Transport Canada Transports Canada

ISSUE 4/2021

AVIATION SAFETY LETTER

In This Issue...

TP 185E

Cover photo: Wikipedia

Canada

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Sécurité aérienne — Nouvelles est la version française de cette publication.

ISSN: 0709-8103
TP 185E

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ON THE RADAR

Canada Adopts New Global Reporting Format for Runway Surface Conditions

by TCCA GRF Implementation Team: Guy Héneault, Drew Dutton, Robert Kostecka, Cheryl Bugden, Aerodrome Standards, and Benoit Saulnier, Commercial Flight Standards

With the implementation of the Global Reporting Format (GRF)—the internationally-accepted method for reporting runway surface conditions—Canada has taken a major step towards improving flight safety.

Canadian implementation of GRF took place on August 12, 2021, approximately three months prior to the target date specified by the International Civil Aviation Organization (ICAO). There were compelling reasons that prompted ICAO to call for a standardized and improved method to report runway surface conditions.

Figure 1. The December 8, 2005 B737-700 accident at Chicago Midway airport resulted in the TALPA ARC, an important safety initiative to address operations on wet and contaminated runways that ultimately led to the GRF.

At its heart, GRF is intended to help mitigate the hazards and risks associated with operations on runways that are wet or contaminated with water, slush, snow, compacted snow, frost, or ice. These hazards and risks are well known and have been thoroughly documented. In Canada, accidents during operations on wet or contaminated runways have included several Transport Category aircraft types, including the Airbus A340, Embraer 145, Boeing 727, and Boeing 737, as well as a variety of other aircraft. In view of these important safety issues, runway overruns have been on the Transportation Safety Board (TSB) *Watchlist* since 2010.

The origins of GRF can be found in the work of the *Takeoff and Landing Performance Assessment Aviation Rulemaking Committee* (TALPA ARC). After a Boeing 737-700 runway overrun accident at Chicago Midway Airport, which occurred on December 8, 2005 (Figure 1), the United States Federal Aviation Administration (FAA) convened the TALPA ARC. The goal of this committee was to consider safety issues associated with takeoff and landing on wet and contaminated runways. Participants included aircraft manufacturers, air operators, airport operators, industry associations (pilot associations, airport associations, etc.), the U.S. National Transportation Safety Board, as well as the US FAA, Transport Canada and other civil aviation authorities.

The TALPA ARC discovered significant gaps in the methods used for reporting runway surface conditions and the performance information used by flight crews. The TALPA ARC developed recommendations to address these shortcomings, which were delivered to the FAA in July 2009. These recommendations, which have collectively come to be known as “TALPA,” included the development of consistent terminology and runway assessment criteria, presented in a standardized format. Ultimately, the recommendations of the TALPA ARC—which the United States Federal Aviation Administration (U.S. FAA) incorporated into the US reporting system in 2016—served as the basis for the ICAO GRF.

The GRF, which is mandated by ICAO, incorporates many of the significant safety enhancements that resulted from the TALPA ARC. The ICAO guidance specifies several important characteristics for runway surface condition reports. These include:

- an agreed set of criteria used in a consistent manner for runway surface condition assessment, aeroplane (performance) certification and operational performance calculation;
- a unique runway condition code (RWYCC) linking the agreed set of criteria… and related to the braking action experienced and eventually reported by flight crews;
- reporting of contaminant type and depth that is relevant to take-off performance;
- a standardized common terminology and phraseology for the description of runway surface conditions that can be used by aerodrome operator inspection personnel, air traffic controllers, aircraft operators and flight crew; and
- globally-harmonized procedures for the establishment of the RWYCC with a built-in flexibility to allow for local variations to match the specific weather, infrastructure and other particular conditions.

The Canadian implementation of GRF meets the intent and important safety elements mandated by ICAO and will also provide some important enhancements that were necessary to improve safety and harmonize with the TALPA reporting format that has been in place in the United States since 2016. One of the main differences from the ICAO format is the ability to report two contaminants (per runway third; or for the entire runway, when reporting by full runway length). Reporting two contaminants:

- allows pilots and flight dispatchers to accurately determine the maximum allowable take-off weight—since the limiting contaminant is not the same for all aeroplanes; and
- harmonizes the reporting in North America, since the United States Field Condition NOTAM (FICON) also lists two contaminants.

One of the most important mitigations for the hazards and risks associated with operations on wet and contaminated runways is the usage of appropriate aeroplane performance information. Some aircraft types—typically large Transport Category aeroplanes—have manufacturer-produced performance data that is designed to account for wet and contaminated runway conditions and also aligns with the new GRF. When manufacturer-produced performance information or performance information from a third-party provider are not available, a landing distance factors (LDF) table—which also aligns with the new GRF—is provided in Advisory Circular (AC) 700-057 (Table 6).

The Canadian Runway Friction Index (CRFI) will continue to be reported. CRFI is a useful tool that enables airport and aerodrome operators to have an objective measure of runway friction and also serves to enhance pilots' situational awareness. There are new regulations that require CRFI to be reported in thirds on longer runways that serve Commuter (Subpart 704) and Airline (Subpart 705) air operators. CRFI information now appears under the header "ADDN NON-GRF/TALPA INFO." CRFI can be used for making time of arrival landing performance assessments by pilots and operators that do not utilize either:

- aeroplane performance information (manufacturer produced or developed by a third party) that accounts for contaminated runway conditions; or
- the (generic) Landing Distance Factor (LDF) table published in AC 700-057.

The hazards and risks of operations on wet and contaminated runways need to be clearly understood and effectively mitigated. The implementation of GRF in Canada is a major step forward that is intended to help accomplish this important goal.

Further information and guidance

Further information and guidance on GRF is available for flight operations personnel as well as airport and aerodrome operators:

- Advisory Circular (AC) 700-057—*Global Reporting Format (GRF) for Runway Surface Conditions: Guidance for Flight Operations*

  Note: The main body of the AC 700-057 provides background information as well as the essential information needed to read and understand the new Global Reporting Format (GRF) for runway surface conditions. The appendices provide more detailed explanations of various aspects of GRF as well as important safety information related to operations on wet and contaminated runways.

- AC 300-019—*Global Reporting Format (GRF) for Runway Surface Conditions*

Related articles on GRF as well as the hazards associated with wet and contaminated runways are planned for the ASL.△

TIPS AND TOOLS

Cracking the Code: Understanding Runway Condition Codes

by TCCA GRF Implementation Team: Guy Héneault, Drew Dutton, Robert Kostecka, Cheryl Bugden, Aerodrome Standards, and Benoit Saulnier, Commercial Flight Standards

Runway Condition Codes (RWYCCs) are one of the features of the Global Reporting Format (GRF) for runway surface conditions. Although these RWYCCs are quite familiar to many pilots operating transport category jet aeroplanes—and have been used for making time of arrival landing performance assessments for more than a decade—they may be quite new to many other pilots. This article will discuss what RWYCCs are, how they were developed and the important safety information that they convey. Most importantly, it will explain how RWYCCs can be used to help pilots address the hazards and risks associated with landings on wet and contaminated runways.

Essentially, the RWYCC is a number, from 0 to 6, which represents the slipperiness of a specific third of a runway and provides a standardized "shorthand" for reporting this information. A RWYCC of 0 corresponds to an extremely slippery runway and 6 corresponds to a dry runway. RWYCCs also serve to enhance all pilots' situational awareness of where the slipperiest runway conditions and contaminants are located on a runway, and they can be used by pilots to make a time of arrival landing performance assessment (for those aeroplanes with suitable performance information).

RWYCCs are included in a Runway Surface Condition (RSC) NOTAM, when runway surface conditions are reported in thirds (e.g., 3/3/2). Reporting in thirds typically occurs on longer runways used by larger, high-performance aeroplanes and is only available for paved runways. The decision whether or not to report by runway thirds or by full runway length is made by the airport or aerodrome operators in consultation with the operators that utilize the facility.

When reporting the runway surface condition information in thirds, the RSC NOTAM for an individual runway will include two reports: one for each runway direction (e.g., RSC RWY 07 and RSC RWY 25). The RWYCCs are presented in the direction of flight for each runway direction to help pilots to visualize where the contaminants are located on the runway. For example:

RSC RWY 07 3/3/5…

RSC RWY 25 5/3/3…

The photograph below illustrates how reporting in thirds helps to improve pilot situational awareness.

Credit: Ron Tidy

Figure 1. The two dashed blue lines overlaid on the photo help to show benefits of reporting runway surface conditions by thirds with associated RWYCCs. For landings in this direction, the RWYCCs would be 3/3/5. This "shorthand" description of runway friction makes it easy for pilots to understand that the contaminants are primarily located in the first two thirds of the runway. For landings in the opposite direction, the RWYCCs would be 5/3/3.

To understand how RWYCCs are determined, one first needs to look at the *Runway Condition Assessment Matrix* (RCAM). The RCAM is a tool that maps the equivalency between standard runway surface descriptions, RWYCCs, braking action reports, and aircraft performance information (data). It is used to harmonize airport observations with time of landing performance assessments made by the flight crew, providing a significant advancement over the previous performance methods and practices.

The RCAM was originally developed by the Takeoff and Landing Performance Assessment Aviation Rulemaking Committee (TALPA ARC), whose work ultimately resulted in GRF. (For more information about the TALPA ARC, please see *Canada Adopts New Global Reporting Format for Runway Surface Conditions*, also in this issue of the ASL.)

The RCAM effectively serves as the cornerstone of GRF. With the RCAM, we now have a powerful tool that integrates the safety benefits from TALPA—and puts all the pieces of the puzzle together:

- AERODROME OPERATORS: With the implementation of GRF, airport and aerodrome operators will now report runway surface conditions in accordance with a standardized format that utilizes standardized, globally accepted terminology. This reporting is now integrated with airplane performance information that is used by flight crews.
- AEROPLANE PERFORMANCE INFORMATION: For the last decade, the major manufacturers of transport category aeroplanes have been producing performance information that is based on the TALPA methods that form the basis of GRF; these methods utilize operationally representative landing distances—which is a significant advancement. For aeroplanes that do not have manufacturer-supplied TALPA-based performance information or performance information developed by a third party, a **Landing Distance Factors Table** is now available in Advisory Circular (AC) 700-057, Table 6.
- FLIGHT CREWS: With the introduction of GRF, flight crews will now receive benefit from standardized runway surface conditions, which is presented in a format that harmonizes with the performance information used to make time-of-arrival landing performance assessments.

Essentially, the RCAM (shown below) consists of two major portions:

- **Assessment Criteria**, which appear on the left (unshaded) half of the RCAM; and
- **Control/Braking Assessment Criteria**, which appear on the right (shaded) half of the RCAM. (Downgrade Assessment Criteria is the equivalent term used in the RCAM for airport and aerodrome operators).

Assessment Criteria		Control/Braking Assessment Criteria	
Runway Surface Description	**RWYCC**	**Vehicle Deceleration or Directional Control Observation**	**Pilot Braking Action**
• DRY	6	-	-
• FROST • WET (The runway surface is covered by any visible dampness or water up to and including 1/8 inch (3 mm) depth) **Up to and including 1/8 inch (3 mm) depth:** • SLUSH • DRY SNOW • WET SNOW	5	Braking deceleration is normal for the wheel braking applied AND directional control is normal	GOOD
-15°C and colder outside air temperature • COMPACTED SNOW	4	Braking deceleration OR directional control is between Good and Medium	GOOD TO MEDIUM
• SLIPPERY WHEN WET (wet runway) • DRY SNOW or WET SNOW (Any depth) ON TOP OF COMPACTED SNOW **Greater than 1/8 inch (3 mm) depth:** • DRY SNOW • WET SNOW **Warmer than -15°C outside air temperature:** • COMPACTED SNOW	3	Braking deceleration is noticeably reduced for the wheel braking effort applied OR directional control is noticeably reduced	MEDIUM
Greater than 1/8 inch (3 mm) depth: • STANDING WATER • SLUSH	2	Braking deceleration OR directional control is between Medium and Poor	MEDIUM TO POOR
• ICE	1	Braking deceleration is significantly reduced for the wheel braking effort applied OR directional control is significantly reduced	POOR
• WET ICE • SLUSH ON TOP OF ICE • WATER ON TOP OF COMPACTED SNOW • DRY SNOW or WET SNOW ON TOP OF ICE	0	Braking deceleration is minimal to non-existent for the wheel braking effort applied OR directional control is uncertain	POOR /NIL

Figure 2. The Runway Condition Assessment Matrix (RCAM) used by flight operations personnel. (The version used by airport and aerodrome operators is similar; it has minor differences and also includes additional information.)

The **Assessment Criteria** (left unshaded half of RCAM) includes **runway surface descriptions** and **RWYCCs**. The runway surface descriptions are categorized based on the type and depth of contaminant (temperature is also considered for compacted snow); these are arranged hierarchically—in order of how "slippery" they are. DRY—which has the most friction—is at the top of the list, and conditions like WET ICE—which have the least friction—are at the bottom. Each runway surface description has a corresponding RWYCC. For example, 1 in. of dry snow (listed on the RCAM as **Greater than 1/8 in. (3 mm) depth)** has a corresponding *preliminary* RWYCC of 3. (An explanation of how preliminary RWYCCs are later confirmed, downgraded or upgraded, appears below.) RWYCCs are determined by the airport or aerodrome operator and provide pilots with a reasonably conservative estimate of the aircraft's landing performance.

Under some conditions, the runway surface may be more slippery than the *preliminary* RWYCC determined by referencing the runway surface descriptions in the RCAM. Especially at temperatures near and above freezing (i.e., at -3°C and warmer), the runway surface condition may be more slippery than indicated by the preliminary RWYCC. At these temperatures, airport and aerodrome operators should exercise vigilance and downgrade the RWYCC, if appropriate. In addition, any process that transfers heat to the surface may make the runway more slippery; possible heat sources include: an aircraft's tires, engine exhaust/thrust reverse, atmospheric conditions, and precipitation. Runway treatments can also temporarily result in more slippery conditions.

The **Control/Braking Assessment Criteria** (right shaded half of RCAM) provides the criteria that the airport and aerodrome operators use to determine if the RWYCC accurately reflects the slipperiness of the runway. The Control/Braking Assessment Criteria on the version of RCAM used by flight crews includes: **Pilot Braking Action** and **Vehicle Deceleration or Directional Control Observations**. (The RCAM version used by airport and aerodrome operators is similar and also includes CRFI information.)

The airport or aerodrome operator should determine whether the *preliminary* RWYCCs accurately reflect the runway conditions. Through this determination, which should consider CRFI (if available), vehicle deceleration or directional control observations, pilot braking action report(s), local knowledge and/or other information, the preliminary RWYCCs will then be: confirmed; downgraded; or upgraded (providing additional stringent criteria are met). This RWYCC is then published in the RSC NOTAM.

To see how this works, consider the previous example, where it was shown that 1 in. of dry snow (listed on the RCAM as "**Greater than 1/8 in. (3 mm)**"), had a corresponding *preliminary* RWYCC of 3. A reliable braking action report of POOR braking would likely lead the airport or aerodrome operator to downgrade the RWYCC to 1. This is illustrated on the next page.

Assessment Criteria		Control/Braking Assessment Criteria	
Runway Surface Description	**RWYCC**	**Vehicle Deceleration or Directional Control Observation**	**Pilot Braking Action**
• DRY	6	-	-
• FROST • WET (The runway surface is covered by any visible dampness or water up to and including 1/8 inch (3 mm) depth) **Up to and including 1/8 inch (3 mm) depth:** • SLUSH • DRY SNOW • WET SNOW	5	Braking deceleration is normal for the wheel braking applied AND directional control is normal	GOOD
-15°C and colder outside air temperature • COMPACTED SNOW	4	Braking deceleration OR directional control is between Good and Medium	GOOD TO MEDIUM
• SLIPPERY WHEN WET (wet runway) • DRY SNOW or WET SNOW (Any depth) ON TOP OF COMPACTED SNOW **Greater than 1/8 inch (3 mm) depth:** • DRY SNOW • WET SNOW **Warmer than -15°C outside air temperature:** • COMPACTED SNOW	3	Braking deceleration is noticeably reduced for the wheel braking effort applied OR directional control is noticeably reduced	MEDIUM
Greater than 1/8 inch (3 mm) depth: • STANDING WATER • SLUSH	2	Braking deceleration OR directional control is between Medium and Poor	MEDIUM TO POOR
• ICE	1	Braking deceleration is significantly re[illegible] significantly reduced	POOR
• WET ICE • SLUSH ON TOP OF ICE • WATER ON TOP OF COMPACTED SNOW • DRY SNOW or WET SNOW ON TOP OF ICE	0	Braking deceleration is minimal to non-existent for the wheel braking effort applied OR directional control is uncertain	LESS THAN POOR /NIL

Figure 3. 1 in. of dry snow (listed on the RCAM as "Greater than 1/8 in. (3 mm)"), had a corresponding preliminary RWYCC of 3. A reliable braking action report of POOR braking would likely lead the airport or aerodrome operator to downgrade the RWYCC to 1. This RWYCC will be published in the RSC NOTAM.

The job of the airport or aerodrome operator is to accurately report the runway surface conditions; essentially, just to “report the news.” Determining how this information is to be used is the responsibility of flight operations personnel. Here again, RWYCCs and the RCAM play an important role.

The RCAM can be used by flight crews to make their time-of-arrival landing performance assessments using data that more accurately represents actual aircraft braking performance. For example, consider a situation where an RSC NOTAM includes RWYCCs of 4/4/3. In this case, many operators will direct their flight crews to base their landing performance assessment on the most conservative RWYCC (in this case 3—which corresponds to MEDIUM braking). If the aircraft subsequently receives a reliable braking action report of POOR, the flight crew may use this as the basis for their landing performance assessment.

Note: The examples above highlight an important distinction: RWYCCs—which are determined by the airport or aerodrome operator—use numbers (0 to 6) to describe how slippery the runway is; while braking action reports from pilots use words such as GOOD, MEDIUM, POOR and NIL.

Flight crews can also use the RCAM to help them mitigate the hazards and risks associated with landing on runways that are wet or contaminated with standing water. The guidance in AC 700-057, Appendix C, warns that due to the challenges of reporting water on a runway—especially during a dynamic event like a thunderstorm—these conditions may not always be reported, or it may not be possible to report them in a timely manner. For example, consider a situation where an RSC NOTAM reports wet runway conditions with corresponding RWYCCs of 5/5/5. AC 700-057 recommends that, due to the risk of standing water, prior to initiating an approach, pilots should verify that the aircraft can stop within the Landing Distance Available using an RWYCC of “2” (corresponding to MEDIUM TO POOR braking), whenever there is the likelihood of:

- moderate or greater rainfall on a smooth runway; or
- heavy rain on a grooved/porous friction course (PFC) runway.

Assessment Criteria		Control/Braking Assessment Criteria	
Runway Surface Description	**RWYCC**	**Vehicle Deceleration or Directional Control Observation**	**Pilot Braking Action**
• DRY	6	-	-
• FROST • WET (The runway surface is covered by any visible dampness or water up to and including 1/8 inch (3 mm) depth) **Up to and including 1/8 inch (3 mm) depth:** • SLUSH • DRY SNOW • WET SNOW	5	Braking deceleration is normal for the wheel braking applied AND directional control is normal	GOOD
-15°C and colder outside air temperature • COMPACTED SNOW		Braking deceleration OR directional control is between Good and Medium	GOOD TO MEDIUM
• SLIPPERY WHEN WET (wet runway) • DRY SNOW or WET SNOW (Any depth) ON TOP OF COMPACTED SNOW **Greater than 1/8 inch (3 mm) depth:** • DRY SNOW • WET SNOW **Warmer than -15°C outside air temperature:** • COMPACTED SNOW		Braking deceleration is noticeably reduced for the wheel braking effort applied OR directional control is noticeably reduced	MEDIUM
Greater than 1/8 inch (3 mm) depth: • STANDING WATER • SLUSH	2	Braking deceleration OR directional control is between Medium and Poor	MEDIUM TO POOR
• ICE	1	Braking deceleration is significantly reduced for the wheel braking effort applied OR directional control is significantly reduced	POOR
• WET ICE • SLUSH ON TOP OF ICE • WATER ON TOP OF COMPACTED SNOW • DRY SNOW or WET SNOW ON TOP OF ICE	0	Braking deceleration is minimal to non-existent for the wheel braking effort applied OR directional control is uncertain	POOR /NIL

Figure 4. During a rainfall event, an RSC NOTAM may report wet runway conditions with corresponding RWYCCs of 5/5/5. Prior to initiating an approach, pilots should verify that the aircraft can stop within the Landing Distance Available using an RWYCC of "2" (corresponding to MEDIUM TO POOR braking), whenever there is the likelihood of: moderate or greater rainfall on a smooth runway; or heavy rain on a grooved/PFC runway.

Conclusion

RWYCCs have been designed to be a simple and effective means of enhancing pilot situational awareness by clearly and concisely indicating how slippery the various sections of a runway are. In addition, they provide a significant safety advancement since they align with aeroplane performance data (information) that can be used for the time-of-arrival landing performance assessment.

A great deal of thought and research by industry experts has gone into the development of RWYCCs and the RCAM; these are powerful tools that are intended to help mitigate the hazards and risks associated with landings on wet and contaminated runways.

Further information and guidance

Guidance on RWYCCs is available for flight operations personnel and for airport and aerodrome operators:

- Advisory Circular (AC) 700-057—*Global Reporting Format (GRF) for Runway Surface Conditions: Guidance for Flight Operations*

  Note: The main body of the AC 700-057 provides background information as well as the essential information needed to read and understand the new Global Reporting Format (GRF) for runway surface conditions. Specific information related to RWYCCs is provided in:

  - Appendix A–Reporting in thirds
  - Appendix B–Runway condition codes
  - Appendix C–Risks associated with wet conditions and standing water
  - Appendix D–Low friction “slippery when wet” runways
  - Appendix E–Time of arrival landing performance assessments

- AC 300-019—*Global Reporting Format (GRF) for Runway Surface Conditions*△

Did You Know?

We have a Web page listing Transport Canada safety seminars and Transport Canada approved recurrent training programs. Check it often—we update it frequently!

Attending one of these presentations is a great way to update your pilot knowledge, and there is no limit on how many presentations you can attend. Also, attending a presentation meets the two-year recurrent training requirement in the *Canadian Aviation Regulations*, Standard 421.05(2).

If you are the organizer of an upcoming Transport Canada approved recurrent training program, please send us a message at TC.GeneralAviation-AviationGenerale.TC@tc.gc.ca. We want to help make your program a success by sharing info on our Web page! △

INSTRUCTOR'S CORNER

Always Expect the Unexpected

by Stuart Doyle MSc., Civil Aviation Safety Inspector, Commercial Flight Standards (AARTF), Aerial Work, Air Taxi, Commuter

Credit: iStock

As chief pilot of a military helicopter squadron, I was training an experienced pilot for an operational deployment in a single-engine helicopter, and part of that training required an entry to autorotation from 3 000 ft AGL at zero groundspeed. The weather was good, with 10 kt of wind under a cloudless sky. After a brief on the ground and reminder in the air, we set up over a field chosen for its suitability, I "chopped" the throttle, and the pilot smoothly entered autorotation: so far so good. Then the pilot associated the sound of the rotor RPM (RRPM) recovering to the normal level with a rotor overspeed condition, which he reacted to with a rather generous application of collective lever. As the RRPM reduced to below the minimum limit, I took control, but only just managed to get the RRPM back to a manageable figure before we landed without injury to anyone or damaging the aircraft. I should point out that this was the type of helicopter that once the throttle was at the idle position, you were committed to landing.

What did I learn?

- Experienced pilots are far more likely to do unexpected things than are inexperienced pilots.
- Always have an escape route.
- Never put a student/candidate/trainee in a position that you cannot get out of. △

TIPS AND TOOLS

Aircraft Ground Icing Operations

by Technical, Programs and Evaluations Team, Standards Branch, Civil Aviation, Transport Canada

In support of Transportation Safety Board of Canada (TSB) Recommendation A18-02, below are just a few reminders with regard to aircraft operations during ground icing conditions.

This information is for all pilots who fly in our tricky climate. Transport Canada wishes to maintain a high level of awareness within the civil aviation community of the hazards of flying with ice or snow (contamination) adhering to the critical surfaces of an aircraft, and flying into icing conditions.

Credit: iStock

The cold weather is upon us and so is the season for de/anti-icing. Past incidents and research have demonstrated that even small amounts of contamination on an aircraft's critical surfaces can have a very large effect on the aircraft's performance and handling qualities. Contamination such as frost with thickness as small as 0.40 mm (1/64 in.) can disrupt air flow over the lift and control surfaces of an aircraft, potentially leading to increased drag, lift loss and impaired maneuverability. This is especially true during the takeoff and initial climb phases of flight.

Ice can also significantly increase aircraft weight, interfere with the movement of control surfaces, and prevent the functionality of critical aircraft sensors.

Remember: there is no such thing as an insignificant amount of contamination; it is imperative that takeoff not be attempted in any aircraft unless it has been determined that all critical surfaces of the aircraft are free from contamination. This requirement can be met if the pilot-in-command verifies or obtains verification from properly trained and qualified personnel that the aircraft is ready for flight.

Aircraft operating from smaller or remote aerodromes may be de/anti-iced by ground handling personnel or sometimes by the pilot using a de/anti-icing fluid applied with a pressure sprayer. Aircraft operators may be responsible for carrying the appropriate de/anti-icing equipment on board the aircraft or storing the equipment at the aerodromes.

The holdover times for SAE-qualified de/anti-icing fluids are obtainable in the Transport Canada holdover time (HOT) guidelines by visiting the Web site or requesting a copy of the *Winter 2021-2022 Holdover Time Guidelines* by emailing DLOTTAEWeb@tc.gc.ca.

Adequate anti-icing fluid coverage is absolutely essential to ensure the expected holdover time (HOT) can be attained. It is imperative that the personnel applying fluids are properly trained to utilize consistent fluid application techniques.

If reliable holdover times are to be achieved, only fluids that are stored, dispensed, and applied in accordance with the manufacturers' instructions can be used. These fluids have undergone laboratory testing and qualification to confirm aerodynamic acceptability.

Pilots should become familiar with the applicable *Canadian Aviation Regulations* (CARs) and Standard 622 of the *General Operating and Flight Rules Standards* (GOFRS)—*Ground Icing Operations*, as well as the procedures recommended by the aircraft manufacturer in the pilot operating handbook (POH), aircraft flight manual (AFM), maintenance manual and, where appropriate, the aircraft service manual. As well, they should comply with all company operations manual (COM) provisions. Ground de-icing and anti-icing procedures vary greatly depending primarily on aircraft type, the type of contamination accumulation on the aircraft, and the freezing point depressant (FPD) or de-/anti-icing fluid type.

TP 14052—*Guidelines for Aircraft Ground Icing Operations* contains information for aircraft in ground icing conditions, including details on application methods, liquid types, and more.△

Reporting Major Modifications and Major Repairs

by Ryan Hennigar, Program Manager Maintenance Performance Standards, Operational Airworthiness, Standards Branch, Civil Aviation, Transport Canada

A person performing a major modification or repair must report it. Any major modification or major repair performed on a type certified Canadian registered aircraft must be reported to Transport Canada Civil Aviation (TCCA). To clarify the reporting requirement in CAR 571.12, we will answer these questions:

- When to report;
- How to report;
- What to report;
- Who must report; and
- How to report for foreign aeronautical products?

Credit: iStock

When to report?

The definitions of "major modification" and "major repair" in CAR 101.01 apply to aeronautical products to which a type certificate has been issued: an aircraft, engine or propeller. When a modification or repair that has been classified as major according to the definitions is performed on an aircraft, propeller or engine, or is performed on a part that is to be installed on an aircraft, the details of the major modification or major repair must be reported.

How to report?

The reporting requirement in CAR 571.12 refers the reader to Standard 571.12 for reporting procedures. There is no longer an official TCCA form to use, like there was in the past. There is now flexibility in the way major modifications and repairs are reported; but, there are specific details that must be included and a format to follow, including numbered blocks and headings. These formatting requirements are described in Standard 571 Appendix L.

What to report?

The information in the report must be accurate and describe in detail the work that was performed. Information about the aeronautical product (e.g. aircraft, registration and owner) and details regarding the work accomplished must be reported. The description of the work accomplished needs to be clear, concise, and legible and accurately describe exactly what was done on the aeronautical product; location of the repair or modification, specific data used, and its details and reference such as an STC number or manufacturer's installation instructions. When quoting references such as the FAA AC 43.13, specific reference to the chapter, section and paragraph is required.

Who is required to submit the report?

CAR 571.12 states that the person who performs a major modification or major repair shall report it. This could be the holder of an appropriately rated AME licence or a representative from the approved maintenance organization (AMO). A copy of the report must be submitted to TCCA within 30 days following the aircraft's return to service.

How to report for foreign aeronautical products?

TCCA has entered into several international agreements or arrangements on maintenance with civil aviation authorities (CAA) around the world. These agreements/arrangements detail modification data, repair data and the reporting requirements that AMOs must follow when performing work on foreign aeronautical products. Depending on the agreements/arrangements, some of these details may be in the AMO's maintenance policy manual (MPM) supplement. Some foreign agreements/arrangements require the use of forms and procedures specified by the foreign CAA. AMOs must be familiar with the terms of the agreements/arrangements they are working under.△

Resuming Travel with your Family Soon?

by Technical, Programs and Evaluations Team, Standards Branch, Civil Aviation, Transport Canada

Although children under 2 years old may be held in your arms during a flight, **Transport Canada highly recommends that you use an approved child restraint system (car seat)** for all phases of the flight. Any car seat intended for use on board an aircraft must have a statement of compliance label indicating the date it was manufactured and confirming that it meets the applicable design standard.

Credit: iStock

Remember:

- Planning is key
- Child restraint systems
- One passenger for each child under 2 years old

For the safety of both adults and children, the *Canadian Aviation Regulations* require that no passenger can be responsible for more than one infant (child under the age of 2). If you have two children under the age of 2, another passenger must accompany one of your children, even if you buy seats for them.

The use of a car seat provides the best protection for the infant or child and minimizes the effects of unanticipated turbulence. Using a familiar car seat will make your child more comfortable and you can also use it when you reach your destination. Always check with your airline for specific policies, follow the manufacturer's installation instructions, and tighten the aircraft seatbelt through the correct path on the car seat. Child restraint systems approved for aircraft, along with a list of devices that are not approved, can be found on the Web site listed below.

For more information, along with some packing and pre-boarding tips for a smooth and pleasant flight, check out our Web page. △

RECENTLY RELEASED TSB REPORTS

The following summaries are extracted from final reports issued by the Transportation Safety Board of Canada (TSB). They have been de-identified. Unless otherwise specified, all photos and illustrations were provided by the TSB. For the benefit of our readers, all the occurrence titles are hyperlinked to the full report on the TSB Web site. —Ed.

TSB Final Report A19Q0153—Loss of Control and Collision with Terrain at Night

History of the flight

On the evening of 4 September 2019, the occurrence pilot arrived at Montréal-Mirabel International Airport (CYMX), Quebec, along with another pilot, to prepare for a night visual flight rules (VFR) flight. After reviewing the weather information, they prepared for a flight to Sherbrooke Airport (CYSC), Quebec, to conduct a touch-and-go and then return to CYMX. Both pilots would be conducting the same flight, but in separate aircraft.

At approximately 2000, the pilots reviewed the flight plan and weather with a flight instructor and, after consultation with the chief flight instructor, the flight was authorized.

At 2101, the other pilot departed CYMX in a Cessna 172M aircraft. The occurrence pilot departed CYMX at 2103 in another Cessna 172M aircraft.

At 2106:10, once the occurrence aircraft was airborne and clear of the CYMX mandatory frequency (MF) area, the occurrence pilot contacted the Montreal area control centre (ACC) controller and requested a direct route to CYSC. The controller provided vectors to ensure the aircraft avoided aircraft arriving at Montréal/Pierre Elliott Trudeau International Airport, and instructed the occurrence pilot to climb to an altitude of 2 500 ft above sea level (ASL). A few minutes later, the controller instructed her to climb to 3 000 ft ASL.

At approximately 2115, the controller instructed the aircraft to proceed direct to CYSC.

At 2119:13, the controller instructed the occurrence pilot to climb to 3 500 ft ASL and provided the position of the other aircraft, which was still approximately 1 NM (nautical mile) ahead of the occurrence aircraft and also climbing to 3 500 ft ASL.

At approximately 2124, both aircraft were informed that they were leaving controlled airspace and were instructed to switch to the en route frequency.

The occurrence aircraft was travelling slightly faster than the other aircraft and at approximately 2132, the occurrence aircraft passed the other Cargair aircraft. Both aircraft continued the flight towards CYSC, with the occurrence aircraft now ahead of the other aircraft.

At approximately 2142, the occurrence aircraft entered instrument meteorological conditions (IMC) and descended to an altitude of 3 000 ft ASL to return to visual meteorological conditions (VMC). The other aircraft encountered the same conditions and descended as well. Both aircraft were approximately 32 NM northwest of CYSC at the time, and continued the flight towards CYSC in level flight at 3 000 ft ASL.

Shortly after descending to 3 000 ft ASL, the other aircraft lost sight of the occurrence aircraft as the occurrence aircraft flew into IMC for a second time. At 2147, the occurrence aircraft disappeared from radar when it was approximately 19 NM northwest of CYSC. After the other aircraft also encountered IMC a second time, the pilot decided to return to CYMX.

The wreckage of the occurrence aircraft was located three days later, on 7 September 2019, in a heavily wooded area near Racine, Quebec (Figure 1), at an elevation of 887 ft ASL. The aircraft had struck trees and been destroyed by impact forces. The pilot received fatal injuries on impact.

Figure 1. Aerial view of the wreckage site (Source: Sûreté du Québec)

Surface observations

At 2000 on 4 September 2019, a low-pressure system was centred near the Gaspé Peninsula, about 60 NM northeast of Mont-Joli Airport, Quebec. A warm front extended from the low-pressure system eastward into eastern Quebec and a cold front extended southeastward through the U.S. state of Maine. A ridge of high pressure, located to the west, had moved eastward, extending its influence into southwestern Quebec. At 2100, before the occurrence aircraft departed CYMX, the area between CYMX and CYSC remained under a stratocumulus cloud deck behind the cold front. Although the winds had died down and the skies had started to clear at CYMX, the skies remained overcast near CYSC, with gusty westerly winds.

At approximately the time of and near the area of the occurrence, precipitation-rain radar images showed convective cloud embedded within the stratocumulus cloud, as well as possible light showers. Images also showed the presence of shallow towering cumulus (TCU) cloud embedded within the stratocumulus layer (Figure 2).

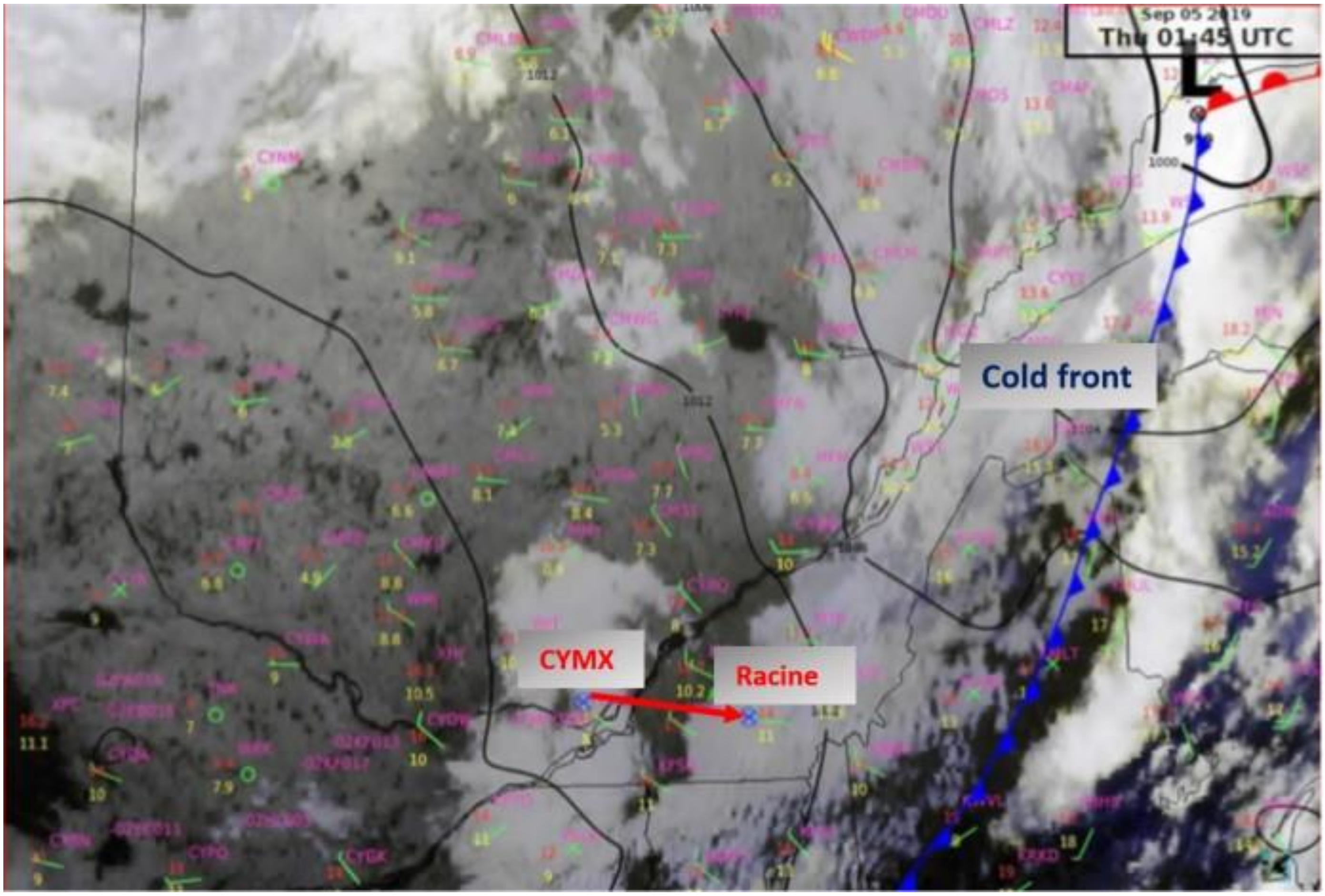


Figure 2. Multi-spectral satellite imagery valid at 2145 on 4 September 2019 depicting cold front (Source: Environment and Climate Change Canada, with TSB annotations)

Graphic area forecast

Graphic area forecasts (GFAs) show the general upcoming weather conditions for a given geographic area. On the day of the occurrence, a clouds and weather chart issued at 1331 and valid at 2000 showed a low-pressure system located near Baie-Comeau, in eastern Quebec, with a cold front extending south into the USA, moving eastward at 20 kt. The cold front was forecast to be west of CYSC at 2000 (Appendix A).

In the vicinity of the cold front, the following conditions were expected:

- broken ceilings at 3 000 ft ASL, with tops at 24 000 ft ASL;
- visibility variable between 4 and more than 6 statute mi. (SM);
- light rain and mist;
- occasional altocumulus castellanus with tops at 22 000 ft, giving visibilities of 2 SM in light rain showers;

- patchy ceilings between 300 and 600 ft above ground level (AGL);
- isolated cumulonimbus clouds with tops at 36 000 ft ASL, giving visibility of 1 SM in heavy thundershowers and mist; and
- winds gusting to 35 kt.

Behind the cold front, the following conditions were expected:

- broken ceilings at 3 000 ft ASL, with tops at 6 000 ft ASL;
- visibility of more than 6 SM;
- isolated altocumulus castellanus with tops at 20 000 ft ASL, visibility of plus 6 SM in light rain showers and mist; and
- over eastern/southern sections, local ceilings at 1 500 ft AGL.

At 1911, a revised GFA (Appendix B) was issued with similar conditions to those depicted in the GFA issued at 1331, with the following exceptions:

- The cold front was forecast to be east of CYSC at 2000; and
- over eastern/southern sections, isolated TCU with tops at 8 000 ft ASL, visibility of 5 SM in light rain showers, mist and patchy ceilings between 800 and 1 500 ft AGL.

Sherbrooke aerodrome routine meteorological reports and aerodrome forecasts

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

The CYSC METAR AUTO issued at 2000 on 4 September 2019 reported the following:

- wind 280° true (T) at 17 kt, gusting to 29 kt;
- visibility more than 9 SM;
- a few clouds at 2 800 ft AGL, a broken ceiling at 3 900 ft AGL, and an overcast layer at 4 800 ft;
- temperature 17°C, dew point 12°C; and
- altimeter setting 29.85 in. of mercury.

At 2058, a few minutes before the aircraft departed from CYMX, a SPECI was issued. It reported the following:

- wind 280°T at 11 kt, gusting 22 kt;
- visibility more than 9 SM;
- broken ceiling at 2 100 ft AGL, with additional broken layers at 3 200 ft AGL and 4 900 ft AGL;
- temperature 15°C, dew point 12°C; and

- altimeter setting 29.92 in. of mercury.

Between 2100 and 2200, while the occurrence aircraft was in flight, the AWOS issued four SPECIs, at 2101, 2112, 2115 and 2138, indicating changes in the cloud cover. Weather sequences are found in table 4.

Aerodrome forecasts (TAFs) provide a description of the most probable weather conditions expected to occur within a 5 NM radius around an aerodrome, and are amended when the forecast conditions are no longer representative of the current or expected conditions (i.e., the conditions improve or deteriorate).

The TAF issued for CYSC at 1943 on 4 September 2019, which was valid from 2000 until 2300, forecasted the following conditions:

- winds from 270°T at 15 kt, gusting to 25 kt;
- visibility of more than 6 SM;
- broken ceiling at 4 000 ft AGL;
- broken cloud layer at 7 000 ft AGL; and
- a gradual change to winds was forecast to occur between 2000 and 2200, when winds were forecast to decrease to 280°T at 10 kt.

Accident site

The accident site was in a heavily wooded area near Racine, Quebec. The aircraft's wings first struck two tall evergreen trees. Damage to the trees indicate that the aircraft was travelling at high velocity in a nose-down, banked attitude before it struck them (Figure 3).

Figure 3. Damage to trees caused by the occurrence aircraft looking back towards the direction of flight (Source: Sûreté du Québec, with TSB annotation)

After the first strike, the aircraft collided head on with a hardwood tree. The aircraft's fuselage wrapped around the tree's trunk before striking the ground, inverted, on the opposite side. All flight control surfaces were accounted for and came to rest scattered within a restricted perimeter from the point of impact, indicating that the aircraft broke up on impact and not in flight. There were no signs of pre-impact failures of material or component malfunctions.

Damage to the propeller as well as the number and proximity of the propeller marks on the tree's trunk were consistent with power being produced at the time of impact. The throttle was found to be in the full-power position.

Instrument analysis

The instruments recovered from the wreckage were sent to the TSB Engineering Laboratory in Ottawa, Ontario, for analysis. The damage observed on the instruments was indicative of high deceleration forces at impact.

Engine tachometer

The engine tachometer was found with the pointer missing. The TSB laboratory carried out a microscopic examination of the tachometer's face, and a clear pointer-to-face mark was observed extending from the pointer shaft to the 2 850 rpm gradation, 150 rpm over the red-line limit. The engine tachometer is a mechanical instrument driven by a torsion cable that is connected to the engine's tachometer drive housing and, as such, does not require electrical power to operate. It will provide a reading as long as the engine is turning. Therefore, the 2850 rpm pointer-to-face witness marks are considered to be an accurate representation of engine revolution at the time of impact.

Airspeed indicator

The airspeed indicator was found still attached to the instrument panel. Although the pointer was missing, the examination revealed a faint pair of parallel lines, possibly caused by the pointer striking or being pressed against the dial face. These lines were at or near the pointer stop of 200 mph (174 kt indicated airspeed [KIAS]), indicating that the aircraft likely had exceeded the never exceed speed (Vne) of 184 mph (160 KIAS).

Vertical speed indicator

The vertical speed indicator was severely damaged; however, a microscopic examination revealed a faint sequence of impact marks extending radially from the centre of the dial and roughly aligning with a 1 900 fpm descent rate, nearing the maximum indicated rate of descent of 2 000 fpm.

Directional gyroscope

Examination of the directional gyroscope determined that the instrument had a recorded heading of approximately 280° at impact, which is a 165° change in direction from the occurrence aircraft's last radar track of 115°.

Regulatory requirements for night flight

According to the *Canadian Aviation Regulations* (CARs), pilots in VFR flight within or outside controlled airspace must operate their aircraft with visual reference to the surface, during the day and at night. The CARs define a surface as "any ground or water, including the frozen surface thereof."

In addition to the visual reference to the surface required for night VFR flight in an aircraft in uncontrolled airspace, the following conditions must be met:

- flight visibility is not less than 3 mi.;
- if the aircraft is operated at or above 1 000 ft AGL, the distance from cloud is not less than 500 ft vertically and 2 000 ft horizontally; and

- if the aircraft is operated at less than 1 000 ft AGL, it must stay clear of cloud.

Pilot decision making

Pilot decision making is a cognitive process consisting of gathering information, evaluating it, then selecting an option between alternatives. Once a course of action is being performed, the decision-making process starts again in order to validate whether the decision made corresponds to the best possible option. Decision making is therefore a dynamic process. By anticipating and addressing possible issues that could occur during the flight, pre-flight planning decisions avoid the need for potentially more difficult in-flight decisions. This is particularly critical for night VFR flights, when considering the risk of encountering adverse weather.

Throughout pilot training, instructors play a vital role in teaching pilots how to make decisions. Pilots with limited experience can lack the experience necessary to clearly recognize hazards and options available to them. They often rely on their instructor's judgment and experience to guide them and teach them how to assess various situations and associated hazards. It is therefore important for an instructor to emphasize how to identify hazards ahead of time and show the pilot how to assess the associated risks and determine acceptable limits.

Cross-country flights require that pilots apply several theoretical subjects they have studied during their training, such as flight planning, meteorology, human factors, regulations, and multi-tasking.

Pilot decision making varies depending on how much time the pilot has to act:

- Before the flight, there is "ample time decision making."
- During the flight, there is "time critical decision making," since a quick decision and reaction is necessary, often based on similar previous experience or one that was simulated during training.

Once a flight has begun, an instructor cannot correct time-critical decisions made by the pilot. Also, inexperienced pilots "are less able to recognize and accurately interpret a situation, they are more often forced into knowledge-based behaviour" rather than experience-based behaviour. Since their knowledge is generally more limited, "they are more likely to make knowledge-based mistakes."

In this occurrence, the pilot had limited night and instrument flight experience and knowledge of the risks associated with night flying.

A number of cognitive biases can also influence pilot decision making. Plan continuation bias is best described as "the unconscious cognitive bias to continue with the original plan in spite of changing conditions," or "a deep-rooted tendency of individuals to continue their original plan of action even when changing circumstances require a new plan." Once a plan is made and committed to, it becomes increasingly difficult for stimuli or conditions in the environment to be recognized as necessitating a change to that plan. Often, as workload increases, the stimuli or conditions will appear obvious to people external to the situation; however, it can be very difficult for a pilot caught up in the plan to recognize the saliency of the cues and the need to alter the plan. Plan continuation bias can be a factor for continued flight in adverse weather conditions.

Encountering weather at night

At night, it is more difficult to visually detect and stay clear of cloud, terrain and obstacles. Unlike on day VFR flights, weather phenomena are difficult to observe at night because of the low-light conditions. It is possible that pilots departing in weather conditions that legally permit night VFR flight would be unable to observe a deterioration in weather conditions and take the necessary measures before inadvertently entering IMC. The consequences of flying in reduced visibility are exacerbated when flying at night, in light conditions that do not permit sufficient warning for the pilot to see and avoid worsening weather conditions.

In this occurrence, the pilot had obtained weather information for the flight-planned route on the internet and had reviewed it with a flight instructor. The forecasted weather conditions met regulatory requirements for a night VFR flight; however, the review raised some concerns regarding the prevailing winds at CYSC. After discussion, the pilot and instructor determined that the weather was sufficient for the proposed flight to CYSC, and agreed that the pilot would not attempt to land if the winds were too strong. The chief flight instructor was consulted and the flight was authorized.

A post-occurrence review of the METARs and TAFs that were available at the time of flight planning detailed ceilings that were, or were expected to be, above the planned cruise altitude of 3 500 ft ASL. Although the METARs and TAFs described favourable conditions, the available GFA detailed that ceilings in the flight plan area were expected to be broken at 3 000 ft ASL, below the planned cruise altitude. It could not be determined which, if any, GFA was reviewed at the time the flight was planned.

This GFA forecast was later determined to be accurate (following the occurrence), as the METAR issued shortly before the occurrence aircraft departed CYMX, recorded the ceiling at CYSC as 2 100 ft AGL, or approximately 2 900 ft ASL.

Spatial disorientation

There are a number of hazards associated with night flying. First and foremost, visual performance is significantly degraded under conditions of night illumination. Even under ideal night VFR conditions with a full moon, a pilot likely has a visual acuity in the order of 20/200 or less. This means that a person can see at 20 ft what he or she would normally be able to see at 200 ft in daylight.

This degraded visual performance can create compelling sensory illusions that can lead to spatial disorientation, which is defined as “the inability of a pilot to correctly interpret aircraft attitude, altitude or airspeed in relation to the Earth or other points of reference.” In other words, spatial disorientation occurs when a person’s brain misinterprets cues from the environment, and that person experiences difficulty resolving mentally why, for instance, an aircraft does not appear to be doing what the brain believes that it is doing. If pilots do not quickly detect and control this spatial disorientation, they can rapidly lose control of the aircraft.

Humans have the ability to discern the orientation of their body (lying down, standing, leaning, etc.) when they are in physical contact with the ground. Humans are not accustomed to the three-dimensional environment of flight, and conflicts may arise between the senses and illusions that make it difficult or impossible to maintain spatial orientation.

Humans process information from three sensory systems to orient themselves in space:

- the visual system;
- the vestibular system (information from the inner ear); and
- the proprioceptive system (information from muscles, joints and bones).

The visual system provides 80% of the information used for spatial orientation. If visual information is lost, all that remains is the 20% of information that comes from the vestibular and proprioceptive systems. The information from these two systems is less precise and more susceptible to error because it is prone to illusions and misinterpretation.

Since visual cues play an important role in human balance and orientation, spatial disorientation tends to occur in conditions of limited visibility; pilots can rapidly become spatially disoriented when they lose sight of the surface. To this effect, a report published by the Australian Transport Safety Bureau (ATSB)[1] stated the following:

The significance of visual cues on human balance and orientation may be demonstrated by the short period of time it takes for a person to become spatially disoriented once visual cues are lost:

> ***"Disorientation is very uncommon when the pilot has well-defined visual cues; but when he attempts to fly when sight of the ground or horizon is degraded by cloud, fog, snow, rain, smoke, dust or darkness he quickly becomes disorientated unless he transfers his attention to the aircraft instruments. The ability to maintain control of an aircraft without adequate visual cues is quite short, typically about 60 seconds, even when the aircraft is in straight and level flight at the time vision is lost and shorter still if the aircraft is in a turn. In such circumstances, loss of control occurs because the non-visual receptors give either inadequate or erroneous information about the position, attitude and motion of the aircraft."***

(Benson, A.J. *Spatial Disorientation–General Aspects*, 1988)

In a degraded visual environment (such as intentionally or inadvertently flying into IMC), where a pilot is unable to maintain a reference with the surface, these illusions can bring on spatial disorientation, which can lead to improper flight control inputs and result in a loss of control. The strength of these illusions can be so intense that, especially for pilots with limited flight and instrument experience, even a conscious cross-reference to flight instruments may be insufficient to prompt the pilot to apply the appropriate corrective input to the flight controls.

Not recognizing spatial disorientation immediately may lead to loss of control of the aircraft or to controlled flight into terrain. Several published studies and TSB investigation reports have addressed the phenomenon of spatial disorientation and its consequences.

Shortly after losing sight of the occurrence aircraft, the pilot of the other Cargair aircraft reported experiencing spatial disorientation after entering IMC, resulting in a loss of control of the aircraft. However, she recovered in time to avoid a collision with the ground and was able to return to CYMX.

[1] Bureau of Air Safety Investigation (former name of the Australian Transport Safety Bureau), SAB/RP/95/01, *Dark Night Take-off Accidents in Australia* (April 1995), p. 8.

Analysis

Flight planning and flight instructor supervision

The occurrence pilot had obtained the weather for the flight-planned route on the internet. The pilot and the instructor discussed the cross-country flight to Sherbrooke Airport (CYSC) and the weather conditions that prevailed that evening. They assessed the forecast ceiling and visibility for the route as acceptable for the VFR night flight; however, some concerns were raised about the prevailing winds when the aircraft was expected to reach CYSC. It was agreed that if the winds were too strong, the pilot would not attempt to land. The chief flight instructor was then consulted before the flight was authorized.

Cloud ceilings reported in the METARs and TAFs were mainly VFR. However, both of the graphic area forecasts (GFA) relevant for the time period indicated that, in the vicinity of, and behind the cold front, broken ceilings at 3 000 ft ASL, which was below the planned flight altitude of 3 500 ft ASL, could be expected. Additionally, local or patchy ceilings of 1 500 ft AGL were forecast. This information was available to the flight instructor and pilot while reviewing the weather.

In-flight decision making

Pilots flying VFR can inadvertently enter IMC; this is especially true at night, when it is more difficult to observe a deterioration in weather conditions and take the necessary measures to avoid the worsening conditions. Pre-flight planning reduces the potential for in-flight decision errors because it can help prepare the pilot for situations that may arise during the flight. Not carrying out this planning can result in decisions being made when the pilot is under a considerable amount of stress and increases the likelihood of poor or incorrect decision making.

Before takeoff, pilots should develop a plan for what they will do if the weather en route is different from what they expected or if the weather deteriorates. This plan should consider a requirement to divert or turn back before entering IMC.

The tendency to stick to the initial plan, referred to as plan continuation bias, is an unconscious cognitive bias that involves continuing with an initial plan of action despite changing conditions. Once a plan is made and committed to, it can become increasingly difficult for the individual involved, especially during periods of high workload, to recognize stimuli or conditions that suggest a need to alter the plan.

Continuing visual flight rules flight into instrument meteorological conditions

After the occurrence aircraft levelled off at its cruise altitude of 3 500 ft ASL, as filed in the flight plan, it remained at that altitude for approximately 23 minutes. Approximately 32 NM northwest of CYSC, the occurrence pilot and the pilot of the other aircraft lost visual reference to the surface and both aircraft descended to 3 000 ft ASL to continue the flight towards CYSC. This descent to regain visual reference and then to remain clear of cloud was the first indication that the weather ahead may be deteriorating.

After entering IMC for the first time, the pilot was likely affected by an unconscious cognitive bias and her proximity to CYSC, which led her to continue the VFR flight into deteriorating weather conditions.

At this time, in the area surrounding CYSC, cloud layers varied greatly, as evidenced by the four SPECIs issued between 2100 and 2200. At 2112, scattered cloud layers as low as 2 100 ft AGL (approximately 2 900 ft ASL) were recorded at CYSC.

Shortly after levelling off at 3 000 ft ASL, approximately 19 NM northwest of CYSC, the pilot of the other aircraft reported losing sight of the occurrence aircraft before encountering IMC herself for a second time, and losing visual references with the ground. Because cloud bases in the area were lower than the occurrence aircraft's altitude and visual contact with the aircraft was lost, it was determined that as the occurrence aircraft neared CYSC, the pilot inadvertently encountered IMC for a second time, which resulted in a loss of visual reference to the surface.

Limited experience with night visual flight rules flight

Night flight requires pilots to develop additional skills so they can operate in an environment that is different from that of daytime flight. To compensate for the reduced visual acuity, which is the main source of information to maintain spatial orientation, pilots must refer more frequently to their flight instruments. This skill is initially acquired through training and maintained through practice.

Spatial disorientation

When weather conditions deteriorate, the associated risks must be properly managed at the same time as pilot workload increases. Furthermore, pilots must be able to recognize when conditions are no longer favourable to continue flight and take decisive action. All of this is more difficult for a pilot with limited experience.

Unexpected VFR flight into IMC requires a quick transition to instrument flight to maintain control of the aircraft. Once pilots in this situation become aware of what is happening, their stress level tends to rise rapidly. Pilots are typically able to maintain control of an aircraft without adequate visual cues for about 60 seconds if the aircraft is in straight and level flight at the time visual cues are lost. If the aircraft is in a turn, this amount of time is even shorter. Pilots with limited knowledge of, and practice with, instrument flight run the risk of making inappropriate manoeuvres and control inputs, and can become spatially disoriented.

Findings

Findings as to causes and contributing factors

1. When the plan for the night flight was reviewed by the flight instructor, the ceiling and visibility detailed in the aerodrome routine meteorological reports and aerodrome forecasts were assessed as acceptable, and the training flight was authorized.
2. After entering instrument meteorological conditions for the first time, the pilot was likely affected by an unconscious cognitive bias and her proximity to Sherbrooke Airport, Quebec, which led her to continue the visual flight rules flight into deteriorating weather conditions.
3. As the occurrence aircraft neared Sherbrooke Airport, the pilot inadvertently encountered instrument meteorological conditions for a second time, which resulted in a loss of visual reference to the surface.
4. Given the established correlation between loss of visual references and a loss of control, it is highly likely that the pilot, who had limited experience flying by sole reference to instruments, lost control of the aircraft as a result of spatial disorientation.

Findings as to risk

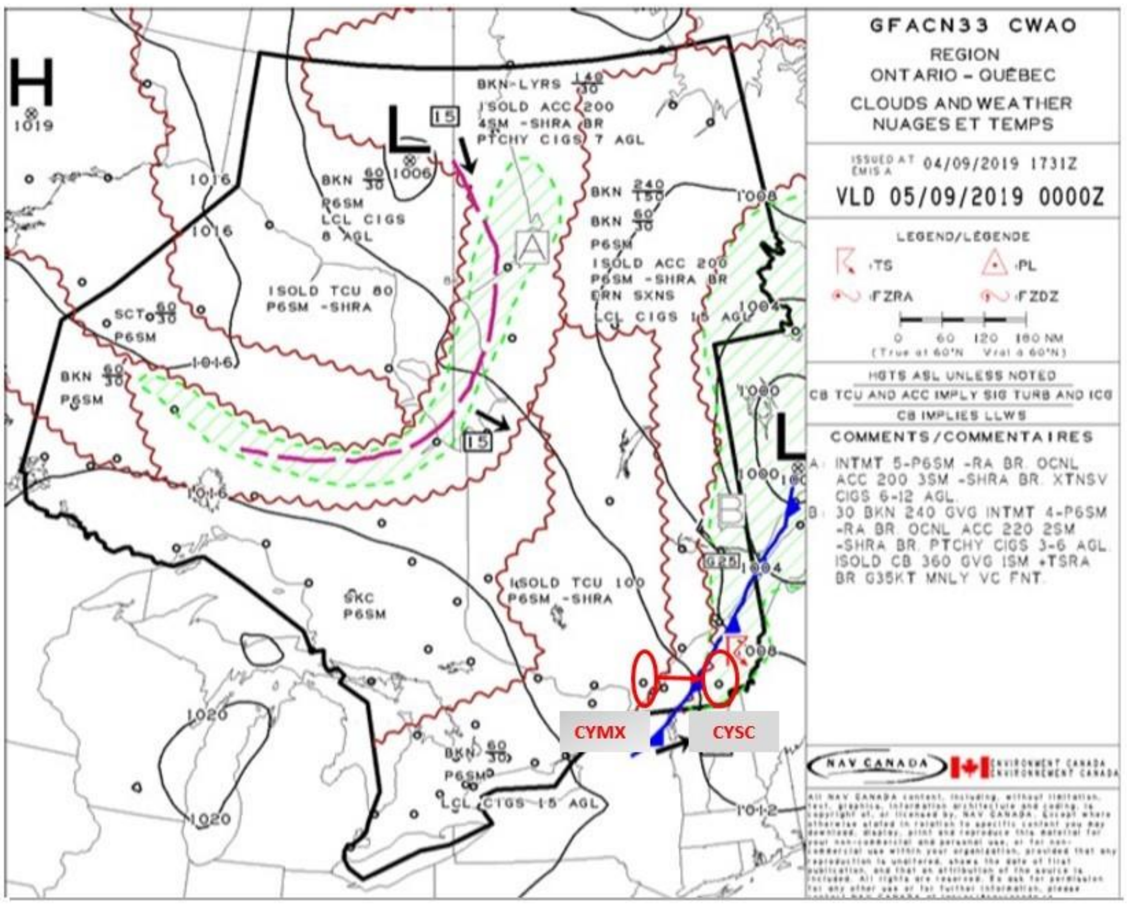
1. If a pre-flight weather review does not include all available information or does not assess the weather's effect on the ability to maintain visual reference to the surface

throughout a flight, especially for a planned night flight, there is an increased risk of encountering adverse weather or instrument meteorological conditions.

2. If the *Canadian Aviation Regulations* do not clearly define what is meant by "visual reference to the surface," night flights may be conducted with inadequate visual references, which increases the risks associated with night visual flight rules flight, including controlled-flight-into-terrain and loss-of-control accidents.

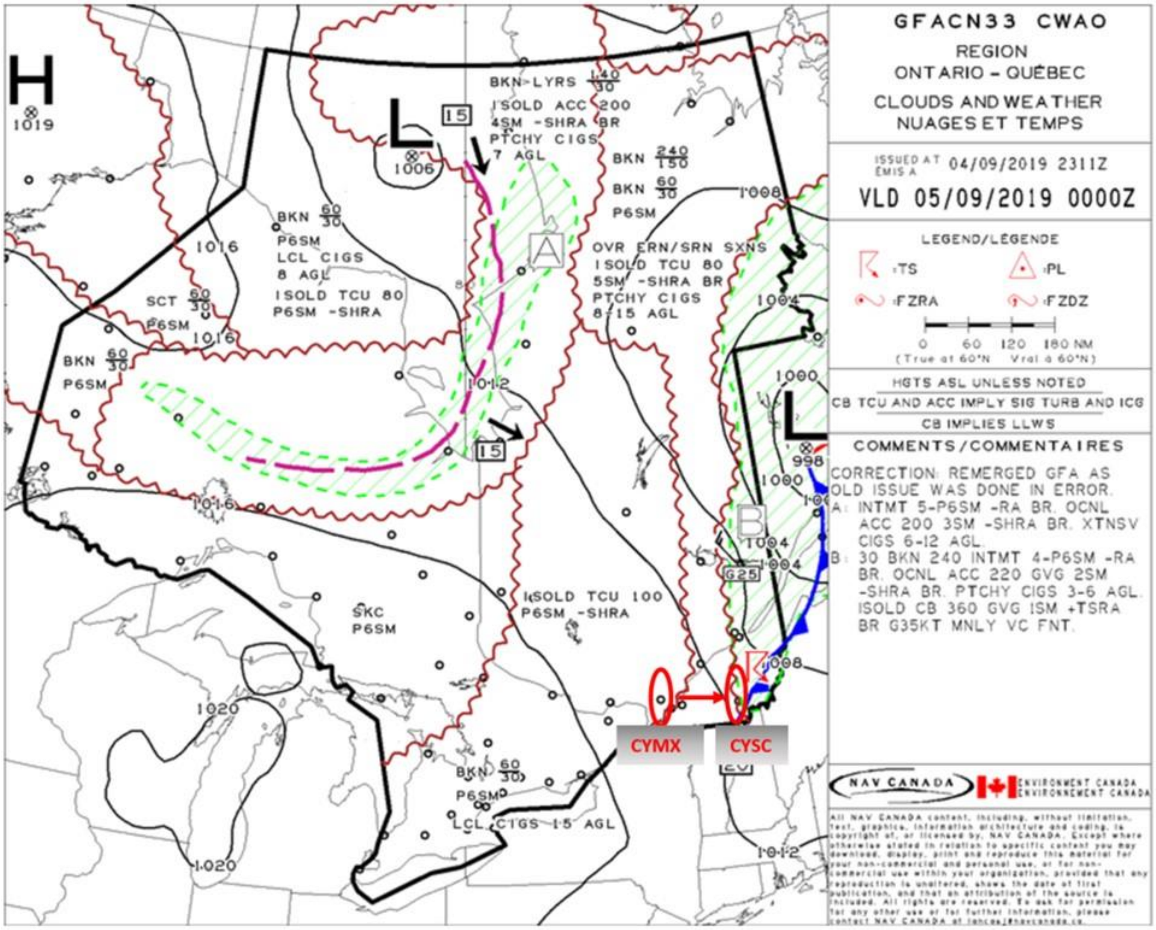
Appendices

Appendix A—Graphic Area Forecast (GFA) Clouds and Weather Chart—GFACN33 issued at 1331 Eastern Daylight Time



Source: NAV CANADA, with TSB annotations

Appendix B—Graphic Area Forecast (GFA) Clouds and Weather Chart—GFACN33 issued at 1911 Eastern Daylight Time



Source: NAV CANADA, with TSB annotations

TSB Final Report A20C0037—Runway Excursion

Factual information

On 28 April 2020, the Beechcraft King Air A100 aircraft was scheduled to depart Yellowknife Airport (CYZF), Northwest Territories, fly to Cambridge Bay Airport (CYCB), Nunavut, pick up freight there, and then continue on to Kugaaruk Airport (CYBB), Nunavut.

At approximately 0800, the captain arrived at the company hangar at CYZF to begin preparations for the flight. The first officer arrived at the hangar at 0900. The captain arranged for the aircraft to be fuelled while the first officer filed an instrument flight rules (IFR) flight plan from CYZF to CYCB. The aircraft departed CYZF at 0952 for its flight to CYCB, with the captain occupying the left seat and the first officer occupying the right seat.

The aircraft landed at CYCB at 1149. The aircraft was refuelled and freight, consisting of boxed cans of camp fuel (naphtha), was loaded into the cabin and belly pod. The first officer checked the weather and filed an IFR flight plan for the flight from CYCB to CYBB with Gjoa Haven Airport (CYHK), Nunavut, as the planned alternate airport.

Occurrence flight

At 1216, the aircraft departed CYCB for CYBB, a flight that would last approximately one hour and 30 minutes. The first officer was the pilot flying. As the aircraft passed by CYHK, the flight crew noted that, based on the weather reported by the airport's automated weather observation system, CYHK was still acceptable to use as an alternate airport. At 1319, when the flight was about 80 nautical miles (NM) from CYBB at flight level 210, the flight crew called the CYBB community aerodrome radio station. The flight crew received the runway surface condition report and were informed that the winds were from 200° true (T), at 24 kt gusting to 33 kt. At 1320, the community aerodrome radio station operator called the flight crew and relayed the CYBB 1300 weather observation, reporting that the horizontal visibility was ¼ statute mile (SM) in light snow and blowing snow and that the vertical visibility was 400 ft. The flight crew noted that the visibility had decreased since their departure from CYCB but continued the approach. The reported wind would result in a 12- to 16-kt crosswind component from the left on Runway 23. The captain took control at 1327 at the start of the descent and descent checks were carried out.

The captain transferred control back to the first officer at the initial approach waypoint, DATLA, and briefed for a pilot-monitored area navigation (RNAV) approach to Runway 23 (Figure 1). The final approach is flown on a track of 244°T, which is offset 15° from the runway heading of 229°T (Figure 1). When the runway is acquired visually at or before the minimum descent altitude (MDA), a left turn is required to align the aircraft with the runway heading.

During the descent, the flight crew activated the runway lights and the precision approach path indicator (PAPI) system via the aircraft radio control of airport lighting system (ARCAL). The captain set the flaps to the approach setting (40%) and the first officer flew the descent. When the captain then confirmed visual contact with the runway, snow was blowing across it at an angle from left to right. The runway itself was apparent as a black shape within the blowing snow; however, the runway lighting and PAPI were not observed. The captain set the flaps to the land setting (100%) and then, as part of the pilot-monitored approach procedure, assumed control of the aircraft as the pilot flying. The first officer looked up from the instruments and observed, through the blowing snow, the runway, as well as the community aerodrome radio station and airport apron ahead and off to the left.

The aircraft crossed the runway threshold at 100 kt indicated airspeed. As the captain flared the aircraft, the first officer warned the captain of snowbanks off to the right side of the runway.

At 1350, when the right main landing gear touched down, the aircraft veered to the right and departed the runway surface. The right wing contacted snowbanks and the aircraft turned approximately 90° to the right before colliding nose first with a high snowbank.

The aircraft was substantially damaged; however, the freight remained secure.

There were no injuries to the two flight crew members.

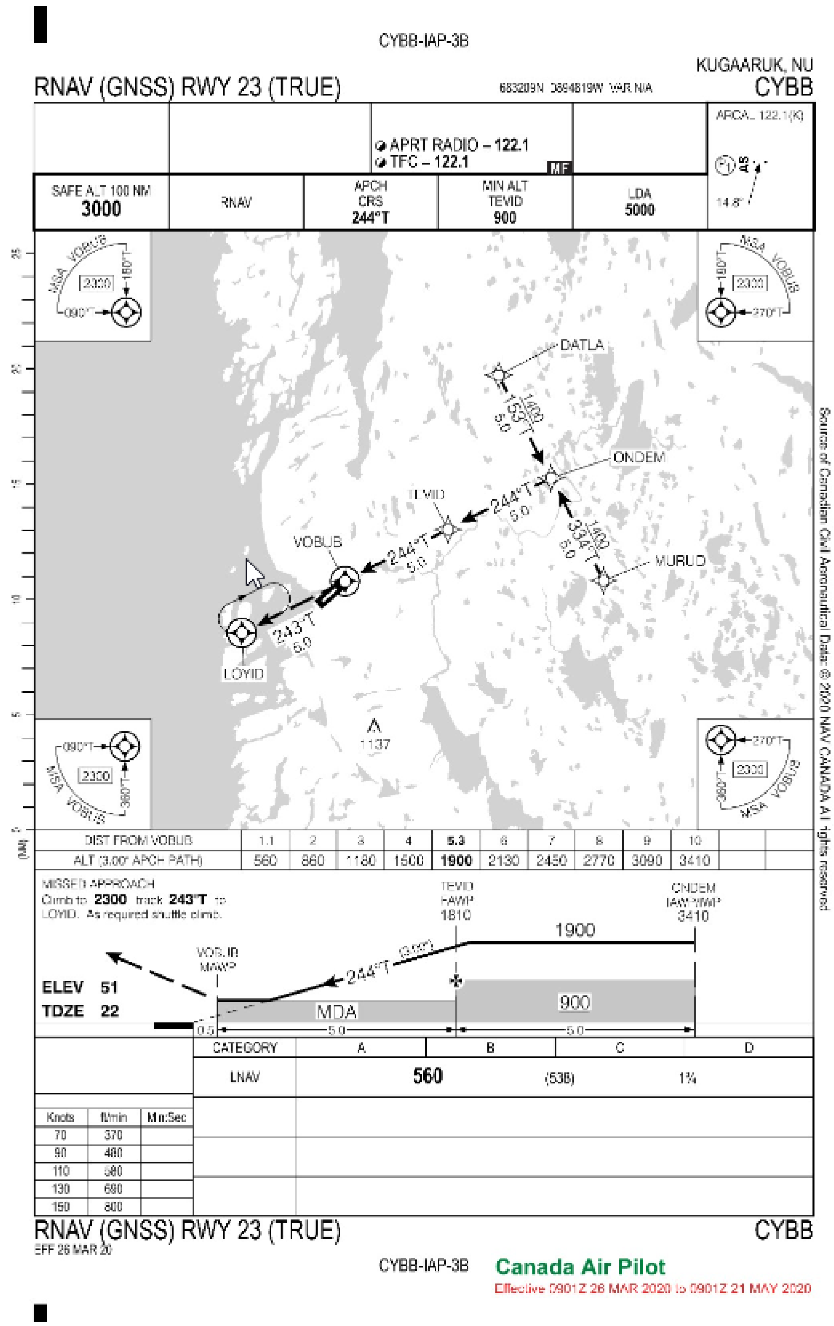


Figure 1. Approach chart for RNAV (GNSS) Runway 23 at Kugaaruk Airport (CYBB), Nunavut (not to be used for navigation purposes)

Damage to aircraft

The aircraft's fuselage, nose, engines, propellers, nacelles, flaps, wing centre section, and right wing spar were damaged (Figure 2).

Figure 2. Wreckage of the occurrence aircraft (Source: Third party, with permission)

Personnel information

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

Aircraft information

The Beechcraft King Air A100 is a pressurized, twin-engine, turboprop, fixed-wing aircraft manufactured by Beech Aircraft Corporation.

Records indicate that there were no outstanding defects at the time of the occurrence. There was no indication that a component or system malfunction played a role in this occurrence.

Meteorological information

In the early morning hours of 28 April 2020, winter storm conditions were present at CYBB and wind speeds began to increase at approximately 0500. Light snow, combined with blowing snow, produced poor visibility that made travel difficult within the hamlet and at the airport. These conditions persisted until after the occurrence.

When the first officer checked the weather during the stop at CYCB, the CYBB aerodrome forecast issued at 1146 was the following:

- from 1100 to 1700, winds from 200°T at 20 kt, gusting to 30 kt, visibility 1 SM in light snow and blowing snow, overcast ceiling at 2 000 ft; and
- temporarily from 1100 to 1700, visibility 3 SM in blowing snow, overcast ceiling at 2 500 ft.

The 1300 CYBB aerodrome routine meteorological report (METAR) provided to the flight crew at 1320 indicated the following:

- winds from 200°T at 24 kt, gusting to 33 kt
- visibility ¼ SM in light snow and blowing snow
- vertical visibility 400 ft

Approximately 10 minutes after the occurrence, the 1400 METAR indicated the following:

- winds from 200°T at 24 kt, gusting to 32 kt
- visibility ¼ SM in light snow and blowing snow
- vertical visibility 400 ft

Aerodrome information

CYBB is owned by the Government of Nunavut and is operated by the Nunavut Airports Division of the Department of Economic Development and Transportation.

There is no air traffic control tower at CYBB. Weather and aircraft advisory services are provided by the CYBB community aerodrome radio station on the 122.1 MHz mandatory frequency. The community aerodrome radio station is located approximately 1/5 SM from the threshold of Runway 23.

Runway 05/23

The runway at CYBB (Runway 05/23) is a 5 000-ft-long, 100-ft-wide gravel runway. The runway strip is graded to a width of 151 ft. Runway 23 is oriented to 229°T, and the threshold is 20 ft above sea level. Runway 23 is certified with an aerodrome operating visibility of ½ SM.

A runway surface condition report was issued on 28 April 2020 at 0808 that described the runway conditions as 70% bare and dry, and 30% dry snow over a trace of compacted snow.

Runway lighting

Runway 05/23 is equipped with runway threshold lights and runway end lights, which appear green and red respectively. The runway edge lights are white and pole-mounted 27 in. (70 cm) above the surface (this is higher than the standard 35 cm).

Aircraft radio control of aerodrome lighting

The airport lighting is controlled by an ARCAL type K system operating on 122.1 MHz. Keying a microphone seven times initially will turn the lighting on at maximum intensity for 15 minutes. The lighting intensity can be adjusted by keying the microphone seven, five, or three times within 5 seconds to select the high, medium, or low level, respectively.

Precision approach path indicator

Runway 05/23 is served by type P1 PAPIs, which are calibrated for aircraft with an eye-to-wheel height of up to 10 ft. The PAPI was activated automatically when the flight crew turned on the runway lights with the ARCAL system.

Winter maintenance

The Nunavut Airports Division's Winter Maintenance Plan is common to all airports operated by the Division. The Winter Maintenance Plan was prepared using TC Advisory Circular 302-013[1] as a guide.

Airport snow removal during blizzards is to be curtailed when the airport maintainer determines that travel to the airport is too hazardous, as was the case on the day of the occurrence. TC's Advisory Circular 302-013 recommends that, if successive hours or days of snowfall cause priority areas to exceed the snowbank slope limitations, the airport operator should indicate this by issuing a NOTAM.[2] The Winter Maintenance Plan does not contain this guidance, nor was a NOTAM issued.

[1] Transport Canada, Advisory Circular (AC) 302-013: *Airport Winter Maintenance and Planning, Issue 04* (31 October, 2018).

[2] Transport Canada, Advisory Circular (AC) 302-013: *Airport Winter Maintenance and Planning, Issue 04* (31 October 2018), section 4.4(3).

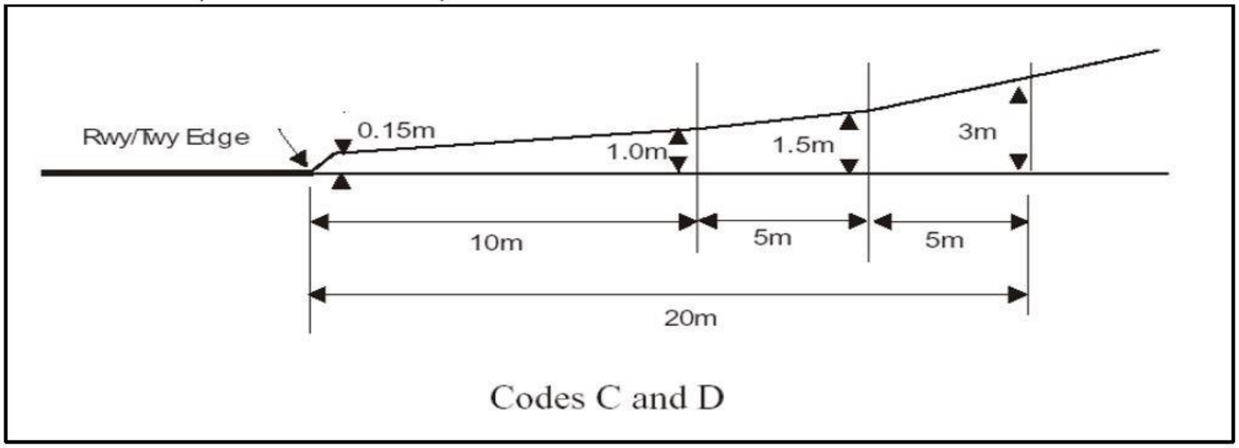


Figure 3. Maximum snow accumulation on the edge of a runway or taxiway for code C or D airports (Source: Transport Canada, Advisory Circular 302-013: Airport Winter Maintenance and Planning, *Appendix A)*

Wreckage and impact information

During the runway excursion, the aircraft turned almost 90° to the right when the right wing contacted a snowbank. The aircraft came to rest nose first against a high snowbank on the northwest side of Runway 23, approximately 1 900 ft past the threshold.

At the time of the occurrence, the snowbank height and proximity to the runway edge lights was in excess of TC guidance[3] in some areas along the length of the runway. Drifting snow that accumulated during the day appeared to have built up around, and as high as, the runway edge lights.

A photo of the runway was taken the day following the occurrence, after snow clearing had begun (Figure 4). Due to the presence of snowbanks along the runway, the only portion of the aircraft that is visible in the photo is the vertical stabilizer. The photo also shows that the snow accumulation along the runway is almost as high as runway edge lights, which are 27 in. high.

[3] Transport Canada, Advisory Circular (AC) 302-013: *Airport Winter Maintenance and Planning, Issue 04* (31 October 2018), Appendix A.

Figure 4. View toward the threshold of Runway 23
(Source: Third party, with permission and TSB annotations)

Additional information

Visibility published in the *Canada Air Pilot*

When the approach chart used by the occurrence flight crew was designed, the published advisory visibility for the RNAV (GNSS) approach to Runway 23 (True) was 1¾ SM. This was based on an aircraft's distance from the runway threshold when it reaches the MDA while flying the optimal descent slope of 3°. In all likelihood, this visibility should enable pilots to see the visual references required to proceed with the landing (see *Aerodrome operating visibility* of the report). However, in Canada, these published landing visibilities are provided for information purposes only and, as stated in the *Canada Air Pilot*, General Pages (CAP GEN), 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.

Operational approach and landing minima

The CAP GEN states that:

> CAR 602 specifies that landings are governed by published DH (decision height)/MDA. 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.

In Canada, minimum visibility is defined as a calculation that applies to all approaches but varies depending on the type of operation. This calculation, known as the approach ban, is applied to the published visibility (which is not limiting, but rather provided for information purposes only).

Approach ban

The approach ban's minimum visibility calculations are:

- 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 occurrence flight was conducted under commercial operations without Operations Specification 019. The minimum visibility calculation of ¾ of the 1¾ SM published visibility for the RNAV (GNSS) approach to Runway 23 (true) at CYBB would be 1½ SM. The CAP GEN lists the hierarchy that dictates which visibility report will take precedence in the calculation of the approach ban:

> A runway visual range (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.

However, the CAP GEN also states the following:

> Ground visibility will only impose an approach ban at aerodromes south of 60°N latitude.

Due to the fact that CYBB provides neither RVR nor runway visibility reports, and that the aerodrome is located north of 60°N latitude, there is no approach ban for any approach at CYBB, regardless of the reported ground visibility.

Aerodrome operating visibility

When deciding whether to conduct a flight, the pilot in command (PIC) of the aircraft must be satisfied that the conditions at the destination aerodrome are suitable for the intended operation. The PIC must ensure that the expected visibility falls within the aerodrome's certified operating visibility. When an aerodrome is certified for an operating visibility of less than ½ SM, RVR 2600, the limit is published in the runway section of 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, as is the case for CYBB, it means that operations are not authorized when visibility is less than ½ SM.

At aerodromes without an air traffic control tower, such as CYBB, the operating visibility for arrivals is determined in accordance with the following hierarchy:

- RVR for the runway of intended use
- ground visibility (METAR)

- visibility as determined by the pilot

The runways at CYBB are not equipped to measure RVR; therefore, the operating visibility is determined by ground visibility (from the METAR) or, in the absence of this report, by the visibility as determined by the pilot.

There are exceptions where a landing can occur below the published aerodrome operating visibility. At CYBB, there is no RVR installation, so these exceptions are limited to cases in which:

- the visibility report is received after the aircraft has passed the final approach waypoint inbound (TEVID).
- prior to 1 000 ft 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."

At the time of the occurrence aircraft's landing, the visibility (¼ SM) was below the aerodrome operating visibility for Runway 23 (½ SM).

Required visual reference for landing

Once it has been established that an approach is authorized based on approach ban criteria and the aerodrome operating visibility, an aircraft may descend below the MDA during the approach, provided that the visual references required by the pilot include at least one of the following references for the intended runway and are distinctly visible and identifiable to the pilot:

a. the runway or runway markings;
b. the runway threshold or threshold markings;
c. the touchdown zone or touchdown zone markings;
d. the approach lights;
e. the approach slope indicator system;
f. the runway identification lights;
g. the threshold and runway end lights;
h. the touchdown zone lights;
i. the parallel runway edge lights; or
j. the runway centre line lights.

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 defenses to mitigate the risk of an approach- or landing-related accident.

Visual illusions

To a pilot conducting an approach and landing into drifting snow, the aircraft may appear to be drifting sideways in a direction opposite to the blowing snow. To correct this apparent drift, the pilot might make control inputs that result in undue drift correction and could result in an off-runway landing. In crosswind conditions, the illusion can be described as a "moving runway."

Analysis

There was no indication of airframe, engine, or system malfunction during the occurrence flight. The aircraft was being operated within the allowable weight and centre-of-gravity limits, and the flight crew were certified and qualified for the flight in accordance with existing regulations.

Snow clearing

During much of March and April of 2020, the snowblower at Kugaaruk Airport (CYBB), Nunavut, was out of service. The airport's loader was also out of service on a number of occasions. In the absence of a working snowblower, the height of snowbanks that had accumulated close to the runway exceeded the limits published in CYBB's Winter Maintenance Plan.

On the day of the occurrence, the airport had been under winter storm conditions since about 0500, when the wind speed began to increase. Due to the reduced visibility, there was no active snow clearing taking place; consequently, snow drifts had built up around the runway edge lights and along the runway edges. There were also pre-existing snowbanks in close proximity to the runway edge lights.

Operating in low-visibility environments

In countries other than Canada, instrument flight rules (IFR) approaches are banned if the reported visibility is less than the applicable published visibility on the approach chart. However, in Canada, several rules and conditions associated with approach bans, along with exceptions to them, are published in the *Canada Air Pilot*, General Pages (CAP GEN).

The approach ban requirements based on the reported ground visibility of an aerodrome do not apply north of 60°N latitude. Therefore, in this occurrence, the approach was not prohibited even though the ground visibility was reported as ¼ statute mile (SM) at the time of the approach, which is well below the 1½ SM (¾ of the published visibility) that would have been required if the approach ban ground visibility was limiting north of 60°N latitude.

Finding as to causes and contributing factors

Approaches to airports north of 60°N latitude are not restricted by ground visibility and, as a result, the flight crew continued the approach when the reported visibility was ¼ SM, which is lower than the published advisory visibility of 1¾ SM for this approach.

Every aerodrome also establishes an operating visibility limit that is independent of the approach ban. 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, as is the case for CYBB, this means that operations are not authorized when visibility is less than ½ SM.

To determine whether an approach is permitted, the approach chart (in the CAP) and the approach ban criteria (in the CAP GEN) must be consulted. The runway section in the CFS must then be consulted to determine whether landings are authorized when visibility is less than ½ SM. Either the approach ban or an aerodrome's operating visibility can prevent authorization to conduct an approach or land at that aerodrome.

In this occurrence, the approach was authorized given the exception to the approach ban stipulating that the use of the reported ground visibility north of 60°N latitude was not required; however, the aerodrome operating visibility did not authorize landings since the prevailing visibility at the time of the landing was less than the ½ SM required for CYBB. The application of these two independent requirements can lead to confusion and give some pilots the impression that, if the approach ban is not in effect, landings are authorized without the need to take into account the aerodrome operating visibility requirements.

Finding as to causes and contributing factors

The flight crew believed that the lack of an approach ban permitted a landing and landed at CYBB even though the reported ground visibility was below the minimum aerodrome operating visibility.

Landing

During the later stages of the approach, the runway surface was visible through the drifting snow, but the runway lights and precision approach path indicator (PAPI) were not observed. Once the runway was visually acquired, a left turn was necessary to align the aircraft to the runway heading due to the 15° offset IFR approach. The pilot flying was also contending with a 12- to 16-kt crosswind component from the left, which was within the aircraft's maximum demonstrated crosswind of 25 kt. Snow blowing at an angle across the runway from left to right was likely creating a moving runway illusion, which made it appear to the pilot flying as though the aircraft was drifting sideways to the left in relation to the runway.

As the captain flared the aircraft for landing, the first officer's observation and warning to the captain of snowbanks in close proximity to the right wing of the aircraft indicated that the snow accumulation was unusual and unexpected. The aircraft then landed on the right side of the runway close to, or possibly outside, the runway edge.

As the aircraft continued further from the runway surface, the right wing contacted the high snowbanks observed by the first officer.

Findings

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. Approaches to airports north of 60°N latitude are not restricted by ground visibility and, as a result, the flight crew continued the approach when the reported visibility was ¼ SM, which is lower than the published advisory visibility of 1¾ SM for this approach.
2. The flight crew believed that the lack of an approach ban permitted a landing and landed at Kugaaruk Airport, even though the reported ground visibility was below the minimum aerodrome operating visibility.
3. The offset approach, the crosswind component from the left, and the moving-runway illusion created by the blowing snow all contributed to the aircraft's alignment with the right side of the runway.
4. The aircraft touched down near the right edge of the runway and, when the right landing gear impacted the deeper snow along the runway edge, the aircraft veered to the right and departed the runway surface.
5. The snow depth adjacent to the runway was allowed to exceed the limits dictated by the airport operator's Winter Maintenance Plan. Consequently, the aircraft sustained additional damage when it departed the runway surface.