Transportation Safety Board of Canada

Bureau de la sécurité des transports du Canada

# AIR TRANSPORTATION SAFETY INVESTIGATION REPORT A21W0001

## COLLISION WITH TERRAIN

Privately registered
Robinson R44 Raven II (Helicopter), C-FBGT
Grande Prairie, Alberta, 39 NM NE
01 January 2021

Canada

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## Summary

At 1941 Mountain Standard Time on 01 January 2021, the privately registered Robinson Helicopter Company R44 Raven II helicopter (registration C-FBGT, serial number 13801) departed a farm 6 nautical miles south of Eaglesham/Delta Tango Field Aerodrome, Alberta, on a night visual flight rules flight to DeBolt, Alberta, approximately 30 nautical miles to the south-southwest. The pilot and 3 passengers were on board. At approximately 1954 Mountain Standard Time, the helicopter collided with terrain 10 nautical miles southwest of Eaglesham, Alberta (25.5 nautical miles northeast of DeBolt). The 4 occupants were fatally injured. The helicopter was destroyed and there was a post-impact fire. An emergency locator transmitter signal was received by the search and rescue satellite system.

## 1.0 FACTUAL INFORMATION

### 1.1 History of the flight

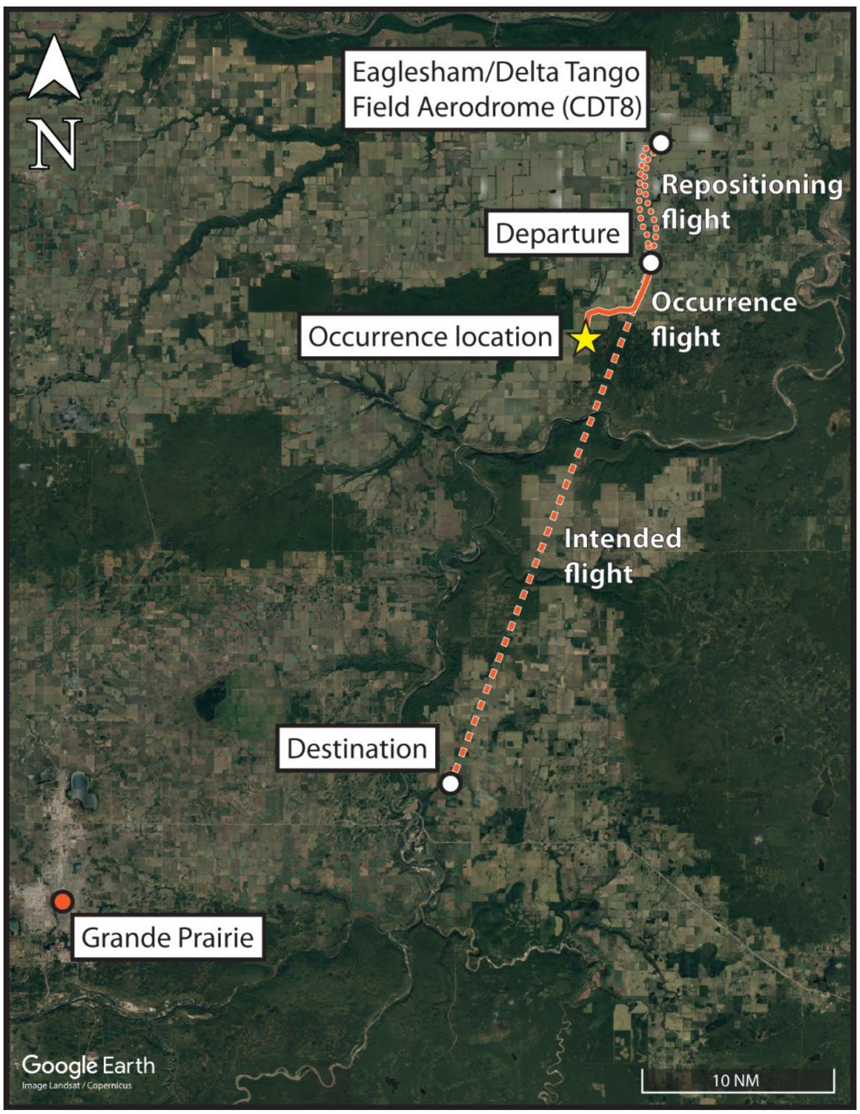
In the early afternoon on 01 January 2021, the privately registered Robinson Helicopter Company (RHC) R44 Raven II helicopter (registration C-FBGT, serial number 13801) departed a residence near DeBolt, Alberta, with the pilot and 3 family members—1 adult and 2 children—on board, on a visual flight rules (VFR) flight to a family farm near Eaglesham, Alberta, approximately 30 nautical miles (NM) to the north-northeast. The helicopter landed at the farm at approximately 1400[1] and the pilot's family members got out of the helicopter. The pilot then flew the helicopter approximately 1 NM north, to store it in a heated hangar at a private airstrip.

1 All times are Mountain Standard Time (Coordinated Universal Time minus 7 hours).

The pilot and his family stayed at the farm until the early evening. During the course of the day, the pilot was asked by family members on several occasions if the weather was going to be acceptable for the return flight that evening. The pilot replied that he had checked the weather on his phone and the weather was going to be fine for the return flight. The investigation was not able to determine with certainty the source of the pilot's weather information or which weather products he had viewed.

At approximately 1920, during the hours of darkness, the pilot pulled the helicopter out of the heated hangar and conducted the pre-flight inspection. Then, the pilot and 2 adult passengers boarded the helicopter and departed for a local night VFR flight to reposition the helicopter back to the family farm. The short 6-NM flight to the north took them over the Eaglesham/Delta Tango Field Aerodrome (CDT8), Alberta, and back to the farm where the pilot's family was waiting for him (Figure 1).

**Figure 1. Map showing the repositioning flight (dotted line), the intended flight path (dashed line) and the actual flight path (solid line) (Source: Google Earth, with TSB annotations)**



The helicopter approached the farm from the southwest and landed in a parking area at 1936. The pilot and 2 passengers got out while the helicopter remained running. Several minutes later, the pilot and the same 3 passengers as the flight in the early afternoon—1 adult and 2 children—boarded the helicopter. At 1941, the helicopter departed to the south, heading to their residence near DeBolt, approximately 30 NM to the south-southwest. The ground elevation of the point of departure was approximately 1853 feet above sea level (ASL).

Upon departure, the helicopter initially flew on a direct track (approximately 204° magnetic [M]) to the destination for 2.45 NM. During this segment of the flight, the helicopter reached its highest altitude (2364 feet ASL). At 1943:43, the helicopter's track changed to the west, to approximately 270°M, for 2.3 NM. Between 1945:23 and 1945:52, the helicopter descended at a rate of up to 1049 fpm to an altitude of 2081 feet ASL. The ground elevation was 1970 feet ASL at this point. The helicopter then climbed back up to 2279 feet ASL. At 1946:40, the helicopter's track changed back to a south-southwest direction (approximately 188°M). At 1948:21, the helicopter began a 360° turn to the left. At this point, control of the helicopter was lost and, 8 seconds later, it collided with terrain.

At approximately 1954, a signal from the occurrence helicopter's emergency locator transmitter (ELT) was detected by the Canadian Mission Control Centre and that information was relayed to the Joint Rescue Coordinate Centre (JRCC) in Trenton, Ontario.

JRCC Trenton informed the pilot's family members of the ELT transmission at approximately 2010. A private search was initiated using a Cessna 182 aircraft and an RHC R66 helicopter. The Cessna 182 took off at approximately 2020 from the private airstrip 1 NM north of the family farm near Eaglesham. Several minutes later, the pilot of the Cessna 182 noticed the post-impact fire in an open field approximately 5 NM to the southwest and returned to the airstrip.

First responders were on scene by 2122. RCMP (Royal Canadian Mounted Police) arrived on scene at 2158.

## 1.2 Injuries to persons

The pilot and 3 passengers were fatally injured.

**Table 1. Injuries to persons**

| Degree of injury | Crew | Passengers | Persons not on board the aircraft | Total by injury |
|---|---|---|---|---|
| Fatal | 1 | 3 | – | 4 |
| Serious | 0 | 0 | – | 0 |
| Minor | 0 | 0 | – | 0 |
| Total injured | 1 | 3 | – | 4 |

## 1.3 Damage to aircraft

The helicopter was destroyed as a result of impact forces and the post-impact fire.

## 1.4 Other damage

Except for ground scars and some small fuel and oil spills, there was no property damage in the area surrounding the accident site.

## 1.5 Personnel information

Records indicate that the pilot held the appropriate licence and rating for the occurrence flight in accordance with existing regulations.

The pilot had purchased the occurrence helicopter in October 2018 and started training for a private pilot licence — helicopter in the same month. He received his licence in January 2019 and obtained a night rating in March 2019. According to the pilot's personal log, he had accumulated 624.75 hours in the occurrence helicopter, which included 41 hours of night flying and 10.1 hours of simulated instrument time before the occurrence. The last helicopter flight recorded in his personal log was on 05 December 2020.

On 15 December 2020, the pilot obtained his private pilot licence — aeroplane. According to the pilot's personal log, he had accumulated 43.7 hours of dual flight time and 26.8 hours as pilot-in-command (PIC) in a fixed-wing aircraft. His last recorded flight in a fixed-wing aircraft was on 19 December 2020.

To carry passengers on a night flight, Transport Canada (TC) requires that the licence holder conduct 5 takeoffs and 5 landings at night within the preceding 6 months.[2] In the 6 months before the occurrence, the pilot had flown 8.5 hours at night on 5 separate dates and had conducted at least 5 takeoffs and 5 landings.

The pilot had flown to Eaglesham on several occasions since obtaining his helicopter pilot licence in January 2019. Details from both the helicopter's journey log and the pilot's personal log show 10 flights to Eaglesham, including 1 night flight. The pilot was familiar with northern and central Alberta as most of his flying was conducted in this region.

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2 Transport Canada, SOR/96-433, *Canadian Aviation Regulations*, clause 401.05(2)(b)(i)(B).

**Table 1. Personnel information**

| | |
|---|---|
| Pilot licence | Private pilot licence — helicopter, private pilot licence — aeroplane |
| Medical expiry date | 01 November 2022 |
| Total flying hours | 695.25 |
| Flight hours on type | 624.75 |
| Flight hours in the 7 days before the occurrence | Unknown* |
| Flight hours in the 30 days before the occurrence | 13.34 |
| Night flight hours in the 30 days before the occurrence | 3.44 as PIC (helicopter)<br>1.6 as PIC (fixed-wing)<br>5.1 dual flight (fixed-wing) |
| Flight hours in the 90 days before the occurrence | 55.99 |
| Flight hours on type in the 90 days before the occurrence | 48.09 |
| Night flight hours on type in the 90 days before the occurrence | 7.2 as PIC |

* The pilot's personal log was last updated on 19 December 2020. The aircraft journey log book was last updated on 05 December 2020. It is not known if the helicopter was flown in the 7 days preceding the accident.

## 1.6 Aircraft information

### 1.6.1 General

The RHC R44 II is a 4-seat helicopter with a maximum gross weight of 1134 kg (2500 pounds). The helicopter had no known deficiencies before the occurrence flight and was operating within its weight-and-balance limits.

The helicopter was equipped with the following flight instruments: a vertical speed indicator, an electronic attitude indicator, an airspeed indicator, an altimeter, and a clock. The helicopter was not, however, equipped with all the required instrumentation for night VFR flight, as stipulated in section 605.16 of the *Canadian Aviation Regulations* (CARs). For example, the CARs include the requirements that aircraft be equipped with either a turn and slip indicator or a turn coordinator and, when the aircraft is flown in an area where no aerodrome can be seen from the aircraft, either a stabilized magnetic direction indicator or a gyroscopic direction indicator. At the time of the occurrence, the helicopter was not equipped with these instruments.

The aircraft was equipped with an Appareo Stratus 2S battery-operated portable receiver. The receiver works with the ForeFlight Mobile app to provide pilots with a source of GPS (global positioning system) position data, automatic dependent surveillance–broadcast weather information (where available), traffic information, and other related data. The investigation could not determine which of these services the pilot was using during the flight. The receiver also functions as an attitude heading reference system, a flight data recorder, and a pressure altitude sensor.

**Table 3. Aircraft information**

| | |
|---|---|
| Manufacturer | Robinson Helicopter Company |
| Type, model and registration | R44 Raven II, C-FBGT |
| Year of manufacture | 2015 |
| Serial number | 13801 |
| Certificate of airworthiness issue date | 08 March 2015 |
| Total airframe time | 939.35 hours |
| Engine type (number of engines) | Textron Lycoming IO-540-AE1A5 (1) |
| Rotor type (number of rotor blades) | Semi-Rigid (2) |
| Maximum allowable take-off weight | 1134 kg |
| Recommended fuel types | 100, 100LL, 100VLL, UL91, UL94 |
| Fuel type used | 100LL |

### 1.6.2 Pitot-static system

The pitot-static system consists of a pitot tube on the forward lower edge of the mast fairing above the cabin and static ports on the sides of the fuselage aft of the rear doors. The pitot tube and static ports supply the air pressure needed to operate the airspeed indicator, altimeter, and vertical speed indicator.

Records indicate that the occurrence helicopter was not equipped with a heated pitot tube; it was not required to be by regulation. A heated pitot tube kit is available from RHC.

### 1.6.3 Changes to flight instruments

The aircraft was delivered from the manufacturer without some of the required instruments for night VFR flight. Shortly after the aircraft was acquired in 2018, a stabilized magnetic direction indicator, turn coordinator, and an attitude indicator were installed while the pilot was in training for his night VFR rating. In April 2019, the turn coordinator and stabilized magnetic direction indicator were removed and installed on another aircraft.

## 1.7 Meteorological information

### 1.7.1 Forecast weather

The nearest available aerodrome forecast (TAF) to the point of departure was issued for the Peace River Airport (CYPE), Alberta, 35 NM to the northeast. The most recent TAF was issued on 01 January 2021 at 1738 and was valid from 1800 to 0600 (02 January 2021). It forecast the following conditions for the time of the flight:

- winds from 020° true (T) at 12 knots
- visibility 1 ½ statute miles (SM)
- light snow and mist
- overcast ceiling at 2000 feet above ground level (AGL)
- temporarily between 1800 and 0300

    - visibility 6 SM
    - light snow

The nearest available TAF to the destination was issued for the Grande Prairie Airport (CYQU), Alberta, 24 NM west-southwest of the destination. The TAF was issued on 01 January 2021 at 1738 and was valid from 1800 to 0600 (02 January 2021). It forecast the following conditions for the time of the flight:

- winds 070°T at 8 knots
- visibility greater than 6 SM
- overcast ceiling at 12 000 feet AGL
- becoming between 2100 and 2300
    - winds variable at 3 knots

The graphic area forecast (GFA) for the Prairies Region was issued on 01 January 2021 at 1625 and was valid from 1700 to 0500 (02 January 2021)(Appendix A). It indicated that the Grand Prairie and Peace River areas were forecast to be under the influence of an upper warm front that was moving northeasterly at 20 knots. Weather ahead (east) of the front featured cloud bases at 3000 to 4000 feet ASL with tops at 22 000 feet ASL, giving visibilities of 1 to 3 SM in light snow showers with occasional visibilities of ½ SM in snow showers with patchy cloud ceilings of 800 to 1500 feet AGL. Behind (west of) the upper warm front, the weather was forecast to have scattered clouds with bases at 4000 feet ASL and tops at 6000 feet ASL.

The GFA icing, turbulence, and freezing level chart issued on 01 January 2021 at 1625, valid from 1700 to 0500 (02 January 2021) (Appendix B), indicated a large area of moderate mixed icing from 3000 to 4000 feet ASL through 14 000 feet ASL ahead of the warm front.

### 1.7.2 Actual weather

The nearest available aerodrome routine meteorological report (METAR) to the point of departure was issued at CYPE. The METAR issued at 1900 indicated the following:

- winds from 010°T at 12 knots
- visibility 15 SM
- light snow
- overcast ceiling at 1700 feet AGL
- temperature −07 °C
- dew point −08 °C
- altimeter 29.42 inches of mercury (inHg)

The nearest available METAR to the destination was issued at CYQU. The METAR issued at 1900 indicated the following:

- winds from 060°T at 7 knots
- visibility 25 SM

- broken ceiling at 12 000 feet AGL
- overcast cloud layer at 17 000 feet AGL
- temperature −06 °C
- dew point −07 °C
- altimeter 29.31 inHg

Shortly after the accident, an RHC R66 helicopter departed a private residence to search for the accident site. The pilot of that helicopter noted that during approximately 20 minutes of flying time northeast of CYQU, there was a layer of cloud below him. The helicopter was flying at 1500 feet AGL, and the pilot estimated the cloud layer to be between 800 feet and 1000 feet AGL.

The intended route of flight was in uncontrolled airspace. According to the CARs,[3] for helicopters operating in uncontrolled airspace at night in accordance with VFR, the visibility must be not less than 3 SM. If the helicopter is operating at altitudes above 1000 feet AGL, it must maintain a distance of at least 2000 feet horizontally and 500 feet vertically from cloud, and if operating at altitudes less than 1000 feet AGL, it must remain clear of cloud.

### 1.7.3 Ground observations

The RCMP drove from the Spirit River, Alberta, detachment to the accident site, approximately 30 NM away, and arrived on scene at 2158, 2 hours and 4 minutes after the accident. On the way to the accident site, they drove in and out of low cloud. Approximately 1 hour after they arrived on site, occasional precipitation in the form of mixed snow, rain, and freezing rain began to fall.

### 1.7.4 Post-occurrence assessment

Following the occurrence, the TSB requested that Environment and Climate Change Canada complete a meteorological assessment. The following information is taken from that assessment.

Between 1700 and 2300 on 01 January 2021, a pacific frontal system was moving northeast across British Columbia (BC) and into west-central and northern Alberta. This system was producing widespread and continuous snow and snow showers over most of central BC as well as northern sections of Peace River County, Alberta. There was a surface pressure trough extending from the Fort St. John, BC, area southeast towards southeast Alberta. There was a ridge of high pressure over Great Slave Lake, Northwest Territories. Grande Prairie had fair conditions through the evening with winds less than 10 knots and ceilings generally above 10 000 feet. This is expected given that Grande Prairie is located in an area of subsidence of the Rocky Mountains, where descending air in the lee of the mountains dries and there is a break in precipitation and cloud.

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3 Transport Canada, SOR/96-433, *Canadian Aviation Regulations*, section 602.115.

The observations from Peace River indicated a significantly different air mass than Grande Prairie. Peace River had continuous snow through the evening with a couple of instances of rapidly deteriorating conditions and low visibilities. Specifically, snow resulted in visibilities less than 3 SM from 1706 through 1838 as well as from 2037 through 2100. These periods of lower visibilities were indicative of convection occurring within the air mass.

Conditions between Grande Prairie and Peace River were highly varied with fair conditions in Grande Prairie and deteriorating conditions towards Peace River. Low-level winds in the region would not have varied that significantly in speed through the evening; however, their direction would have gradually changed as the low developed. Satellite and radar data indicate the presence of convective development at the time of the occurrence. Convective snow can rapidly reduce visibilities as well as ceilings; it can also lead to significant turbulence and icing conditions. Furthermore, conditions at Peace River indicated that convection was occurring given that the visibilities dropped on 2 occasions during the period from 1700 to 2300. Notably, the 2037 observation indicated that visibilities had dropped to 1½ SM approximately 40 minutes after the accident. These conditions suggest that the helicopter may have experienced a similar rapid reduction to prevailing visibility and ceilings during the flight. Convective development also has the potential to produce significant turbulence and/or icing conditions over a small geographical area, which may have had an effect on the helicopter during its flight.

## 1.8 Aids to navigation

Not applicable.

## 1.9 Communications

Not applicable.

## 1.10 Aerodrome information

Not applicable.

## 1.11 Flight recorders

The occurrence helicopter was not equipped with a flight data recorder or a cockpit voice recorder, nor was it required to be by regulation. However, the helicopter's Stratus 2S receiver recorded several parameters of data. The receiver was sent to the TSB Engineering Laboratory in Ottawa, Ontario, where the recorded flight path data was successfully recovered.

## 1.12 Wreckage and impact information

### 1.12.1 General

The wreckage was located in an open snow-covered farm field. There were no trees or other obstacles in the vicinity of the accident site. The helicopter came to rest less than 30 feet from the initial point of impact. All of the helicopter's components were located and identified within a 100-foot radius of the aircraft (Figure 2).

Figure 2. Photo of the occurrence site (Source: TSB)

The left side of the airframe sustained impact damage. The right fuel tank was consumed by the fire. The left fuel tank was located 25 feet from the main wreckage and contained approximately 10 U.S. gallons of fuel.

Most of the cockpit and cabin area were consumed by fire, making it impossible to establish flight control continuity. All flight control input components were accounted for, except for those made of aluminum, which were consumed by the fire in the cabin and pylon area.

The engine had broken away from its mounts in the airframe, resulting in damage to the oil sump, accessory case, and associated components. Engine controls were severed during the impact sequence.

The main rotor severed the tail boom in front of the horizontal stabilizer during the impact sequence, which also severed the tail rotor drive shaft and tail rotor pitch control shaft. The main rotor transmission and mast had broken away from the airframe. The main rotor assembly was still mounted to the mast, and the mast to the transmission. The main rotor blades showed distortion from contact with the ground and the tail boom.

Ice was observed on the leading edge of one of the rotor blades. This ice was not consistent in shape and color with ice associated with in-flight icing. Water had been used by first responders to put out the post-impact fire.

### 1.12.2 Annunciator lights

The caution lights from the occurrence helicopter's instrument panel were analyzed at the TSB Engineering Laboratory in Ottawa, and it was determined that the following lights were likely illuminated at the time of the impact: the alternator light, the full-throttle light, and the low-rotor light.

The helicopter is supplied electrical power by a 28 V system, which includes a battery and an alternator. If voltage drops to a range of 24 to 26 V, the alternator annunciator light illuminates to warn of low voltage or possible alternator failure.

The full-throttle annunciator light "is activated by a switch in the throttle linkage and indicates that the engine is near full throttle."[4]

The low-rotor caution system comprises the light and a horn. The low-rotor annunciator light illuminates when the rotor rpm is below 97%.[5] When the main rotor rpm falls below 97%, increasing collective (an increase in main rotor blade pitch angle) will continue to reduce main rotor rpm if there is not enough power from the engine to meet the increased power demand. Engine rpm will also decrease because there is not enough engine power to overcome the increased drag produced by the main rotor blade.

### 1.12.3 Alternator and engine component testing

The alternator and engine were examined at a TC-approved engine repair facility, with the TSB in attendance. The alternator was tested and it was determined that it would have been functional at the time of the accident. The investigation could not determine what caused the alternator light to be illuminated before impact.

Nothing was found in the engine that would have impaired its operation or prevented it from developing rated power. The fuel servo throttle plate was found in the full open position, which is associated with full-power throttle setting and is consistent with the full-throttle light.

## 1.13 Medical and pathological information

There was nothing to indicate that the pilot's performance was degraded by medical or pathological factors.

## 1.14 Fire

The post-impact fire burned for approximately 1.5 hours after the accident. The fire was mainly in the cabin area and consumed most of the seats and some aluminum components and structure. The fire was fed by the ruptured right fuel tank. The source of ignition could not be conclusively determined; however, it was most likely an arcing electrical source or hot engine components.

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4 Robinson Helicopter Company, *RH44 II Pilot's Operating Handbook and FAA Approved Rotorcraft Flight Manual* (11 May 2020), Section 7: Systems Description, p. 7-25.

5 The Robinson R44 II Pilot Operating Handbook lists the maximum rotor speed limit with power on as 102%, and the minimum as 101%. (Source: Ibid., Section 2: Limitations, p. 2-2.)

## 1.15 Survival aspects

In this occurrence, the pilot was not wearing an aviation helmet, nor was he required to by regulation. The pilot and passengers were secured by the available lap belts and shoulder harnesses. The accident was not survivable.

### 1.15.1 Emergency locator transmitter

The occurrence helicopter's 406-MHz ELT[6] activated upon impact. The ELT initially transmitted 1 distress signal data burst and, although, it was eventually consumed by the post-impact fire, it transmitted 1 additional signal 30 minutes after the initial one.

## 1.16 Tests and research

### 1.16.1 TSB laboratory reports

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

- LP005/2021 – Warning And Caution Lamps Analysis
- LP006/2021 – Instruments Analysis
- LP009/2021 – NVM Data Recovery – iPad
- LP063/2021 – NMV Data Recovery – Stratus
- LP077/2021 – Flight Animation
- LP082/2021 – Crankshaft Dowel Pin Examination

## 1.17 Organizational and management information

Not applicable.

## 1.18 Additional information

### 1.18.1 Pilot decision making

Pilot decision making (PDM) 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.

6 Kannad Integra AF.

According to an educational package from TC,[7] PDM is a function of time, so that before the flight, there is “ample-time decision making,” and while in flight, in a dynamic environment, there can be “time-critical decision making.”[8]

Thorough and timely flight planning allows for ample-time informed decisions on the ground to avoid the need for potentially more difficult in-flight decisions. Flight planning in regards to weather is particularly important for night VFR flights considering the inherent risks when encountering adverse weather. For example, when planning a night VFR flight, it is critical to obtain relevant timely weather data to make an informed decision to conduct the flight or not, and if the decision is made to undertake the flight, it can reduce the risk of flying inadvertently from VFR conditions into instrument meteorological conditions (IMC).[9] Several factors, contextual circumstances, and biases can affect PDM, including the flight objective or goal, and the pilot’s knowledge, experience, and training.[10]

Mental models are an intrinsic component of decision making. They are internal representations that allow an individual to describe, explain, and predict events or situations in their environment.[11] When a mental model is adopted, it generates expectations and is resistant to change. Compelling new information must be absorbed to modify a mental model.

### 1.18.2 Flight planning

Section 602.71 of the CARs requires that “[t]he pilot-in-command of an aircraft shall, before commencing a flight, be familiar with the available information that is appropriate to the intended flight.”[12] In addition, section 602.72 of the CARs requires that “[t]he pilot-in-command of an aircraft shall, before commencing a flight, be familiar with the available weather information that is appropriate to the intended flight.”[13]

#### 1.18.2.1 NAV CANADA

NAV CANADA provides flight planning and weather information services to pilots. These services can be obtained on the internet or by calling a flight information centre by phone or

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7 Transport Canada, TP 13897, *Pilot Decision Making – PDM*, at https://www.tc.gc.ca/eng/civilaviation/publications/tp13897-menu-1889.htm (last accessed on 24 February 2022).

8 Ibid.

9 Instrument meteorological conditions means “meteorological conditions less than the minima specified in Division VI of Subpart 2 of Part VI for visual meteorological conditions, expressed in terms of visibility and distance from cloud.” (Source: Transport Canada, SOR/96-433, *Canadian Aviation Regulations*, subsection 101.01(1).)

10 M.R. Endsley, “Toward a Theory of Situation Awareness in Dynamic Systems,” in *Human Factors*, Vol. 37, No. 1 (1995), pp. 32–64.

11 E. Salas, and D. Maurino, *Human Factors in Aviation*, 2nd edition (Academic Press, 2010), p. 266.

12 Transport Canada, SOR/96-433, *Canadian Aviation Regulations*, section 602.71.

13 Ibid., section 602.72.

over the aircraft's radio. Flight service specialists interpret and provide comment on the weather data to help pilots make informed decisions about their route based on the weather.

NAV CANADA records all services it provides, including information provided over the phone. There are no NAV CANADA records to indicate that the occurrence pilot contacted a flight information centre by phone to obtain a weather briefing or to file a flight plan before the occurrence flight.

#### 1.18.2.2 Web-based flight planning tools

Various web-based flight planning tools are available to pilots—be they private pilots or commercial pilots—to gather weather and airport information efficiently. Many of these tools are available as mobile apps, which can be used to plan the route and file a flight plan, to access and manage electronic charts and maps, to organize flight publications, and as a reference to en-route navigation aids.

The investigation could not determine which, if any, web-based flight planning tools the pilot used before the occurrence flight.

### 1.18.3 Spatial disorientation

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 3-dimensional environment of flight, and conflicts may arise between the senses and illusions, thus making it difficult or impossible to maintain spatial orientation. Pilot spatial disorientation 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."[14]

Humans process information from 3 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).[15]

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 2 systems is less precise

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14 Australian Transport Safety Bureau, ATSB Transport Safety Investigation Report – Aviation Research and Analysis Report – B2007/0063, *An overview of spatial disorientation as a factor in aviation accidents and incidents* (Canberra City, Australia, 2007), p. vii, at https://www.atsb.gov.au/publications/2007/b20070063.aspx (last accessed on 24 February 2022).

15 Ibid., p. 4.

and more susceptible to error because they are prone to illusions and misinterpretation.[16] When visual cues from the ground are poor or non-existent, spatial disorientation can be overcome by referring to flight instruments to control the aircraft's position.[17]

To avoid a loss of control, pilots must be familiar with the mechanisms that lead to spatial disorientation, be aware of the potential for disorientation when visibility and ground references are reduced, and understand how to handle such a situation.[18]

The *Transport Canada Aeronautical Information Manual* (TC AIM) describes the potential for disorientation. It refers to vision as our strongest orienting sense and stresses that when in whiteout or cloud, this sense is not available, which increases the likelihood of disorientation. It provides the following example:

> For example, once a turn has been entered and is being maintained at a steady rate, the sensation of turning will disappear. Upon recovering from the turn, pilots may feel as though they are turning in the opposite direction and erroneously re-enter the turn, even causing the aircraft to enter into a spin or spiral.[19]

While the conditions mentioned are whiteout and cloud, a similar lack of external visual cues and resultant disorientation can occur in darkness. Spatial disorientation can lead to loss of control of the aircraft or controlled flight into terrain.[20]

### 1.18.4 Night visual flight

Night flying involves numerous risks owing to poor visual cues, especially on takeoff and landing. The fact that there are few or no visual references at night can lead to various illusions causing spatial disorientation due to the lack of discernible horizon. Night flying in, out of, or over featureless terrain, such as bodies of water or forest, is difficult. These areas are referred to as black holes.

Flying VFR at night is more hazardous than flying VFR during the day due to human vision limitations, the potential absence of external visual cues, and vulnerability to illusions. Estimating distance from cloud and adverse weather at night or in darkness is difficult for pilots and increases the risk of inadvertent VFR flight into IMC, which can quickly result in spatial disorientation and a loss of control.

Simply put, night VFR flight inherently offers the pilot limited visual cues to be able to see and avoid worsening weather conditions. Flight planning is especially important for night

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16 Ibid.

17 Ibid, p. 25.

18 Ibid., p. 23.

19 Transport Canada, TP 14371, *Transport Canada Aeronautical Information Manual* (TC AIM), AIR – Airmanship (08 October 2020), section 3.7: Disorientation.

20 Australian Transport Safety Bureau, ATSB Transport Safety Investigation Report – Aviation Research and Analysis Report – B2007/0063, *An overview of spatial disorientation as a factor in aviation accidents and incidents* (Canberra City, Australia, 2007), at https://www.atsb.gov.au/publications/2007/b20070063.aspx (last accessed 24 February 2022).

flights: specifically, a review of weather conditions and their corresponding impact on the intended aircraft track; the available moonlight; the estimated flight time over large bodies of water or areas with little or no cultural lighting; and the flight path's proximity to rising terrain and significant obstacles.

While in flight, it is important for pilots to obtain weather updates and compare visual weather indications at regular intervals for visibility and proximity to cloud against expectations established in the flight-planning phase. Because it is difficult to visually detect and stay clear of terrain and obstacles at night, it is critical that pilots plan and maintain flight at altitudes above the published maximum elevation figure on VFR charts.

#### 1.18.4.1 Visual reference to the surface

The principle behind VFR flight is that the pilot uses visual cues (e.g., visual horizon, ground references) outside the aircraft to determine the aircraft's attitude. Therefore, some basic requirements must be met when conducting VFR flight—day or night.

According to CARs 602.114 and 602.115, the aircraft must be "operated with visual reference to the surface,"[21] regardless of whether it is operated in controlled or uncontrolled airspace. The CARs define surface as "any ground or water, including the frozen surface thereof."[22] However, the term "visual reference to the surface" is open to interpretation, because it is not defined in the regulations. Industry has widely interpreted it to mean visual meteorological conditions (VMC).[23,24]

In addition to the requirements for visual reference to the surface, the regulations also prohibit the operation of an aircraft under VFR at night in areas where flight visibility or ground visibility, if it is reported, is less than 3 SM.[25]

Therefore, a flight conducted over an area with less than 3 SM visibility or away from cultural lighting and where there is inadequate ambient illumination to have visual reference to the surface would not meet the requirements for operation under night VFR. Instead, such flight would require pilots to rely on their flight instruments to ensure safe operation of the aircraft.

Following a TSB investigation[26] into a helicopter accident in May 2013 where the VFR flight had departed under night VMC from a remote airport with minimal nearby lighting, the TSB

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21 Transport Canada, SOR/96-433, *Canadian Aviation Regulations*, sections 602.114 and 602.115.

22 Ibid., subsection 101.01(1).

23 Visual meteorological conditions means "meteorological conditions equal to or greater than the minima specified in Division VI of Subpart 2 of Part VI, expressed in terms of visibility and distance from cloud." (Source: Ibid.)

24 The Federal Aviation Administration's *Code of Federal Regulations* does not state requirements for visual flight rules aircraft to be operated with visual reference to the surface.

25 Transport Canada, SOR/96-433, *Canadian Aviation Regulations*, sections 602.114 and 602.115.

26 TSB Aviation Investigation Report A13H0001.

raised concerns with the lack of clarity in the practical meaning of the definition of a "flight with visual reference to the surface." The Board recommended that

> The Department of Transport amend the regulations to clearly define the visual references (including lighting considerations and/or alternate means) required to reduce the risks associated with night visual flight rules flight.
>
> **TSB Recommendation A16-08**

In its most recent response to this recommendation, TC informed the TSB that it published an updated version of Advisory Circular (AC) 603-001 – *Special Authorization for Night Vision Imaging Systems Operations*. This AC includes the new language that will form the basis of the Notice of Proposed Amendment (NPA) to night VFR requirements and conditions for night vision imaging system operations.

TC also published NPA 2021-007 – *Minimum Visual Meteorological Conditions for VFR Flight - Sections 602.114 and 602.115 of the* Canadian Aviation Regulations for consultation on the Canadian Aviation Regulation Advisory Council website. TC anticipates that comments on this NPA may lead to several other NPAs addressing related issues in Part IV, Part VI, and Part VII of the CARs. TC anticipates that the NPAs will be published in the *Canada Gazette*, Part I mid-2022.

The Board's most recent published assessment of TC's response to Recommendation A16-08 was completed in March 2022 and was rated as **Satisfactory Intent**.[27]

Since May 2013, the TSB has investigated 7 other fatal accidents involving private aircraft on night VFR flights; these reports have highlighted the lack of clarity in the regulations regarding visual references.[28]

## 1.19 Useful or effective investigation techniques

Not applicable.

[27] For further details relating to this recommendation, along with Transport Canada's responses to the recommendation and the TSB's assessment of these responses, visit https://www.bst-tsb.gc.ca/eng/recommandations-recommendations/aviation/2016/rec-a1608.html (last accessed 24 February 2022).

[28] TSB air transportation safety investigation reports A19Q0153, A19O0178, A19O0026, A18Q0016, A17O0209, A15O0188, and A14O0217.

## 2.0 ANALYSIS

There was no indication that an aircraft system malfunction contributed to this collision with terrain.

The analysis will focus on the factors that contributed to the accident: flight planning, and more specifically the pilot's awareness of the weather; pilot decision making; night flight regulations; spatial disorientation; and helicopter equipment required for night visual flight rules (VFR) flying.

### 2.1 Flight planning – available weather information

Many sources of weather information are available to pilots when planning a flight. Before departing on a VFR flight, it is important for pilots to review all relevant weather reports and forecasts. This thorough flight planning allows for informed decisions on the ground to avoid the need for potentially more difficult in-flight decisions.

The aerodrome routine meteorological reports (METAR) for Grande Prairie (the closest reporting point to the occurrence flight's destination) and Peace River (the closest reporting point to the point of departure) showed that the visibility and ceilings were acceptable for VFR flight at night. The aerodrome forecast (TAF) for Grande Prairie also showed favourable weather. However, the graphic area forecast (GFA) for the proposed flight, as well as the TAF for Peace River, indicated visibilities below VFR minima.

Finding as to causes and contributing factors

The pilot departed into weather that was forecast to be below the limits required for a night VFR flight and, as a result, there were limited external visual cues available to the pilot during the flight.

Although the investigation could not determine exactly what weather information the pilot consulted, there is no record of him calling a NAV CANADA flight information centre for a weather briefing before departure. NAV CANADA flight service specialists are trained to provide a pilot with interpretations of weather forecasts, including GFAs, along the route of flight specified by the pilot. This information can contribute to making the best decisions possible during flight planning.

Findings as to risk

If pilots do not access all available weather information, such as weather briefings from NAV CANADA flight service specialists, there is an increased risk that they will fly into hazardous weather conditions.

### 2.2 Pilot decision making

On the day of the occurrence, at various times throughout the day, the pilot discussed with family members the weather information he had researched on his mobile app. When asked by a family member about weather conditions for the occurrence flight, the pilot was positive and did not voice any concern.

The pilot's lack of concern for the weather suggests that he either used the destination METAR, incorrectly assessed other available products, or possibly minimized their meaning with a bias towards the destination METAR and TAF. Nevertheless, not having voiced any concerns suggests that the pilot's mental model was that the weather conditions were suitable for him to undertake a night VFR flight to return home as initially planned.

Findings as to causes and contributing factors

The decision to depart for the occurrence flight was likely a result of the pilot's mental model that weather conditions were suitable based on his assessment of the weather products he accessed.

In addition, the successful repositioning flight over the Eaglesham/Delta Tango Field Aerodrome and to the family farm likely confirmed or reinforced the pilot's mental model that the weather conditions were suitable for him to undertake the occurrence night VFR flight.

Finding as to causes and contributing factors

The success of the short repositioning flight over the nearby Eaglesham/Delta Tango Field Aerodrome likely reinforced the pilot's mental model regarding the suitability of the weather and influenced his decision to depart on the occurrence flight.

## 2.3 Loss of control

### 2.3.1 Night flight regulations

A flight flown during the day does not have the same characteristics as when it is flown at night. During a night flight, given the darkness, it can be difficult or even impossible to perceive deteriorating weather conditions. If visibility is good, well-lit areas may compensate for areas with less lighting. However, if visibility deteriorates to the point where the pilot is unable to see beyond an area with little ground lighting, the risk of losing reference to the surface increases. Therefore, when planning a night VFR flight, it is preferable that the flight path be determined in consideration of those areas that provide the most ground lighting possible, and not necessarily flown in a straight line.

Pilots flying under VFR must maintain visual reference to the surface, regardless of whether the flight is conducted in daylight or darkness. The *Canadian Aviation Regulations* (CARs) stipulate that all night VFR flights, whether conducted in controlled or uncontrolled airspace, be "operated with visual reference to the surface." However, what the term "visual reference to the surface" means is open to interpretation, as the concept is not defined in the regulations.

In 2016, the TSB issued Recommendation A16-08 concerning the lack of clarity in the practical meaning of "flight with visual reference to the surface." Transport Canada is in the process of drafting notices of proposed amendment that will lead to updating the night VFR requirements. However, until the details of the proposed regulatory amendments are fully known, the TSB cannot evaluate whether these measures will fully address the risks associated with night VFR flights.

Findings as to risk

If the CARs do not clearly define what is meant by "visual reference to the surface," night VFR flights may be conducted with inadequate visual references, which increases the risk of an accident as a result of controlled-flight-into-terrain or a loss-of-control.

### 2.3.2 Spatial disorientation

It is likely that, shortly after departure, the pilot encountered deteriorating weather consisting of surface-based layers and/or low cloud and poor visibility. It is also likely that the pilot did not see the approaching weather given that it was night, and that he had inadvertently entered the low-level cloud.

The pilot may have also encountered precipitation. Responders on the ground observed rain, freezing rain, and snow shortly after the accident. In addition, the GFA forecast possible icing conditions in the area at altitudes slightly above the helicopter's flight path. The helicopter was not equipped with a heated pitot static system; however, the investigation could not determine if the helicopter encountered any in-flight icing.

Although required by regulation for night VFR flight, the helicopter was not equipped with either a stabilized magnetic direction indicator or a gyroscopic direction indicator, and either a turn and slip indicator or a turn coordinator. The unintentional flight into reduced visibility required the pilot to shift his focus from outside the cockpit to the instruments inside the cockpit to maintain control of the helicopter.

Finding as to risk

If night VFR flights are conducted without the minimum equipment required by the CARs, pilots will be at increased risk of spatial disorientation when operating with limited external visual cues.

Based on the data from the Stratus 2S, the pilot lost control of the helicopter shortly before the collision with the ground. This is also supported by the fact that the low-rotor caution light and full-throttle light were illuminated at the time of the accident. Without an external visual horizon and other external visual cues, the pilot was vulnerable to spatial disorientation.

Finding as to causes and contributing factors

As a result of the limited external visual cues, the pilot became spatially disoriented while en route and lost control of the helicopter, and the helicopter collided with the ground.

# 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 pilot departed into weather that was forecast to be below the limits required for a night visual flight rules flight and, as a result, there were limited external visual cues available to the pilot during the flight.

2. The decision to depart for the occurrence flight was likely a result of the pilot's mental model that weather conditions were suitable based on his assessment of the weather products he accessed.

3. The success of the short repositioning flight over the nearby Eaglesham/Delta Tango Field Aerodrome likely reinforced the pilot's mental model regarding the suitability of the weather and influenced his decision to depart on the occurrence flight.

4. As a result of the limited external visual cues, the pilot became spatially disoriented while en route and lost control of the helicopter, and the helicopter collided with the ground.

## 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 pilots do not access all available weather information, such as weather briefings from NAV CANADA flight service specialists, there is an increased risk that they will fly into hazardous weather conditions.

2. If night visual flight rules flights are conducted without the minimum equipment required by the *Canadian Aviation Regulations*, pilots will be at increased risk of spatial disorientation when operating with limited external visual cues.

3. If the *Canadian Aviation Regulations* do not clearly define what is meant by "visual reference to the surface," night visual flight rules flights may be conducted with inadequate visual references, which increases the risk of an accident as a result of controlled-flight-into-terrain or a loss-of-control.

# 4.0 SAFETY ACTION

## 4.1 Safety action taken

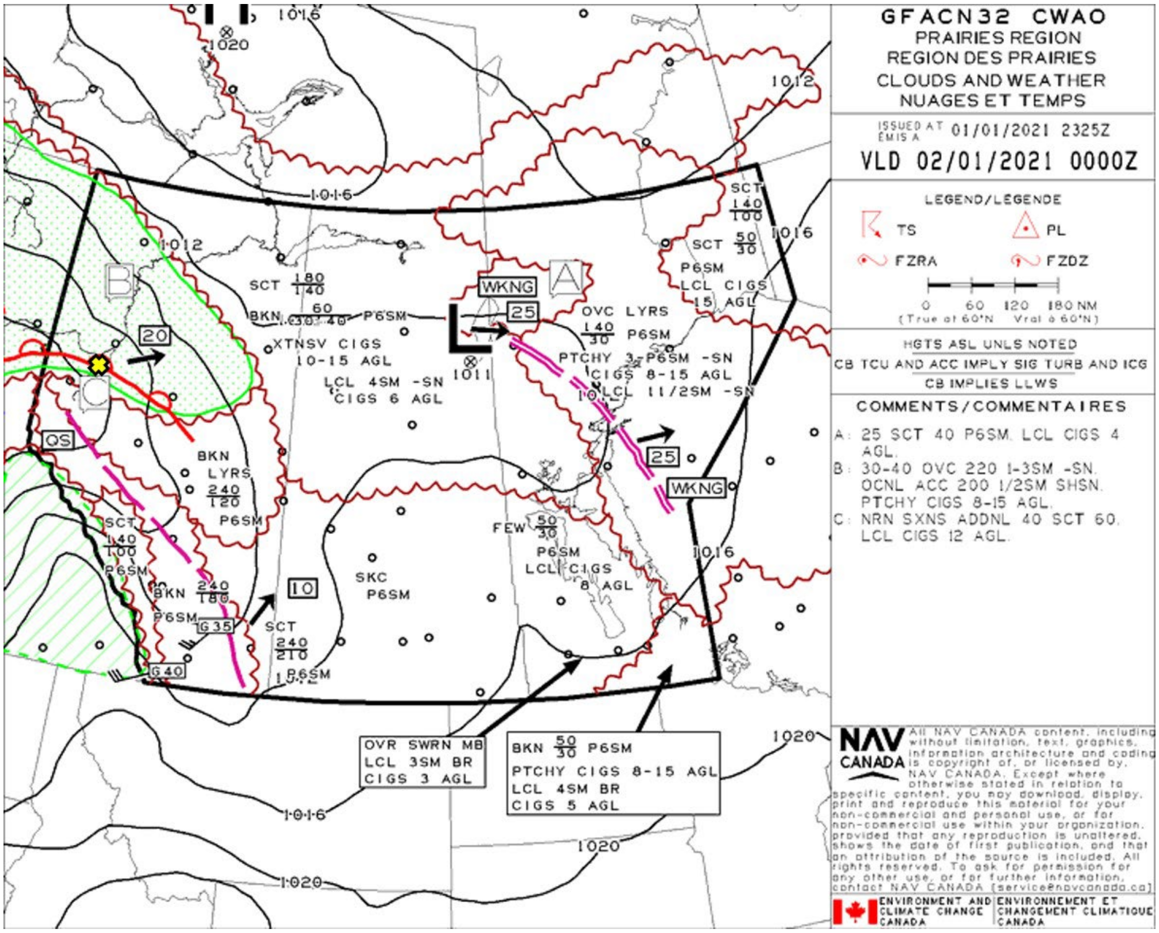
The Board is not aware of any safety action taken following this occurrence.

This report concludes the Transportation Safety Board of Canada's investigation into this occurrence. The Board authorized the release of this report on 13 April 2022. It was officially released on 11 May 2022.

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.

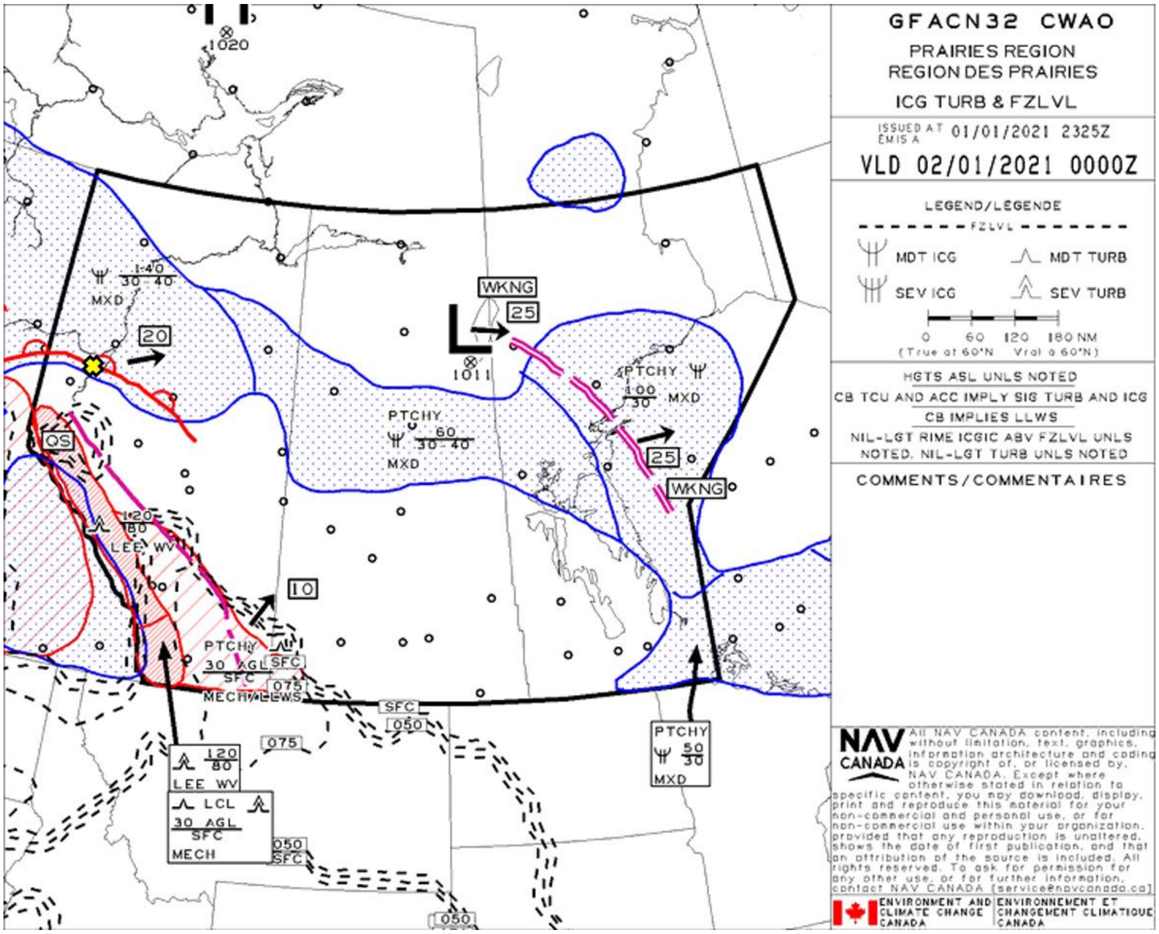
## APPENDICES

### Appendix A – Graphic area forecast – Clouds and weather chart valid at 1700 Mountain Standard Time on 01 January 2021 (Yellow 'X' denotes accident site)




Source: Environment and Climate Change Canada with TSB annotation

## Appendix B – Graphic area forecast – Icing, turbulence, and freezing level chart valid at 1700 Mountain Standard Time on 01 January 2021 (Yellow 'X' denotes accident site)




Source: Environment and Climate Change Canada with TSB annotation