted in the United States and Canada on the protection of occupants in small aircraft during accidents have indicated that the likelihood of surviving the forces of impact are considerably higher when an upper body restraint system is used (see 1.15.2). Although the forces of deceleration did not affect occupant survivability, a minor injury received by 1 passenger was attributed to the shock of his upper body hitting a fixed part of the aircraft. Therefore, if the passenger seats on small aircraft are not equipped with a shoulder harness, passengers face a greater risk of injury, more or less serious, perhaps even fatal, in the event of an accident.

2.3.3 Emergency response plan at Havre St-Pierre Airport

After bringing the aircraft to rest, the captain told Madeleine Radio that he did not require assistance. The 911 call centre was not contacted at that time. Consequently, fire protection services were not contacted either to secure the accident site.

When an accident occurs at an airport, airport staff are responsible for applying the emergency response plan procedures and assessing whether all of the measures are necessary, after establishing the passengers' condition and securing the accident site. Therefore, if the airport emergency response plan is interrupted and fire protection services are not contacted quickly to secure the accident site in the event of a fuel spill or fire, there is a risk of injury to the people at the accident site, and damages to airport facilities and the environment.

2.3.4 Runway end safety area

Runway 08/26 at CYGV was designed and certified in accordance with the recommended standards and practices for aerodromes stated in the 4th edition of TP 312. It includes a 60 m strip extending away from the threshold runway and beyond the end of the runway. The more recent 5th version of TP 312 now requires a runway end safety area (RESA) at least 150 m in length for runways longer than 1200 m. However, according to CARs section 302.07, commonly referred to as the "grandfather clause", CYGV is not required to meet the new RESA standards.

Runway overruns may result in damages to aircraft, and injuries or losses of lives, and may have particularly serious consequences if there is not a sufficient RESA or an appropriate arresting system (see 1.18.3.2).

The occurrence aircraft passed the threshold and runway strip (60 m), then hit a snow bank, which brought the aircraft to rest. The aircraft sustained substantial damages, particularly to the landing gear, which bent backward. Half of the passengers received minor injuries. If it had not hit the snow bank, the aircraft would have continued its landing roll and ended up in a ditch, which might have caused serious injuries to the occupants. Consequently, if runways 1200 m or longer do not have a RESA at least 150 m long, or some other arresting system that provides aircraft with an equivalent level of safety, there is a risk of injury to the aircraft occupants in the event of a runway overrun.

2.3.5 Snow removal and runway closure

Because weather conditions were deteriorating and snow showers were getting heavier on the day of the occurrence, snow removal operations were being carried out continuously at CYGV. According to the CYGV snow clearance plan, several criteria may be used to determine whether a runway must be closed, including snowdrifts taller than 30 inches, less than 100 feet of usable runway, or a CRFI less than 0.15.

When the aircraft landed at CYGV, Runway 08 had been cleared to a width of 80 feet, but there were snowdrifts 30 inches tall, which was the limit, meaning that the usable portion of the runway was less than 100 feet. Given that runway closure was not mandatory when only one snow removal criteria was out of tolerance, the runway remained open. Consequently, if airport operators are not required to close a runway when one of the criteria stated in their snow clearance plan has been exceeded, there is a greater risk of a runway overrun.

2.4 Human factors associated with runway overruns

2.4.1 General

To better understand the captain's choice and decisions, it is important to look at the context of the occurrence flight, more specifically, air taxi flights governed by CARs subpart 703. Air taxi operators generally have less means of providing operational support than airlines, who have specific policies and procedures, and dispatchers who plan flights. Furthermore, airline flights are generally conducted to and from larger airports where support is available in the air and on the ground. The captain of the occurrence aircraft was solely responsible for planning and conducting all of his flights, with little support or supervision.

Several of the overrun risk factors identified by the Flight Safety Foundation (FSF)[108] were present at the flight planning stage of this flight: visibility at CYGV was at the approach minima, in snow showers; the runway was covered with snow; there were 30-inch snowdrifts; and the CRFI was 0.38. The snow showers intensified during the flight, reducing visibility to ¼ SM, and consequently reducing the probability of landing at CYGV as scheduled. The captain did the flight planning on his own, based on his knowledge and skills, and decided on his own how to manage risks. There was no indication that the company put pressure on the flight crew to land at CYGV, nor that the crew put pressure on themselves.

2.4.2 Crew resource management

The effectiveness of crew resource management (CRM) depends largely on the captain's cognitive and interpersonal skills in managing the flight. Therefore, CRM training is an invaluable tool that assists pilots in managing and coordinating crew tasks, issues and threats, and decision making. In January 2019, TC published a new standard (see 1.18.2.2) requiring that air taxi operators such as Strait Air provide modern CRM training to its staff by 30 September 2019. In order to be effective, and to assist pilots in making the right decisions, this training should be relevant and evaluated, and subject to oversight. It must be part of a corporate culture where safe decisions are the norm and unsafe practices are not accepted.

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108 Flight Safety Foundation, *Reducing the Risk of Runway Excursions: Report of the Runway Safety Initiative* (May 2009), pp. 157–160.

2.4.2.1 Threat and error management

Threat and error management (TEM) is based on the anticipation, identification and correction of threats and errors. In practice, it is carried out through the preparation and adaptation of shared action plans (for example, before departure and during preparation for approach) so that crew members have the same situational awareness.

In the occurrence flight, the threats before departure were associated with the presence of altocumulus castellanus indicated in the graphic area forecast. This type of cloud formation is an early sign of an unstable air mass that could lead to a degradation of weather conditions, particularly visibility due to snow showers. After becoming aware of these forecasts and the expected reduced visibility, the captain changed the alternate airport for the flight to CYGV. The aircraft was not required to immediately head to the alternate airport if a landing was impossible at CYGV, because the amount of fuel on the aircraft was more than the regulatory minima. The captain may have had a plan of action for the flights that day, but he did not discuss it with the FO, who was not aware of the change in alternate airport.

Visibility dropped again and reached the approach ban minima for CYGV, which made landing at CYGV even more unlikely. Furthermore, even if the aircraft was able to land at CYGV, the next departure would also be delayed due to the accumulation of snow on the aircraft.

The amount of snow that was falling at CYGV during snow removal operations indicated that the snow-covered runway might be difficult to identify, particularly because the surrounding terrain was also covered in snow. The presence of 30-inch snowdrifts could obstruct the runway lights and make the runway even more difficult to see. Finally, given the CRFI of 0.38, the landing distance from 50 feet was increasing from 2100 to 2900 feet.

2.4.2.1.1 Flight crew coordination and situational awareness

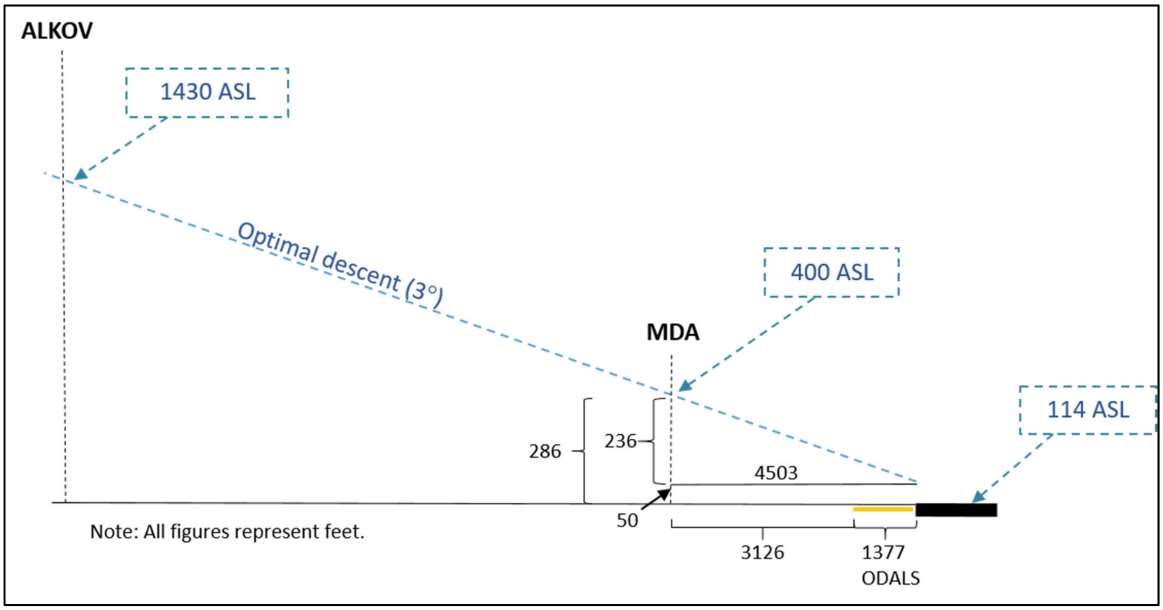
The members of a flight crew must have a shared plan and shared knowledge of a situation in order to be able to take action based on the risks, threats and issues to be managed. The occurrence flight planning was done in accordance with SOPs, which did not require the direct participation of the FO in the assignment of pre-flight tasks. Consequently, the FO was not aware of the weather conditions at the approach ban minima, the change in alternate airport, the amount of fuel on board, the runway conditions, nor the ground de-icing that would be required at CYGV. He therefore had a different situational awareness than that of the captain.

As the aircraft was descending, the crew's workload was heavy: the PM was listening to weather conditions being broadcast on the AWOS frequency, and was taking note of them while the PF was monitoring Madeleine Radio on the mandatory frequency.

The aircraft was planning to descend on final approach on an optimal descent slope of 3°, which ended at the runway threshold at approximately 50 feet. The aircraft would be approximately 4500 feet from the threshold of Runway 08 when it reached the MDA. Given that ODALS is 1377 feet (419.8 m) long, the aircraft would be approximately 3100 feet from the first approach light (Figure 12).

It was unlikely that the flight crew could see the visual references required at the MDA given that a visibility of ¼ SM corresponds to 1320 feet. Also, given that the runway and surrounding area were covered with snow, the runway surface would have been difficult to see, reducing the probability of a landing at CYGV.

Figure 12. Distance from the threshold and the omnidirectional approach lighting system at the minimum descent altitude (Source: TSB)



Even if the aircraft had landed successfully at CYGV, it would have quickly been covered in snow. Given that the departure from CYZV was delayed due to snow accumulation on the aircraft, it was reasonable to expect a delay on the ground at CYGV, where heavy snow showers were occurring. Strait Air did not have a hangar at CYGV and was not authorized to de-ice its aircraft on the ground. Therefore, the aircraft could not take off in the heavy snow conditions because it was impossible to remove the snow from the aircraft, and to taxi into position on the takeoff runway, without the snow sticking to the wings (see 1.17.1.3). The initial plan, which included a landing at CYGV, needed to be revised, particularly because the amount of fuel on board was greater than the minimum required by regulation, and it was possible to proceed to the next scheduled destination, La Romaine (CTT5), Quebec, before heading to the alternate airport (CYGP).

Given that the crew had many tasks to complete before making in straight-in approach to Runway 08, they had little time to revise the initial plan based on the conditions that had just changed. It is likely that the crew were overloaded, completing the most urgent tasks in the order of priority, and they did not have time to reflect on the consequences of the increased snow intensity and the reduced visibility on the landing at CYGV. Therefore, the issues and threats associated with landing in poor visibility conditions in heavy snow on a contaminated runway were not managed jointly by the flight crew members, which increased the risk of an ALA.

The approach briefing mentioned in the Strait Air SOPs, which is done as part of the preparation for approach, includes a review of the approach chart, but does not include establishing the minimum visibility for an approach ban. Runway contamination is mentioned, but there is no reference to a touchdown point or the need to conduct a go-around if this point is passed. If SOP approach briefings do not cover all of the restrictive elements for an approach, pilots may conduct an approach outside the prescribed limits, increasing the risk of an ALA.

2.4.2.1.2 Preparation for go-around

In the *Go-Around Decision Making and Execution Project* report, the FSF stated that not making a decision to go around when it becomes necessary is the main cause of runway incursions on landing. A go-around is one of the final defences, and the primary defence, against ALAs, so preparing for one is vital.

While preparing for approach, the captain and FO did not discuss the high probability of needing to conduct a go-around. The FO therefore did not review the tasks associated with this manoeuvre, which is not executed very often, but must be done without hesitation. Consequently, if pilots are not properly prepared for a go-around on every approach, they may not be ready to react promptly when this manoeuvre becomes imperative, thereby increasing the risk of an ALA.

2.4.2.1.3 Performance during landing and in the runway touchdown zone

The captain did not perform precise calculations to determine the landing distance required on Runway 08 at CYGV, where the CRFI was 0.38. Based on his experience, he determined that there were no particular issues in landing this aircraft on a 4500-foot snow-covered runway. However, without precise calculations, this knowledge was not enough to obtain a quantitative measurement of the margin the crew had to conduct its landing. Therefore, the FO was unable to monitor the progress of the landing using a known distance, so that he could advise the PF of any deviation or significant change. For example, during landing, the FO, with no precise measurements, was aware that the aircraft was approximately at the runway mid-point (2250 feet) before it touched the ground, but he did not have the information he needed to assess the progression of this landing. According to landing distance calculations (Table 4), the aircraft needed 1750 feet for a landing roll and complete stop after an approach and landing with the flaps at 100%. Therefore, without even taking into account the fact that the flaps were not at 100%, the aircraft had to touch down within the next 3 seconds[109] to avoid a runway overrun.

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[109] Margin = 2250−1750 = 500/169 feet/second at 100 knots = 2.96 seconds.

2.4.2.2 Standard operating procedures and Federal Aviation Administration and Flight Safety Foundation recommendations

SOPs are not only guidelines for the general use of aircraft, they are universally recognized as fundamental to safe aviation operations, creating a framework for the application of concepts such as CRM and TEM. SOPs are the reference for crew standardization of roles and responsibilities. They establish the working environment required for effective CRM, assisting flight crew members in maintaining a shared situational awareness. Between 1999 and 2019, SOPs were mentioned in 113 findings as to causes, contributing factors and risks in TSB aviation investigation reports. The deficiencies identified were primarily associated with a lack of precise directives, differences in procedures and a failure to follow procedures.

Given that deviations from SOPs are one of the major causes of ALAs, it is vital that SOPs are developed and regularly updated in a manner that best reflects the tasks completed by crew members. SOPs must also be based on clear policies that define the FO's role and responsibilities and provide the FO with the assertiveness tools needed to express concern in dangerous situations.

Although Strait Air's SOPs complied with CARs requirements from a formal point of view, their effectiveness was not evaluated by TC. CRM principles were not fully incorporated, and in many instances, the procedures were not associated with mandatory policies, leaving room for interpretation by the pilot, who had to use his own judgement. So, when the PF deviated from the SOPs, the PM had to improvise and make a suggestion for a go-around, which was rejected. At that point, the flight crew members lost their shared awareness of the situation. The deviation from SOPs at a critical moment of flight was a source of confusion between the flight crew members, to the point where the aircraft was not configured for a landing, increasing the landing distance required and thereby increasing the risk of a runway overrun.

In 2014, the Federal Aviation Administration (FAA) published a document intended to provide pilots and airplane operators with ways to identify, understand, and mitigate risks associated with runway overruns during the landing phase of flight through the development of specific SOPs (see 1.18.1). In this investigation, several findings as to risk appear to be linked to SOP ambiguities or deficiencies.

The FSF has also released several recommendations promoting policies and SOPs to reduce the risk of runway overruns. Some of these recommendations specifically mention issues and threats that are relevant to the occurrence flight, such as the publication of information and procedures for landing on a contaminated runway, a policy for the preparation and execution of a go-around to discourage hazardous landing manoeuvres, and a policy banning landings beyond the touchdown zone (TDZ). However, Strait Air had not incorporated these recommendations into its operations, and there was no requirement to do so.

2.4.2.2.1 Absence of cockpit voice recorder

Because the aircraft was not equipped with a cockpit voice recorder, it was impossible to clearly establish the activities of the 2 pilots and the communications between them during the flight. If cockpit voice recordings are not available, it is impossible to accurately assess CRM, SOP execution and compliance, and workload management, which may limit the identification of safety deficiencies and the advancement of safety.

2.4.2.2.2 Transport Canada regulatory oversight

Although TC performed an inspection of Strait Air operations every year, this inspection was limited to documentation of the systems put in place by the company. Consequently, it was impossible to assess the effectiveness of training, CRM, TEM, and decision making, or the degree to which SOPs are applied or complied with and how effective they are. Given the importance of SOPs in mitigating the risks of ALAs, it is reasonable to conclude that monitoring is essential on board aircraft. If TC does not provide oversight of flight operations to assess the effectiveness of CRM, TEM, decision making, and SOPs, including application and compliance, these SOPs may be ineffective, increasing the risk of an accident, particularly an ALA.

2.4.3 Decision making

2.4.3.1 Situational awareness

Flight crews make decisions based on factors such as situational awareness, threat management and an assessment of the options available and the associated risks. In this occurrence, the captain had to process new information being received and integrate it with information he already had to create a coherent mental image of the situation and review the issues and threats associated with the initial plan to land at CYGV. He then had to share his evaluation and his plan of action with the FO so that they could come to a shared understanding of the situation. The FO then would have been able to anticipate what was coming, and he and the captain could have coordinated their actions so that they would be coherent and efficient.

2.4.3.2 Cognitive context and decision-making bias

To understand why the captain, who was the PF, continued with the landing when he had very few visual references, we need to look at the context, and his perception and understanding of the situation when decisions were made, because situational awareness is key to pilot decision making. The investigation found that the PF’s workload was heavy during the approach and increased during the landing.

2.4.3.2.1 Tendency to stick with a plan and tendency to anticipate

When the crew received new information about the weather conditions indicating that visibility had been reduced to ¼ SM, the captain had little time to review his initial plan and consider the various options and their associated risks, while completing all the tasks required for a straight-in approach to Runway 08.

The tendency to stick with a plan may have influenced the captain and led him to continue with his initial intention to land at CYGV, despite the significant reduction in visibility. Under these circumstances, it was difficult for him to realize that this change in weather conditions meant that he needed to review his initial plan immediately and consider his options.

When the aircraft reached the MDA, the workload of the captain, who was flying the aircraft manually and at the same time trying to find the required visual references, was heavy. The captain was aware of the snow removal operations being carried out at CYGV while the approach was being conducted. Given that the runway surface is generally visible once snow has been cleared, it is possible that the captain expected to see the black surface of the runway with no problem. However, when the aircraft crossed the threshold, he still could not see the runway. The reality of the situation no longer matched his expectations, which may have delayed his reaction time and the decision to change plans. Therefore, it is likely that a combination of these cognitive tendencies contributed to his hesitation to conduct a go-around immediately after losing sight of all visual references once past the PAPI.

2.4.3.2.2 Narrowed attention

Shortly after passing the PAPI, the crew could see a small portion of paved runway on the right, 20 feet long and 4 feet wide. The captain began a low-level alignment manoeuvre, which added to his workload. People generally have a limited ability to hold attention and process information, which may result in narrowed attention. In this occurrence, the captain was focusing all of his attention on performing the manoeuvre needed to land the aircraft in the middle of the runway, while attempting to distinguish the cleared surface from the rest of the runway. He therefore directed his attention away from other tasks and indicators of an increased risk of an ALA.

For example, the captain did not realize that the SOP calls had not been made and that the aircraft was not set to the landing configuration (F100%). Therefore, the aircraft was still flying at approach speed (120 knots), which was 20 knots greater than the 100-knot landing reference speed (V_{ref}), when it reached the runway threshold. The aircraft touched down approximately 20 seconds after crossing the runway threshold, approximately 700 feet from the end of the runway, which was still not visible.

The cognitive context— a heavy workload and task saturation—led to a decrease in situational awareness and also reduced the cognitive ability to make decisions. Cognitive biases may have also interfered with the decision-making process. Therefore, it is reasonable to conclude that the cognitive context combined with the decision-making biases reduced the captain's cognitive ability to make a decision to conduct a go-around.

It is important to note that a cognitive context that reduces the ability to make decisions can affect all pilots, regardless of experience.

In this occurrence, the captain, who was focused on the landing manoeuvre and experiencing narrowed attention, was unable to make the decision to conduct a go-around.

He lost track of time and flew over the runway for 20 seconds, not realizing that it was now impossible to touch down and come to a stop before the end of the runway.

2.4.3.3 Authority gradient

No authority issues were reported on previous flights. However, there was a significant difference in the levels of authority between the captain (who was also the company's chief pilot) and the FO (who had less than 400 flight hours). This difference in authority level was particularly evident when the aircraft reached the MDA. The FO, who had no visual references in sight, eventually suggested conducting a go-around, but the captain proceeded with the approach. The FO, who still did not have any visual references in sight during the approach, did not make a second suggestion to conduct a go-around.

It is possible that the authority gradient dissuaded the FO from insisting, because some FOs are uncomfortable questioning their captain's decision. Instead, they use indirect or subjective communication, hoping that their message will get across. In this specific case, the investigation was unable to determine why the FO did not react or question the captain's plan of action more openly when he could not see the runway. The FO did not have any directives or assertiveness tools, and had not taken any training that could help him in this situation where the captain was deviating from the SOPs and continuing to follow a plan of action that was potentially hazardous.

Strait Air did not have a policy to address the negative impacts of a difference in authority level between captains and FOs, and there was no requirement for them to have one. Because many pilots begin their career with commercial operators similar to Strait Air, it is critical that these operators implement clear policies and provide training to captains and FOs on the need to follow these policies and comply with the instructions in the company's SOPs.

Operators also need to provide FOs with assertiveness tools. Without policies and procedures such as the Probing, Alerting, Challenging and Emergency Warning (PACE) model, enabling the FO to express concerns with greater assertiveness and giving the FO authority to take control of the aircraft in the captain's place, the FO was limited to an advisory role while he was clearly aware of the increased risk. Without policies, clear procedures, or training, the FO did not have the tools necessary to shift from a passive advisory role to proactive assertiveness strong enough to convince the captain to conduct a go-around. As a result, the FO found himself in a situation outside the parameters of the SOPs and, without any visual references, had no way of preventing the approach from continuing.

2.4.3.4 Flight crew's role

The cognitive context and biases partially explain why the captain, with his heavy workload, decided to continue the approach, and why, as all of his attention was focused on conducting the landing, he touched down past the threshold, 700 feet from the end of the runway. This analysis of human factors found that it was impossible for the PF to realize that his situational awareness no longer matched his actual position over the runway.

The approach ban did not prevent the captain from continuing with the approach in weather conditions that were one third of the authorized visibility minima and one quarter of the visibility recommended when this approach was designed. Therefore, it is reasonable to conclude that the approach ban was ineffective in preventing this approach while visibility on the ground was below the minimum required for an approach ban, which contributed to the runway overrun. Furthermore, given that Canada's approach ban varies depending on the type of operation, an aircraft could receive an approach clearance when it is banned for that flight. Consequently, if a mechanism is not implemented in Canada to prevent an approach that is in fact banned, there is an increased risk of an ALA. Elsewhere in the world, air traffic control will not clear an aircraft to conduct an approach if weather conditions are less than the minima published on the approach chart.

In this occurrence, it was reasonable to question the role of the FO, who was uncomfortable with the situation, yet was unable to clearly communicate his concerns to the captain. We must give consideration to his circumstances, which included the tasks he needed to complete, his situational awareness and the authority gradient between the captain and the FO. In this instance, he had to monitor flight parameters and deal with the deviation from the SOPs, while attempting to determine the aircraft's position in relation to the runway. Without precise information at his disposal, such as the required landing distance, and given that the aircraft was not required to land in the TDZ, the FO did not have precise references to assess the progression of the landing. He therefore had to rely on his limited experience to assess the landing and determine whether a go-around was necessary while the aircraft was flying over the runway. He then had to express his concerns to the captain quickly and clearly and motivate the captain to conduct an immediate go-around. Given the context in which the FO found himself, his limited experience and his position within the company, the FO was unable to assert himself and convince the captain to conduct a go-around.

A review of this accident has revealed the importance of CRM, TEM, and safe decision making by the flight crew to reduce the risk of an accident. The TSB study on air- taxi operations found that the 2 main underlying factors contributing to air-taxi accidents were **acceptance of unsafe practices** and **inadequate management of operational hazards**. The effects of these 2 factors can be mitigated through CRM, TEM, and safety-based decision making, to the degree that taxi operators promote a workplace where unsafe practices are not acceptable. The FSF and the FAA have released several recommendations pertaining to policies, SOPs, and crew training that are intended to reduce the risk of an ALA, but these recommendations are generally not followed. Consequently, one of the first steps to reduce the risk of an ALA is to implement the recommendations made by the FSF and the FAA. Also, CRM, TEM, and safe decision making by the flight crew could be improved through the introduction of strict policies and precise SOPs that provide a framework for operations, and through modern, relevant CRM training that helps crews better manage operational hazards and reduces the acceptance of unsafe practices.

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 captain continued the approach beyond the final approach fix when the reported visibility was below the approach ban minima.

2. During the approach, runway lighting was reduced to medium intensity, which was 30% of maximum strength, thereby reducing the probability of seeing the visual references required to conduct the landing on the runway.

3. The captain proceeded with the landing sequence, without seeing or knowing the length of the remaining runway ahead and unable to accurately assess the aircraft's position.

4. The aircraft landed approximately 3800 feet past the threshold, 700 feet from the end of the runway, and stopped its landing roll in a snowbank, 220 feet beyond the runway.

5. The deviation from standard operating procedures at a critical moment of flight was a source of confusion between the flight crew members, to the point where the aircraft was not configured for a landing, which increased the landing distance required.

6. The captain, focused on the landing manoeuvre and experiencing narrowed attention, was unable to make the decision to conduct a go-around. He lost the notion of time and flew over the runway for 20 seconds, not realizing that it was now impossible to touch down and come to a stop before the end of the runway.

7. Without policies, clear procedures and training, the first officer did not have the tools necessary to shift from a passive advisory role to proactive assertiveness strong enough to convince the captain to conduct a go-around.

8. The approach ban was ineffective in preventing this approach while visibility on the ground was below the minimum required for an approach ban.

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 Transport Canada does not clarify the application of operating visibility and visibility minima for approach bans, flight crews may proceed with an approach that is actually banned, thereby increasing the risk of an approach-and-landing accident.

2. If flight crew members do not have shared situational awareness, they cannot anticipate or coordinate their actions, which increases the risk of an approach-and-landing accident.

3. If pilots continue their approach below the minimum descent altitude with only one visual reference, they risk continuing their landing without having established the additional visual references required to land safely.

4. If a safety briefing is not provided to passengers before landing to remind them to fasten their safety belt, some of them may not fasten their safety belt before landing, which increases the risk of injury in the event of an accident.

5. If the passenger seats on small aircraft are not equipped with a shoulder harness, passengers face a greater risk of injury, more or less serious, perhaps even fatal, in the event of an accident.

6. If the airport emergency response plan is interrupted and fire protection services are not contacted quickly to secure the accident site in the event of a fuel spill or fire, there is a risk of injury to the people at the accident site, and damages to airport facilities and the environment.

7. If runways 1200 m or longer do not have a runway end safety area that is at least 150 m long, or some other arresting system that provides aircraft with an equivalent level of safety, there is a risk of injury to the aircraft occupants in the event of a runway overrun.

8. If airport operators are not required to close a runway when one of the criteria stated in their snow clearance plan has been exceeded, there is a greater risk of a runway overrun.

9. If standard operating procedures approach briefings do not cover all of the restrictive elements for an approach, pilots may conduct an approach outside the prescribed limits, increasing the risk of an approach-and-landing accident.

10. If pilots are not properly prepared for a go-around on every approach, they may not be ready to react promptly when this manoeuvre becomes imperative, thereby increasing the risk of an approach-and-landing accident.

11. If cockpit voice recordings are not available, it is impossible to accurately assess crew resource management, standard operating procedure execution and compliance, and workload management, which may limit the identification of safety deficiencies and the advancement of safety

12. If Transport Canada does not provide oversight of flight operations to assess the effectiveness of crew resource management, threat and error management, decision making and standard operating procedures, including application and compliance,

these standard operating procedures may not be effective, increasing the risk of an accident, particularly an approach-and-landing accident.

13. If a mechanism is not implemented in Canada to prevent an approach that is in fact banned, there is an increased risk of an ALA.

4.0 SAFETY ACTION

4.1 Safety action taken

Transport Canada conducted interviews, enforcement action, and, later in 2018, further inspections of the company as part of its oversight activities.

4.2 Safety action required

On 26 February 2018, a Beechcraft King Air A100 (registration C-GJXF, serial number B-159) operated by Strait Air (2000) Ltd. was conducting charter flight NUK107 according to instrument flight rules, from the Sept-Îles Airport, Quebec, to the Havre St-Pierre Airport, Quebec, with 2 crew members and 6 passengers on board. The aircraft conducted an approach to Runway 08, which was snow-covered, while visibility was reduced due to heavy snow showers, and landed approximately 3800 feet beyond the threshold, at approximately 700 feet from the end of the runway. It continued its landing roll beyond the runway until it came to rest in a snowbank, approximately 220 feet beyond the end of the runway. The accident occurred in daylight, at 1120 Eastern Standard Time. The emergency locator transmitter, transmitting on 406 MHz, did not activate. The aircraft sustained substantial damage. Four of the occupants received minor injuries.

4.2.1 Landing minima in Canada

In designing instrument approaches, the published minimum visibility represents the minimum visibility at which a pilot on approach at the decision height (DH) or the minimum descent altitude (MDA) should be able to establish and maintain the visual reference required up until landing.

International Civil Aviation Organization (ICAO)[110] standards and recommended practices stipulate that an instrument approach shall not be continued unless the reported visibility is at or above the specified minima. These minima are published on approach charts based on the approach type and lighting.

Various civil aviation authorities throughout the world (such as the U.S. Federal Aviation Administration [FAA] and the European Union Aviation Safety Agency [EASA]) have established that the authorized visibility minima are those specified and published for the approach. Therefore, to determine whether an approach is authorized, it is simply a matter of comparing the reported visibility with the visibility published on the approach chart. Consequently, air traffic control (ATC) will not clear an aircraft for approach if the reported visibility is less than what is published on the approach chart.

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110 International Civil Aviation Organization, Annex 6 to the Convention on International Civil Aviation, Eleventh Edition (July 2018), *Operation of Aircraft,* Part I, Chapter 4.

In Canada, visibilities published on approach charts are provided for information purposes only.

To determine whether an aircraft can legally land at an aerodrome in Canada, consideration must first be given to the operational restrictions that apply to the aerodrome in question to ensure that the aerodrome is suitable for the manoeuvre being executed.[111] One of the determining factors is the aerodrome's operating visibility, which is defined in the *Canada Air Pilot* (CAP 5) in the general pages pertaining to operating minima.[112] This operating visibility limit is published in the *Canada Flight Supplement* (CFS), specifically in the box reserved for runway information. If an aerodrome's operating visibility limit is not published in the CFS, it means that operations are not authorized when visibility is less than ½ statute mile (SM).

Next, the minimum visibility for an approach ban must be calculated to determine whether the approach can continue to the DH or the MDA. This minimum visibility is calculated based on the visibility published on the approach chart, and varies depending on the type of operations:

- ¾ of the published visibility for commercial operators;
- ½ of the published visibility for commercial operators who have Operations Specification 019 regarding reduced visibility;
- ¼ SM for private operators, regardless of the approach being conducted.

According to this calculation, the minimum visibility for an approach ban in Canada is less than the visibility published on the approach chart in every case. Consequently, it is likely that, once at the DH or MDA, pilots are not able to establish the required visual reference, which that will help them make a safe landing.

Between December 2006[113] and December 2019, 31 incidents occurred following approaches conducted below the MDA with few visual references. Of these 31 incidents, 17 occurred during a landing in weather conditions where visibility was below what is published on the approach chart.[114]

Furthermore, this situation continues to occur today: 9 of the 17 incidents have occurred within the past 5 years.

In Canada, due to the complexity and variations in minima based on the type of operations, it is difficult for ATC to determine whether the planned approach is banned. It will clear an aircraft for approach regardless of the published minima, contrary to what is done

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111 Transport Canada, SOR/96-433, *Canadian Aviation Regulations,* paragraph 602.96(2)(*b*).

112 NAV CANADA, *Canada Air Pilot* (CAP), CAP 5: Quebec (in effect from 1 February to 29 March 2018), p. 16-18.

113 Implementation date for landing minima regulations (CARs section 602.128) and approach ban regulations (CARs section 602.129).

114 After these 17 occurrences, the TSB published the following aviation investigation reports: A08W0237, A08O0333, A09Q0203, A12Q0216, A14A0067, A15O0015, A15H0002, A16A0041, and A18Q0030.

elsewhere in the world. Therefore, it is up to the captain to interpret the approach ban, and it is the captain who decides whether or not to continue with the approach.

In this occurrence, based on his interpretation of numerous conditions and exceptions relating to the approach ban, the captain incorrectly believed that he was allowed to conduct the approach. The first officer was aware that weather conditions were below the approach minima published in the CAP, but he did not understand all of the details involved in the approach ban. He was therefore unable to challenge the captain's decision to conduct the approach.

Given that it was difficult for the flight advisory service and the aerodrome operator to determine whether the approach was banned, they could not inform the pilots that the approach was banned under the existing conditions, despite the fact that visibility was one quarter of what was published on the approach chart.

Therefore, if Transport Canada (TC) does not simplify approach and landing operating minima, flight crews may proceed with an approach that is actually banned, thereby increasing the risk of approach-and-landing accidents (ALAs), including runway overruns.

Consequently, the Board recommends that

> The Department of Transport review and simplify operating minima for approaches and landings at Canadian aerodromes.
> **TSB Recommendation A20-01**

In this occurrence, the approach ban in effect in Canada did not prevent the captain from continuing with the approach in weather conditions that were one third of the authorized visibility minima and one quarter of the visibility published on the approach chart. During the approach, when the aircraft arrived at the MDA, it was up to the pilot alone to determine whether or not he had established the visual reference required to continue the descent and landing. Therefore, it is reasonable to conclude that the approach ban was ineffective in stopping this approach while visibility on the ground was below the minimum required for an approach ban, which contributed to the runway overrun.

As this occurrence demonstrates, if there is no mechanism to stop an approach that is in fact banned, then pilots may choose to continue their approach, which increases the risk of an ALA.

Consequently, the Board recommends that

> the Department of Transport introduce a mechanism to stop approaches and landings that are actually banned.
> **TSB Recommendation A20-02**

4.3 Safety concern

4.3.1 Transport Canada regulatory oversight of standard operating procedures

Since 2019, TC has been requiring that all commercial air operators provide contemporary crew resource management (CRM) training. However, even though TC performs regular inspections of operators, these inspections are generally limited to documentation of the systems put in place by the company. For example, in this occurrence, the standard operating procedures (SOPs) complied with *Canadian Aviation Regulations* (CARs) requirements from a formal standpoint, but their effectiveness was not evaluated by TC. In this context, it is impossible to assess the effectiveness of training, CRM, threat and error management (TEM), decision making, and the degree to which SOPs are applied or complied with and their effectiveness on board aircraft during operations.

SOPs are not only guidelines for the general use of aircraft; they are universally recognized as fundamental to safe aviation operations, creating a framework for the application of concepts such as CRM and TEM. The Flight Safety Foundation (FSF) and the FAA have released several recommendations pertaining to SOPs to reduce the risk of an ALA.

Between 1999 and 2019, SOPs were mentioned in 113 findings as to causes, contributing factors, and risks in TSB aviation investigation reports. The deficiencies identified were primarily associated with a lack of precise directives, differences in procedures, and deviations from procedures. In this occurrence, a deviation from SOPs at a critical moment of the flight was a key factor that contributed to the runway overrun.

The Board is concerned that if TC does not provide oversight of flight operations by assessing the effectiveness of CRM, TEM, decision making and SOPs, including the degree of application and compliance, these SOPs may not be effective, increasing the risk of an accident, particularly an ALA.

This report concludes the Transportation Safety Board of Canada's investigation into this occurrence. The Board authorized the release of this report on 18 March 2020. It was first released on 21 May 2020.

Correction

At the time this report was published, the Board was not aware of any safety action taken following the occurrence. After the report was published, Transport Canada informed the Board that it had in fact taken safety action following the occurrence. The following changes have been made to the report in consequence:

In section 1.17.2 **Transport Canada Civil Aviation — Regulatory oversight**, the sentence "TCCA did not conduct any specific inspections after this accident" has been deleted,

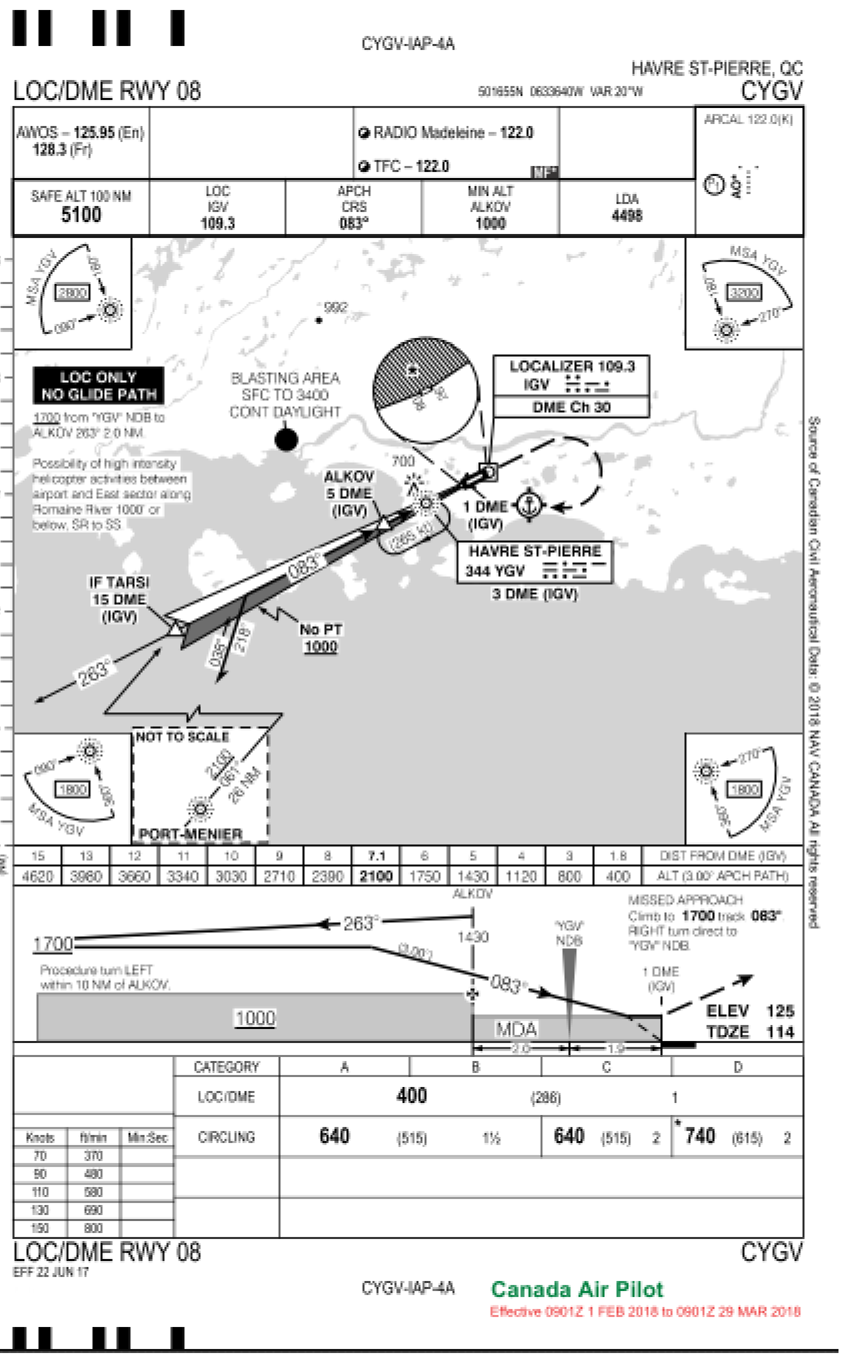
In section 4.1 **Safety action taken**, "The Board is not aware of any safety action taken following this occurrence" has been deleted and replaced with the sentence "Transport Canada conducted interviews, enforcement action, and, later in 2018, further inspections of the company as part of its oversight activities."

This correction was approved by the Board on 15 July 2020; the corrected version of the report was released on 28 July 2020.

Visit the Transportation Safety Board of Canada's website (www.tsb.gc.ca) for information about the TSB and its products and services. You will also find the Watchlist, which identifies the key safety issues that need to be addressed to make Canada's transportation system even safer. In each case, the TSB has found that actions taken to date are inadequate, and that industry and regulators need to take additional concrete measures to eliminate the risks.

APPENDICES

Appendix A – Approach chart for LOC/DME RWY 08 at Havre St-Pierre Airport (not to be used for navigation purposes)



Source: *Canada Air Pilot*

Appendix B – Recommended landing distances

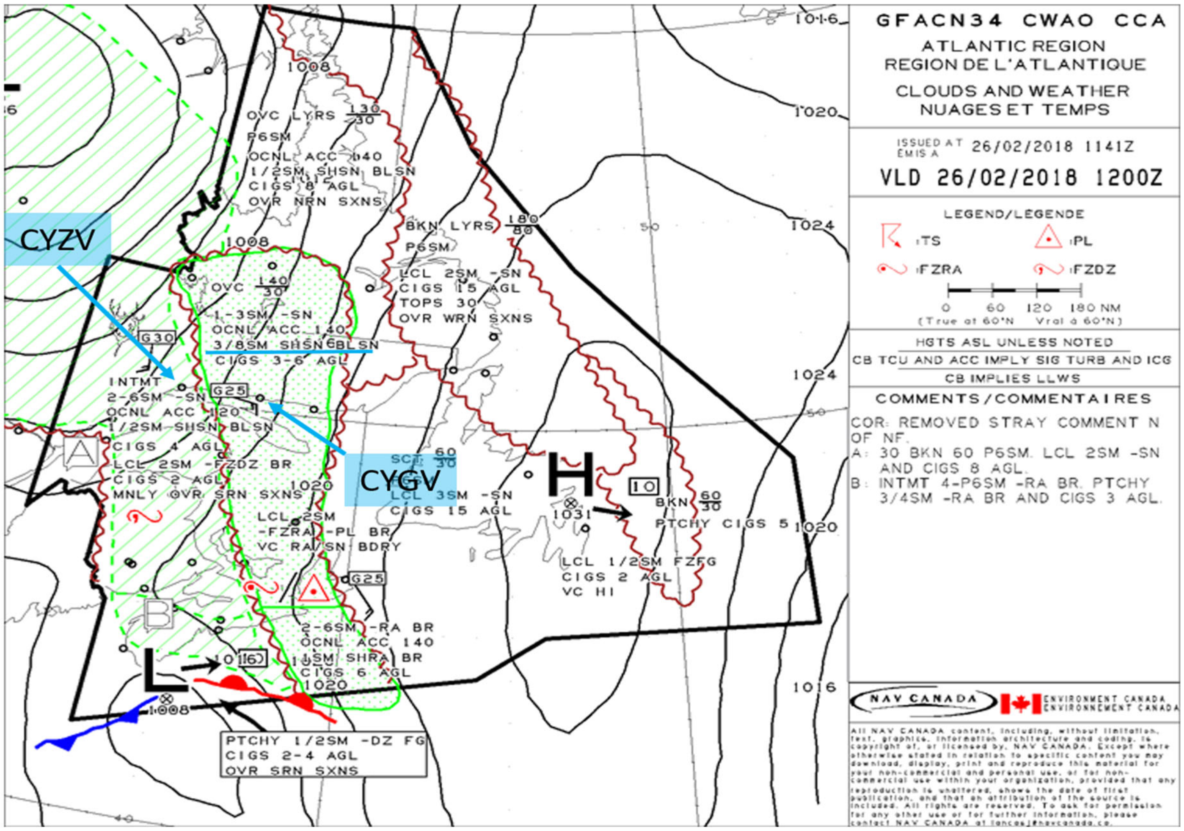
Table 2—CRFI Recommended Landing Distances (Discing/Reverse Thrust)

Reported Canadian Runway Friction Index (CRFI)														
Landing Distance (Feet) Bare and Dry	0.60	0.55	0.50	0.45	0.40	0.35	0.30	0.27	0.25	0.22	0.20	0.18	Landing Field Length (Feet) Bare and Dry	Landing Field Length (Feet) Bare and Dry
Unfactored	Recommended Landing Distances (Discing/Reverse Thrust)												60% Factor	70% Factor
1 200	2 000	2 040	2 080	2 120	2 170	2 220	2 280	2 340	2 380	2 440	2 490	2 540	2 000	1 714
1 400	2 340	2 390	2 440	2 500	2 580	2 660	2 750	2 820	2 870	2 950	3 010	3 080	2 333	2 000
1 600	2 670	2 730	2 800	2 880	2 970	3 070	3 190	3 280	3 360	3 460	3 540	3 630	2 667	2 286
1 800	3 010	3 080	3 160	3 250	3 350	3 480	3 630	3 730	3 810	3 930	4 030	4 130	3 000	2 571
2 000	3 340	3 420	3 520	3 620	3 740	3 880	4 050	4 170	4 260	4 400	4 510	4 630	3 333	2 857
2 200	3 570	3 660	3 760	3 880	4 020	4 170	4 360	4 490	4 590	4 750	4 870	5 000	3 667	3 143
2 400	3 900	4 000	4 110	4 230	4 380	4 550	4 750	4 880	4 980	5 150	5 270	5 410	4 000	3 429
2 600	4 200	4 300	4 420	4 560	4 710	4 890	5 100	5 240	5 350	5 520	5 650	5 790	4 333	3 714
2 800	4 460	4 570	4 700	4 840	5 000	5 190	5 410	5 560	5 670	5 850	5 980	6 130	4 667	4 000
3 000	4 740	4 860	5 000	5 160	5 340	5 550	5 790	5 950	6 070	6 270	6 420	6 580	5 000	4 286
3 200	5 080	5 220	5 370	5 550	5 740	5 970	6 240	6 420	6 560	6 770	6 940	7 110	5 333	4 571
3 400	5 350	5 500	5 660	5 850	6 060	6 310	6 590	6 790	6 930	7 170	7 340	7 530	5 667	4 857
3 600	5 620	5 780	5 960	6 160	6 390	6 650	6 960	7 170	7 320	7 570	7 750	7 950	6 000	5 143
3 800	5 890	6 060	6 250	6 460	6 700	6 980	7 310	7 540	7 700	7 970	8 160	8 380	6 333	5 429
4 000	6 070	6 250	6 440	6 660	6 910	7 210	7 540	7 780	7 950	8 220	8 430	8 650	6 667	5 714

Source: *Transport Canada Aeronautical Information Manual*

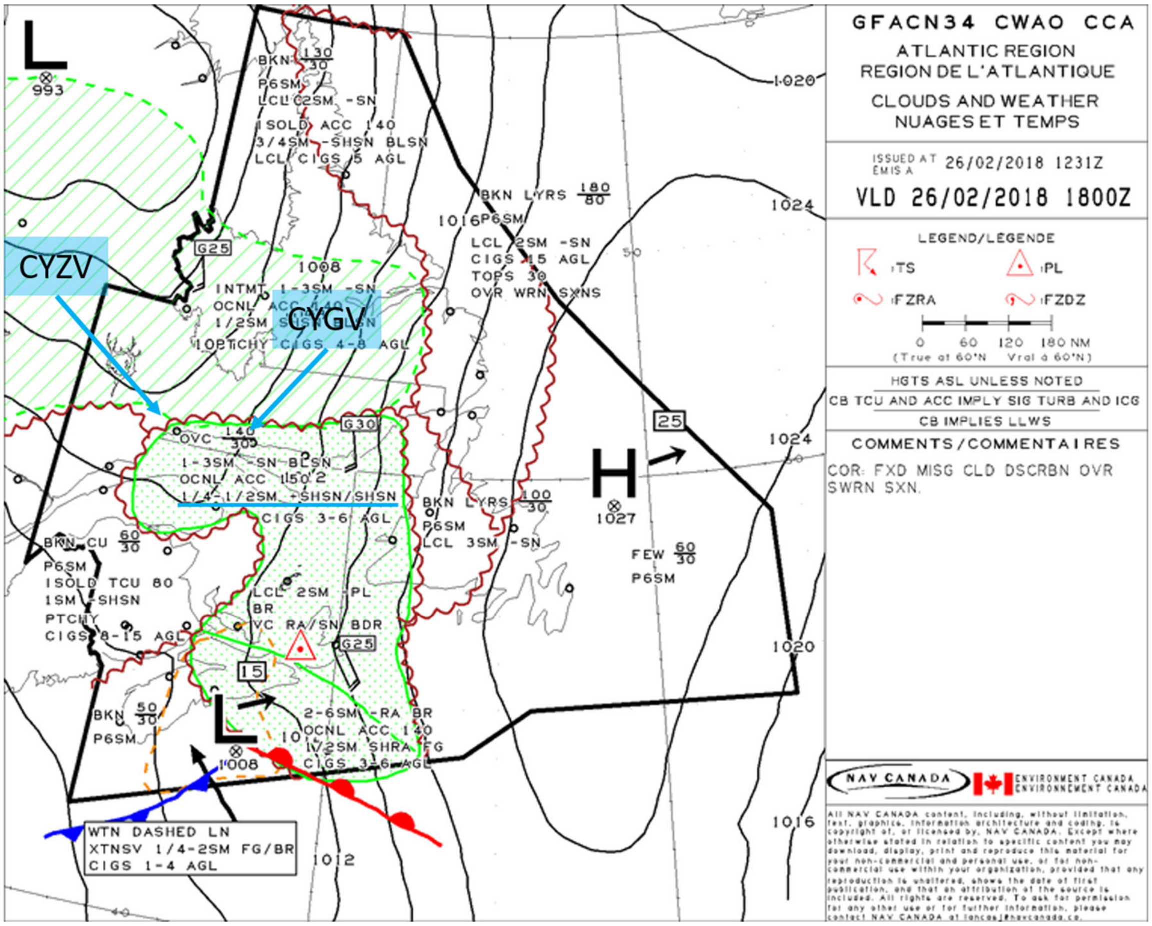
Appendix C – Clouds and Weather charts from graphic area forecasts issued on the day of the occurrence

Figure C1. Clouds and Weather chart for the graphic area forecast issued at 1200 UTC on 26 February 2018



Source: NAV CANADA

Figure C2. Clouds and Weather chart for the graphic area forecast issued at 1800 UTC on 26 February 2018



Source: NAV CANADA

Appendix D – Aerodrome routine meteorological reports, aerodrome special meteorological reports, and aerodrome forecasts for the day of the occurrence

METARs and SPECIs

METAR or SPECI information	Visibility in relation to approach ban minima for the occurrence flight
METAR CYGV 261500Z AUTO 17008KT 2 1/2SM -SN OVC009 M03/M03 A2986 RMK VIS VRB 1 ¾ - 2 ½	Above minima
SPECI CYGV 261519Z AUTO 18010G15KT 1 3/4SM -SN OVC009 M03/M04 A2985 RMK	Above minima
SPECI CYGV 261534Z AUTO 19009KT 3/4SM -SN OVC009 M03/M03 A2985 RMK	At minima
SPECI CYGV 261543Z AUTO 18007KT 3/4SM -SN BKN007 OVC011 M03/M03 A2985 RMK	At minima
METAR CYGV 261600Z AUTO 19007KT 3/8SM SN OVC005 M03/M03 A2984 RMK	Below minima
SPECI CYGV 261609Z AUTO 16004KT 1/4SM +SN VV004 M03/M03 A2984 RMK	Below minima
METAR CYGV 261700Z AUTO 16006KT SM +SN VV006 M02/M02 A2981 RMK	Below minima
SPECI CYGV 261704Z AUTO 15005KT 3/8SM SN BKN006 OVC011 M02/M02 A2980 RMK	Below minima
SPECI CYGV 261716Z AUTO 14004KT 3/4SM -SN BKN009 OVC013 M02/M03 A2980 RMK	At minima
SPECI CYGV 261719Z AUTO 14005KT 3/4SM -SN BKN007 OVC011 M02/M03 A2980 RMK	At minima
SPECI CYGV 261720Z AUTO 15004KT 1SM -SN OVC009 M02/M03 A2980 RMK	Above minima

TAF

TAF CYGV 261338Z 2614/2702 16010G20KT 3/4SM -SN VV008 TEMPO 2614/2622 3SM -SN SCT008 OVC015 BECMG 2620/2622 24010G20KT FM262200 24010G20KT P6SM BKN040 TEMPO 2622/2702 4SM -SHSN RMK FCST BASED ON AUTO OBS. NXT FCST BY 262000Z=

Appendix E – Operating restrictions stated in the *Canada Air Pilot* in effect on the day of the occurrence

Aerodrome Operating Restrictions – Visibility

General

CAR 602 specifies take-offs for all Canadian aircraft as being governed by visibility only, approach restrictions by RVR values only, and landings by published DH/MDAs only.

Aerodrome Operating Restrictions – Visibility

CAR 602.96 (2)(b) requires that before taking off from, landing at or otherwise operating an aircraft at an aerodrome, the pilot-in-command of the aircraft shall be satisfied that the aerodrome is suitable for the intended operation. Additionally, for Air and Private Operators, the CARs (and associated Standards and Operations Specifications) govern operations below RVR 2600 (½ SM).

One factor that needs to be considered to ensure compliance with the regulatory requirements above is the Aerodrome Operating Visibility.

A. The Aerodrome operating visibility is defined as follows:

At sites with an active Air Traffic Control (ATC) Tower
(in accordance with published airport operational procedures)

For arrivals and departures, the aerodrome operating visibility is in accordance with the following hierarchy:

1. Runway Visual Range (RVR) for the runway of intended use
2. Ground visibility (METAR)
3. Tower visibility
4. Pilot visibility

Note: Tower observed visibility does not take precedence over reported ground visibility. Where ground visibility is reported, tower observed visibility is considered advisory only. However, where ground visibility is either not reported or the visibility reported by the AWOS is non-representative of the prevailing visibility at the airport, tower reported visibility, when available, replaces ground visibility and needs to be considered in the determination of the aerodrome operating visibility.

At sites without an active ATC Tower
(outside ATC operating hours, MF, Unicom, CARS, or advisory sites, etc…)

For arrivals, the aerodrome operating visibility is in accordance with the following hierarchy:

1. Runway Visual Range (RVR) for the runway of intended use
2. Ground visibility (METAR)
3. Pilot visibility

For departures, the aerodrome operating visibility is the lowest of the following visibilities:

- Ground visibility (METAR)
- Any reported RVR
- Pilot visibility

B. For the purpose of Subsections (C) and (D), the visibility is less than the minimum visibility required for landing and taxi operations if the aerodrome's operating visibility is less than the level of service published in the CFS for the runway of intended use.

C. Where the Aerodrome Operating Visibility as set out in subsection (A) is less than the minimum visibility published in the CFS, taxi operations are deemed to be occurring below the published aerodrome operating visibility; except when:

- visibility deteriorates below the published aerodrome operating visibility after the aircraft has commenced taxi for departure (including de-icing stop);
- visibility deteriorates below the published aerodrome operating visibility after the aircraft has landed and is taxiing to the destination on the aerodrome;
- the aircraft is taxiing on the manoeuvring area as authorized by ATC in accordance with the aerodrome's published operational procedures*;
- the aircraft is taxiing for departure at a site without an active ATC Tower, in accordance with the aerodrome's operational procedures published pursuant to CAR 602.96(3)(d)*; or
- the aircraft is taxiing on the manoeuvring area for purposes other than take-off or landing as authorized by the Aerodrome Operator in accordance with the aerodrome's RVOP/LVOP*.

***Note:** Where required, the aerodrome operator will publish special reduced/low visibility restrictions or procedures for pilots in the appropriate aeronautical publication(s).

D. Where the aerodrome operating visibility as set out in subsection (A) is less than the minimum visibility published in the CFS, a landing is deemed to occur below the published aerodrome operating visibility for the runway of intended use; except where:

- at the time a visibility report is received, the aircraft has passed the FAF inbound or where there is no FAF, the point where the final approach course is intercepted;
- the RVR for the runway of intended landing is varying between distances less than and greater than the minimum RVR and the ground visibility is equal to or greater than the minimum visibility;
- at sites without an active ATC Tower, the ground visibility is varying between distances less than and greater than the minimum ground visibility and the RVR is equal to or greater than the minimum visibility; or
- at sites without an active ATC Tower, prior to 1,000' above aerodrome elevation the PIC determines that a localized meteorological phenomenon is affecting the ground visibility by observing that the runway of intended landing and the taxi route to the destination on the aerodrome are seen and recognized.

E. The minimum visibility required for take-off operations is stipulated in the TAKE-OFF MINIMA/DEPARTURE PROCEDURES section.

Operating Restrictions – Approach

Approach Ban – Commercial Operators – General – Non-Precision, APV, or CAT I Precision Approach (Ref. CAR 700.10)

With certain exceptions, pilots of commercial aircraft are prohibited from completing a non-precision approach, an APV, or a CAT I precision approach past the FAF inbound or, where there is no FAF, the point where the final approach course is intercepted, if the visibility report is below the value corresponding to the CAP advisory visibility for the approach conducted:

Minimum Visibility – Aeroplanes – Non-Precision, APV, or CAT I

CAP Advisory Visibility (SM, RVR x 100 ft)	**Visibility Report** (Gnd Vis SM, RVR "A" or Rwy Vis ft)
½ RVR 26	⅜, RVR or Rwy Vis 1600
¾ RVR 40	⅝, RVR or Rwy Vis 3000
1 RVR 50	¾, RVR or Rwy Vis 4000
1¼	1, RVR or Rwy Vis 5000
1½	1¼, RVR or Rwy Vis 6000
1¾	1½, RVR or Rwy Vis >6000
2	1½, RVR or Rwy Vis >6000
2¼	1¾, RVR or Rwy Vis >6000
2½	2, RVR or Rwy Vis >6000
2¾	2¼, RVR or Rwy Vis >6000
3	2¼, RVR or Rwy Vis >6000

Minimum RVR – Helicopters – Non-Precision, APV, or CAT I

Measured RVR	Helicopters
RVR "A" Only	1200
RVR "A" and "B"	1200/0
RVR "B" Only	1200

An RVR report takes precedence over a runway visibility report or a ground visibility report, and a runway visibility report takes precedence over a ground visibility report. Ground visibility will only impose an approach ban at aerodromes south of 60°N latitude. If no RVR, runway visibility, or ground visibility is reported, there are no criteria to impose an approach ban. (This concept is similar to the present Subpart 602 of the CARs approach ban, where if there is no RVR reported; there is no criterion to impose an approach ban).

An RVR report is the only visibility report that can impose an approach ban applicable to helicopters.

The following exceptions to the above prohibitions apply to all aircraft:

- when the visibility report is below the required value and the aircraft has passed the FAF inbound or;
- the pilot-in-command has informed the appropriate ATC unit that the aircraft is on a training flight and that the pilot-in-command intends to initiate a missed approach procedure at or above the DA(H) or the minimum descent altitude, as appropriate;
- the RVR is varying between distances less than and greater than the minimum RVR;
- the ground visibility is varying between distances less than and greater than the minimum visibility;
- a localized meteorological phenomenon is affecting the ground visibility to the extent that the visibility on the approach to the runway of intended approach and along that runway, as observed by the pilot in flight and reported immediately to ATS, if available, is equal to or greater than the visibility specified in the CAP for the instrument approach procedure conducted; or
- the approach is conducted in accordance with an Ops Spec issued in accordance with subparts 703, 704 or 705 of the CARs.

No pilot shall commence a non-precision approach, an APV, or a CAT I precision approach to an airport where low-visibility procedures are in effect. Low visibility procedures are associated with CAT III operations. They are specified for an airport in the ***Canada Air Pilot*** and restrict aircraft and vehicle operations on the movement area of the airport when the runway visual range is less than 1,200 feet.

Operating Restrictions - Landing

Landing Minima

CAR 602 specifies that landings are governed by published DH/MDAs. Pilots of aircraft on instrument approaches are prohibited from continuing the descent below DH, or descending below MDA, as applicable, unless the required visual reference is established and maintained in order to complete a safe landing. When the required visual reference is not established or maintained, a missed approach must be initiated. Missed approaches initiated beyond the MAP may not be assured obstacle clearance.

The visual references required by the pilot in order to continue the approach to a safe landing should include at least one of the following references for the intended runway and should be distinctly visible and identifiable to the pilot:

- the runway or runway markings;
- the runway threshold or threshold markings;
- the TDZ or TDZ markings;
- the approach lights;
- the approach slope indicator system;
- the runway identification lights (RILS);
- the threshold and runway end lights;
- the touchdown zone lights (TDZL);
- the parallel runway edge lights; or
- the runway centreline lights.

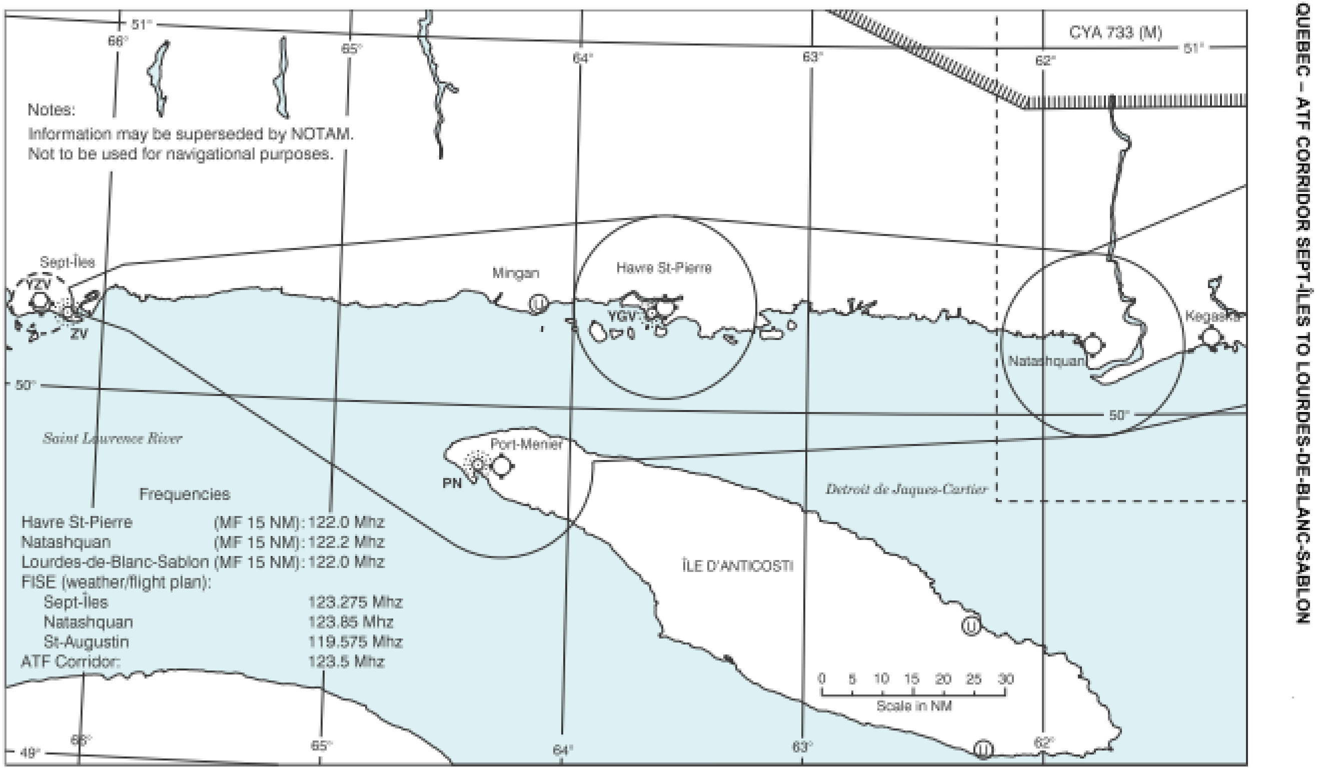
Subject to the Approach Ban, published landing visibilities associated with all instrument approach procedures are advisory. Their values are indicative of visibilities which, if prevailing at the time of approach, should result in the required visual reference being established and maintained to landing. Subject to the Approach Ban, they are not limiting and are intended to be used by pilots to judge the probability of a successful landing when compared against available visibility reports at the aerodrome to which an instrument approach is being carried out.

Altimeter Setting Requirements

Before commencing an instrument approach procedure the pilot shall have set on the aircraft altimeter a current altimeter setting usable for the location where the approach is to be flown. The altimeter setting may be a local setting or a remote setting when so authorized on the instrument procedure chart. A current altimeter setting is one provided by approved direct reading or remote equipment, or by the latest routine hourly weather report. These readings are considered current up to 90 minutes from the time of observation.

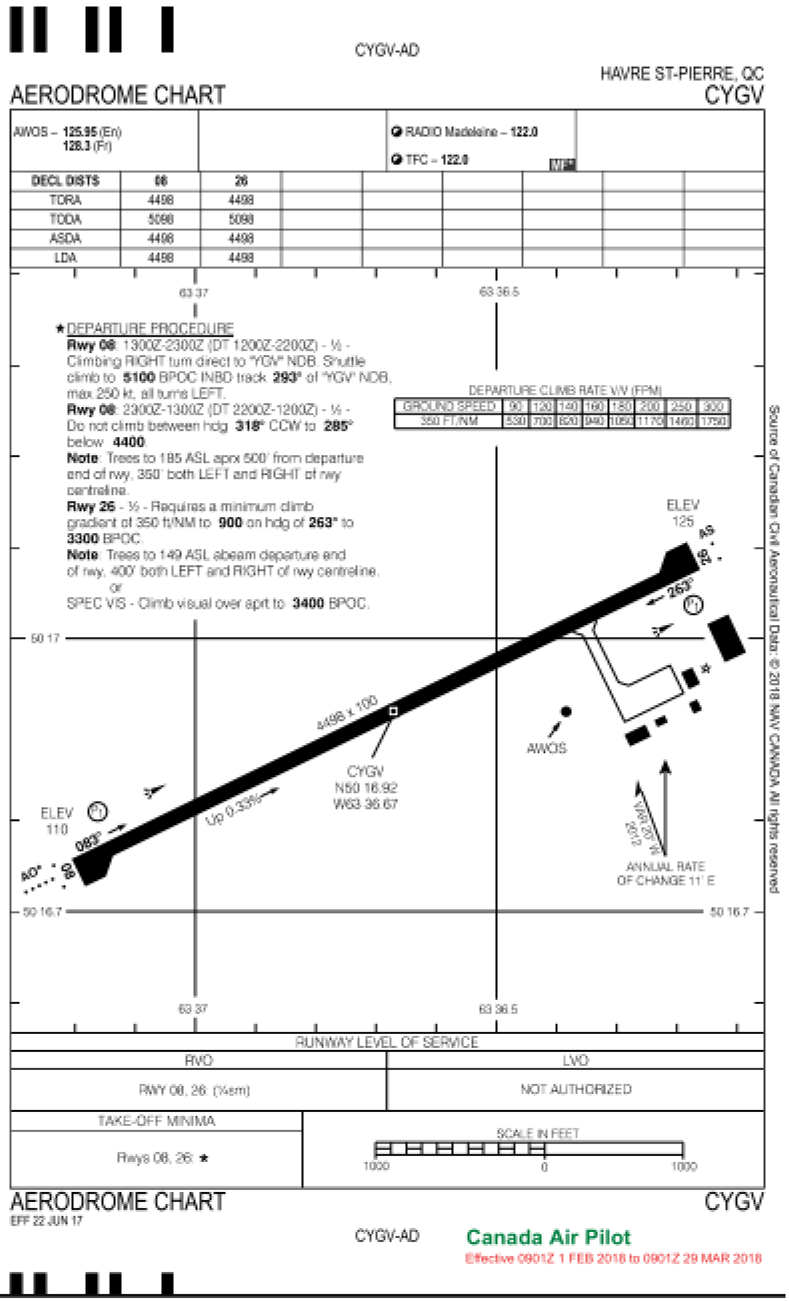
CAUTION: Care should be exercised when using altimeter settings older than 60 minutes or when pressure has been reported as falling rapidly. In these instances a value may be added to the published DH/MDA in order to compensate for falling pressure tendency (0.01 inches mercury = 10 feet correction).

Appendix F – Chart of Lower North Shore ATF Corridor (not to be used for navigation purposes)



Source*: Canada Flight Supplement*

Appendix G – Havre St-Pierre Airport Aerodrome Chart (not to be used for navigation purposes)



Source: *Canada Air Pilot*