Transportation Safety Board of Canada

Bureau de la sécurité des transports du Canada

AVIATION INVESTIGATION REPORT A12C0154

LOSS OF CONTROL AND COLLISION WITH TERRAIN

GOGAL AIR SERVICES LIMITED
CESSNA 208B, C-GAGP
SNOW LAKE, MANITOBA
18 NOVEMBER 2012

Canada

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

Aviation Investigation Report A12C0154

Loss of control and collision with terrain

Gogal Air Services Limited
Cessna 208B, C-GAGP
Snow Lake, Manitoba
18 November 2012

Summary

The Gogal Air Services Limited Cessna 208B (registration C-GAGP, serial number 208B1213) departed Runway 21 at Snow Lake en route to Winnipeg, Manitoba, with the pilot and 7 passengers on board. At approximately 0956 Central Standard Time, shortly after take-off, the aircraft descended and struck the terrain in a wooded area approximately 0.9 nautical miles beyond the departure end of the runway. The pilot was fatally injured, and the 7 passengers sustained serious injuries. The aircraft was destroyed by impact forces, and a small fire ensued near the engine. The aircraft's emergency locater transmitter activated. First responders attended the scene, and the injured passengers were taken to area hospitals. The aircraft's fuel cells ruptured, and some of the onboard fuel spilled at the site.

Ce rapport est également disponible en français.

Table of contents

1.0 Factual information

1.1 History of the flight

Gogal Air Services Ltd. (Gogal) was engaged by a local mining company to transport employees between Snow Lake and Winnipeg, Manitoba (Figure 1), to facilitate crew changes that generally occurred on a 10-day cycle. The mining company requested that Gogal move 13 employees from Snow Lake to Winnipeg on the morning of 18 November 2012, a flight distance of 310 nautical miles (nm).

Gogal planned to use both of its fixed-wing aircraft: a Piper PA 31 Navajo and a Cessna 208B Caravan (Caravan).

The Caravan had arrived in Snow Lake from Winnipeg on 17 November 2012 at 1600. [1] The aircraft was fueled, and the wing covers, tail covers, and engine tent were installed.

The passengers were to meet at the Snow Lake aerodrome for an 0815 departure. On the morning of 18 November, the weather was foggy, and the company informed the passengers that the flight would be delayed by a few hours until the weather improved. The passengers arrived at the aerodrome at about 0930.

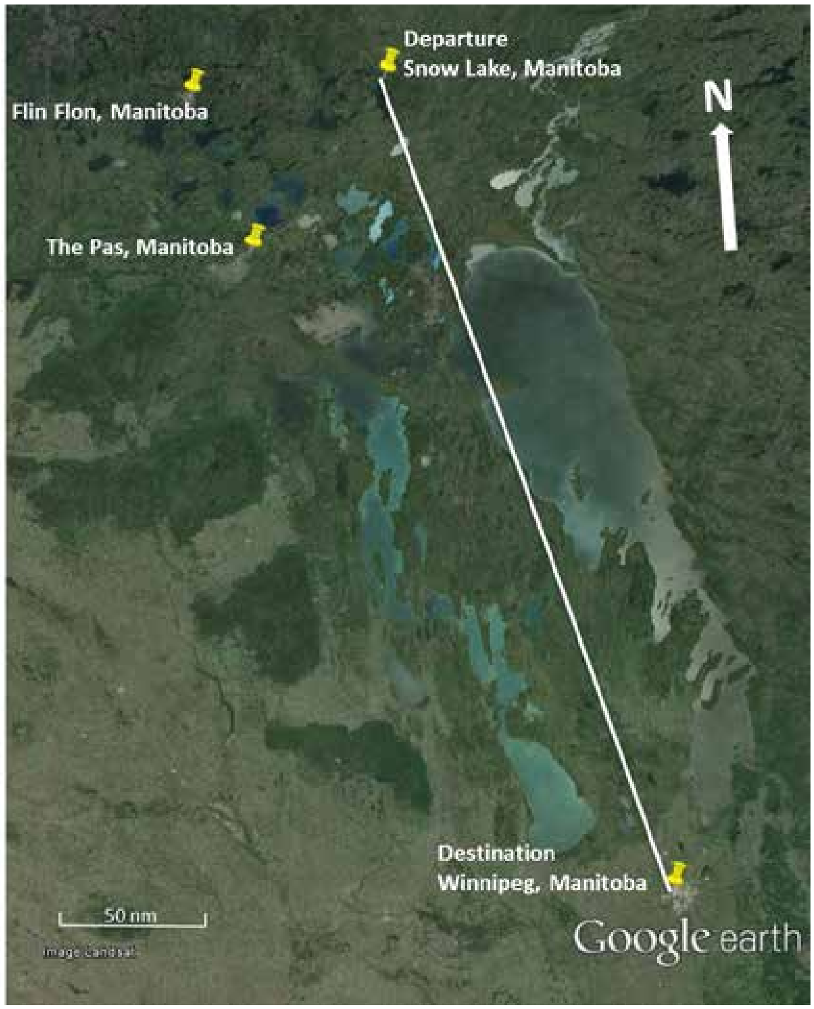


Figure 1. Planned flight route (background image: Google Earth)

The Caravan had accumulated some rime ice on the leading edges of the wings (Photo 1) and the horizontal stabilizer from the flight into Snow Lake on the previous day. During the pre-flight inspection, the pilot tapped the leading edges of the wings with a broom handle in an attempt to remove the ice, but did not do this on the horizontal stabilizer of the aircraft. Ice remained on the leading edges of the wings and tail before the flight. No de-icing or anti-icing

---

[1] All times are Central Standard Time (Coordinated Universal Time minus 6 hours) unless otherwise noted.

fluids were applied to the wing or horizontal stabilizer, and no tactile inspection of the upper wing or tail surfaces was observed.

Photo 1. Ice on leading edge of wing before the accident flight

After the passengers and baggage were loaded, both aircraft departed; the Caravan was first to depart, at 0955.

The Caravan’s engine sound seemed normal throughout the flight. The aircraft climbed to about 225 feet above ground level (agl), and then pitched down. The aircraft’s tail began to shudder and oscillate, the wings rocked, and a more pronounced second downward pitch ensued before the aircraft contacted the trees. A warning horn sounded before impact.

The aircraft’s 406-megahertz (MHz) emergency locater transmitter activated, and was intercepted by the Joint Rescue Coordination Centre. First responders attended the scene, and the injured passengers were taken to area hospitals for medical attention.

The Navajo took off within 5 minutes of the Caravan’s departure; however, its pilot was unaware of the crash. There were no radio communications between the 2 aircraft before or during the occurrence.

1.2 Injuries to persons

Table 1. Injuries to persons

	Crew	Passengers	Others	Total
Fatal	1	–	–	1
Serious	–	7	–	7
Minor / none	–	–	–	–

Total	1	7	–	8

1.3 Damage to aircraft

The aircraft suffered substantial damage and was assessed as destroyed.

1.4 Other damage

The damage to the surrounding landscape and environment was limited to a small area encircling the wreckage. The fuel that spilled during the occurrence evaporated.

1.5 Personnel information

The pilot held a current Canadian commercial pilot licence with a valid medical certificate, and was certified and qualified for the flight in accordance with existing regulations. The pilot did not have an instrument rating. About 2865 hours of total flight time had been accumulated by the pilot, including 1020 hours of flight time on the Cessna 208B Caravan. A review of training records indicated that the pilot's training complied with the training requirements of the company operations manual (COM) approved by Transport Canada (TC). This training included, in part, flight- and duty-time requirements, aircraft instrument and equipment requirements, weather, surface contamination, passenger and cabin safety, and emergency procedures. The pilot had successfully completed aircraft critical-surface contamination training, Cessna 208 recurrent technical training, and a pilot proficiency check on 10 May 2012. In the training examination on critical-surface contamination, the pilot correctly indicated that take-off must not be attempted until confirmation is obtained that the aircraft is clean. There was no information indicating that the pilot had received pilot decision-making (PDM) training, nor is such training required by the *Canadian Aviation Regulations* (CARs) or the COM.

The pilot's flight- and duty-time limits were not exceeded, and there was no indication that fatigue affected the pilot's performance.

1.6 Aircraft information

1.6.1 General

The Cessna 208B Caravan is a high-wing, fixed-gear aircraft equipped with a Pratt & Whitney Canada PT6A-114A turboprop engine. The accident aircraft was manufactured in 2006, and was equipped with a cargo pod and an aircraft payload extender (APE) II kit, in accordance with supplemental type certificate (STC) SA00392SA. The kit increases the authorized gross take-off weight of the aircraft from 8750 to 9062 pounds. The aircraft was also equipped with a Chelton electronic flight instrument system (EFIS) and an engine air data acquisition system (ADAS). Both systems contained stored electronic flight and engine data pertaining to the occurrence flight.

Records indicate that the aircraft was certified, equipped, and maintained in accordance with existing regulations and approved procedures. The aircraft underwent a 100-hour inspection on

14 November 2012 at 1484.8 flight hours, or approximately 2.2 flight hours before the occurrence.

1.6.2 Weight and balance

The aircraft's weight and centre-of-gravity calculations, computed during the investigation, were inconsistent with the flight manifest prepared before the accident flight. The flight manifest had been prepared and left at the operator's office in the town of Snow Lake before the pilot's departure for the aerodrome. The flight manifest indicated that the payload consisted of fuel, the pilot, 7 passengers, and the passengers' baggage. The fuel load was initially entered on the flight manifest as 2000 pounds, but had been amended to read 1800 pounds. Full usable fuel for the Caravan is 2224 pounds. The aircraft was fueled from a company fuel-storage tank at the Snow Lake aerodrome the night before the occurrence. The accident pilot was responsible for fueling of the aircraft and reportedly maintained a log of fueling on a personal cell phone. The information from the pilot's cell phone was not recovered, and damage to the aircraft prevented a post-occurrence measurement of the fuel load on board. The fuel storage tank is equipped with a meter that is resettable and records fuel dispensed in litres. The meter reading after the occurrence was 955 litres, or approximately 1814 pounds of Jet A fuel. Information recovered from the aircraft's Chelton EFIS showed a fuel load of 366 pounds when the unit was first powered up on the day of the occurrence. The pilot has the choice of entering a specific fuel load or pressing the FULL FUEL button, which resets the system with a pre-set fuel value. Three seconds after the system powered up, the fuel load changed to 2220 pounds, indicating that the amount of 2220 pounds had been entered manually, or that the pilot had selected the FULL FUEL button.

The crew and passenger weights were entered as 200 pounds each; the CARs and the COM list the standard winter weight for male passengers at 206 pounds. The baggage weight was entered as 100 pounds; the actual baggage weight as weighed after the occurrence was 215 pounds. No allowance was made for the survival kit or winter covers, which totalled 65 pounds. The total gross take-off weight on the flight manifest was listed as 9003 pounds. The total gross take-off weight calculated after the occurrence, using a fuel load of 2220 pounds, was 9655 pounds, which is approximately 600 pounds greater than the authorized take-off weight.

For centre-of-gravity determination, the aircraft allowable index position, [2] at the maximum gross weight of 9062 pounds, is listed at between –0.2 inches aft limit and –5.2 inches forward limit. A calculated index position of –7.1 was entered on the flight manifest, which is outside of the permissible flight parameters. A calculation of the aircraft's centre-of-gravity index position was undertaken by the Transportation Safety Board (TSB). The aircraft's fuel loading does not alter the index reading, because fuel is stored in the wing tanks at the mid-range centre-of-gravity location. The baggage and passenger weights and location can affect the index position and were entered in various locations to see if a particular loading arrangement could lead to an out-of-range position. All calculations showed that the centre of gravity was likely within the extended centre-of-gravity limits; however, because of the aircraft's weight, it was not within the approved weight and centre-of-gravity envelope at take-off.

---

2 The aircraft was equipped with a SEE GEE centre-of-gravity calculator made by CAVU International for the specific aircraft configuration. The turn-wheel type calculator provides an index range between the forward and aft centre-of-gravity limits at varying aircraft weights to allow for ease of centre-of-gravity determination.

The airplane flight manual (AFM) provides that:

> The pilot must utilize the loading flexibility to ensure the airplane does not exceed its maximum weight limits and is loaded within the center of gravity range before takeoff. Weight is important because it is a basis for many flight and structural characteristics. As weight increases, takeoff speed must be greater since stall speeds are increased, the rate of acceleration decreases, and the required takeoff distance increases. [3]

The Normal Procedures section of the AFM indicates that the wing flaps should be set at 20° for take-off, that the aircraft should be rotated at 70–75 knots, and that the aircraft climb speed should be 85–95 knots. The flaps are retracted to 10° after reaching 85 knots, and 0° after reaching 95 knots. A procedure for departure with anti-ice fluid on the wings is also included. It calls for wing flaps set to 0°, and stipulates that rotation should be at 83 knots and climb speed should be at 104 knots. The operator's procedure was that take-off should be conducted with wing flaps at 20°.

1.6.3 Aircraft performance

Using data stored in the aircraft's EFIS, the investigators calculated that the aircraft's ground roll at take-off was about 2250 feet, and that lift-off occurred at about 75 knots. The performance information in the aircraft's pilot's operating handbook and Federal Aviation Administration (FAA)–approved AFM, as modified in the APE II kit, indicated that the take-off distance, or ground roll, at the prevailing temperature and elevation and a gross weight of 9062, should have been about 1500 feet on a paved, level, dry runway using the short field take-off technique. The normal lift-off speed of the Caravan is 70–75 knots, and initial climb speed is 85–95 knots. For the short field technique, the AFM suggests using 20° flap, raising the nose when practical and climbing out with the tail low, and then levelling the airplane to accelerate to a safe climb speed.

The performance changes resulting from the aircraft's load at the time of the occurrence could not be accurately quantified. The Caravan test data provided by the aircraft manufacturer indicated that a take-off run on a hard gravel surface would be about 11% longer than that on a paved dry runway. The additional ground roll on the accident flight was most likely due to the gravel runway surface, its condition, the aircraft gross weight, and ambient wind. Snow Lake and other aerodromes from which the company operates, have gravel-surfaced runways.

The presence of ice would reduce the margin between the stall speed and the lift-off speed.

1.6.4 Short field take-off technique

The company uses a short field take-off technique consisting of the following:

- A rolling take-off with gradual application of power,
- Using the elevator to lighten the weight on the nosewheel,

---

[3] *Pilot's Operating Handbook and FAA Approved Airplane Flight Manual: Cessna Model 208B (675 SHP)* (revision 23, n.d.), Section 6: Weight and Balance, page 6-3

- Lifting the nosewheel off the runway, once airspeed allows, and
- Rotating and climbing out at normal departure airspeed.

The pilot used this procedure on the accident flight, and other C208 operators also use it at airports with gravel runways, to minimize damage to the aircraft's propeller. The rolling take-off in the procedure is a variation on the short field technique listed in the AFM. A rolling take-off adds to the take-off distance listed in the AFM for both normal and short field take-offs and is dependent on pilot technique.

1.6.5 Ice protection and cautions

The aircraft is equipped for flight into known icing conditions, and the AFM (Supplement S1, revision 10) outlines limitations and procedures related to flight in icing conditions. The supplement specifies a maximum gross weight of 8550, pounds with cargo pod installed, in icing conditions. The take-off is to be done with flaps 20°, a minimum airspeed in icing conditions of 120 knots with flaps up, and 105 knots with flaps 10°, excluding take-off and landing. [4]

The AFM contains the following warnings: [5]

> PREFLIGHT INSPECTION (Continued)
>
> EMPENNAGE
>
> WARNING
>
> It is essential in cold weather to remove even small accumulations of frost, ice, snow, or slush from the tail and control surfaces. To assure complete removal of contamination, conduct a visual and tactile inspection of all surfaces. Exercise caution to avoid distorting vortex generators on the horizontal stabilizer while deicing. Also, make sure the control surfaces contain no internal accumulations of ice or debris.
>
> […]
>
> BEFORE TAKEOFF (Continued)
>
> WARNING
>
> - When ground icing conditions are present, a pre-takeoff visual and tactile check should be conducted by the pilot in command within 5 minutes of takeoff, preferably just prior to taxiing onto the active runway.

---

4 *Pilot's Operating Handbook and FAA Approved Airplane Flight Manual: Cessna Model 208B (675 SHP)*, Supplement S1: Known Icing Equipment (revision 10, 20 February 2007)

5 *Pilot's Operating Handbook and FAA Approved Airplane Flight Manual: Cessna Model 208B (675 SHP)* (revision 23, n.d.), Section 4: Normal Procedures, pages 4–11 and 4–21 [*original in bold and fully capitalized typeface*]

> · Takeoff is prohibited with any frost, ice, snow, or slush adhering to the wings, horizontal stabilizer, vertical stabilizer, control surfaces, propeller blades, and engine inlets.
>
> · Even small amounts of frost, ice, snow or slush on the wing may adversly change lift and drag. Failure to remove these contaminants will degrade airplane performance and may prevent a safe takeoff and climbout.

1.6.6 Stall warning system

The aircraft's stall warning system is designed to activate a warning horn 5 to 10 knots above the stall speed in all configurations. The published stall speed with a non-contaminated wing in a flaps-up, 0˚ bank angle configuration at 9062 pounds with the APE II is 63 knots indicated airspeed (KIAS). The AFM warns that an altitude loss during a stall recovery may be as much as 300 feet from a wings-level stall, and more in a turn; it advises, if pre-stall buffet or uncommanded pitch oscillations are encountered, reducing the aircraft's pitch attitude while increasing engine power to the maximum continuous setting. The AFM recommends that the flaps be promptly extended to 10° to help stabilize the airplane and that the airspeed be increased to 110 KIAS or greater before retracting the flaps.

The AFM Supplement S1, under Rate of Climb, states:

> Ice accumulation on the airframe may cause a loss in rate-of-climb. Expect the service ceiling of the airplane to be significantly reduced. With some ice accumulations, climbing to exit icing conditions may not be an option. Even after cycling the de-ice boots, residual ice on the airframe can result in a decrease in climb performance and service ceiling compared to a clean airframe. [6]

Under Stall Speeds, the AFM Supplement S1 states:

> Ice accumulation on the airframe may result in a 20 KIAS increase in stall speed. Either buffet or aural stall warning should be treated as an imminent stall. [7]

1.7 Meteorological information

For 17 November 2012 at 1200 Coordinated Universal Time (UTC), the clouds and weather graphical area forecast (GFA) (Appendix D) and the icing, freezing level, and turbulence GFA (Appendix E) predicted cloud bases of 3000 feet agl, with patchy cloud bases of 1200 feet agl, for the route of flight from Winnipeg to Snow Lake. Moderate mixed icing in cloud between 3000 feet and 6000 feet agl was forecast, and in the southern area of the flight, patchy clear ice in isolated areas of freezing drizzle was forecast.

There are no routine weather observations available for the Snow Lake aerodrome. The observed aviation routine weather report (METAR) for 18 November 2012 at 1000 for Flin Flon, Manitoba, 67 nautical miles (nm) west of Snow Lake, was as follows: wind 140° true (T) at 5 knots, visibility 1.5 statute miles (sm) in mist, vertical visibility 200 feet, temperature –4°C, and

---

[6] *Pilot's Operating Handbook and FAA Approved Airplane Flight Manual: Cessna Model 208B (675 SHP)*, Supplement S1, (revision 10, 20 February 2007), section 5, page 47

[7] Ibid., page 47

dew point –4°C; remarks: fog 8 oktas. [8] The remarks section includes sky condition, for layers aloft. A vertical visibility (VV) is reported in hundreds of feet when the sky is obscured. [9]

The METAR for 18 November 2012 at 1000 for The Pas, Manitoba, 71 nm southwest of Snow Lake, was as follows: wind 140°T at 8 knots, visibility 1 sm in mist, vertical visibility 300 feet, temperature 0°C, and dew point 0°C; remarks: fog 8 oktas.

The clouds and weather GFA for 18 November 2012 at 0600, from 0600 to 1200 UTC (Appendix B), indicated that the area was affected by a low-pressure system centred over central Alberta that resulted in extensive cloud over central Manitoba, with extensive ceilings of 300 to 500 feet agl, visibilities 2 to 6 sm in snow, light snow and mist, local ceilings of 100 to 300 feet agl and visibilities of 1 to 3 sm in snow, light freezing drizzle, snow grains, and mist. The GFA (Appendix C) predicted local, patchy, moderate mixed icing in cloud from 3000 feet to 5000 feet agl, and clear icing from the surface to 3000 feet agl in local freezing drizzle. The freezing level was at the surface.

1.8 Aids to navigation

Not applicable.

1.9 Communications

There was no information as to any radio communication from the pilot before or during the occurrence.

1.10 Aerodrome information

The Snow Lake aerodrome is a registered aerodrome owned and operated by the town of Snow Lake. It is located approximately 9 nm south of Snow Lake and has no commercial services beyond aerodrome maintenance. Gogal maintains a small storage shed to keep service items for its aircraft, and provides its own fueling facilities. The aerodrome has a single runway, Runway 03/21, that is 3510 feet long by 75 feet wide at an elevation of 993 feet above mean sea level. Runway 21 has an upslope of 0.6% for the first 1500 feet, with a 0.7% downslope for the remaining 2010 feet. The gravel-surfaced runway was clear of snow and firm at the time of the occurrence.

The airspace in the immediate vicinity of Snow Lake is uncontrolled. The CARs provide that in uncontrolled airspace, aircraft in flight below 1000 feet agl must operate clear of cloud with a flight visibility of not less than 2 miles during day flight. [10]

---

8 Oktas refers to the layer type and opacity in eighths of sky concealed of clouds and/or obscuring phenomenon.

9 Transport Canada, TP14371: *Transport Canada Aeronautical Information Manual* (TC AIM), MET: Meteorology (04 April 2014), section 3.15.3(o), page 155

10 *Canadian Aviation Regulations* (CARs), Subpart 602, Division VI: Visual Flight Rules, Section 602.115

1.11 Flight recorders

1.11.1 General

The aircraft was not equipped with a flight data recorder (FDR) or a cockpit voice recorder (CVR), nor was either required by regulation. The aircraft was equipped with 2 Chelton EFIS and an ADAS. Both systems had the capability of storing electronic flight and engine data pertaining to the occurrence flight. The EFIS and ADAS were sent to the TSB Laboratory for retrieval of the stored information.

1.11.2 Air data acquisition system

The engine ADAS is mounted in the engine bay and records calendar date and time, engine inter-stage turbine temperature (ITT), torque, gas generator turbine revolutions per minute (rpm) (Ng), power turbine rpm (Np), fuel flow, altitude, airspeed, bus voltage, and engine exceedances.

The recovered information indicates that the aircraft took off at the maximum recommended engine power setting of 1865 foot-pounds (ft-lbs) of torque and 1900 rpm of propeller speed. The engine speeds, temperature, and fuel flows were normal. Once airborne, the engine torque and propeller speed were reduced to 1727 ft-lbs and 1847 rpm respectively, and remained there until 3 seconds before impact, when the engine went to its full available power of 2400 ft-lbs of torque in acceleration mode, with a normal rate of acceleration. The propeller rpm increased to 1855 rpm. There were no recorded engine unserviceabilities or performance issues.

1.11.3 Chelton electronic flight instrument system information

The 2 EFIS indicator display units (IDUs) record calendar date and time, latitude and longitude, mean sea level altitude, pitch and bank angle, heading and track, indicated airspeed, true airspeed, ground speed, vertical speed, wind speed, wind direction, outside air temperature, density altitude, fuel flow, and fuel totalizer quantity. The parameters are recorded at intervals varying from 1 to 3 seconds, depending on the parameter. No control input or flight control surface information is recorded.

Information recovered indicated that the time stamp on each of the IDU log files was different, so direct time correlation between the 2 files was not possible. After the 2 data sets were aligned and compared, there were only minor variations in the data between the IDU log files. The discontinuities noted in the recorded aircraft speeds made the use of these speeds for analysis problematic. The aircraft latitude and longitude were found to be accurate, so these data were used to calculate the distance that the aircraft travelled and the aircraft speeds. The calculated ground speed is shown in a comparison of the aircraft speeds of the accident flight and 4 previous flights in Appendix G. The calculated speeds did not have the speed anomalies resulting from the discontinuities in the recorded speeds. IDU1 and IDU2 recorded the aircraft pitch angle. A comparison of the accident flight pitch angles with the pitch angles of 4 previous flights is shown in Appendix F. Calibrated airspeed (CAS) was used in the examination of the EFIS information, because errors or momentary deviations in the aircraft's displayed KIAS were not recorded.

The recorded data indicated that after lift-off, the aircraft began to climb at a CAS between 85 and 90 knots, and reached a maximum speed of 90 knots. The pitch remained at approximately 9° while the flight path angle was between 2° and 4°. Between 0955:28 and 0955:32, the pitch decreased to approximately 8°. At 0955:32, the pitch began to increase again, with the CAS remaining at between 85 and 90 knots. From 0955:39, the calculated CAS and the flight path angle began to decrease and the pitch angle was approximately 11°. The decrease in the flight path angle indicated that the angle of attack was increasing and was at approximately 10°. From 0955:44 to 0955:50, the pitch angle began to fluctuate between 11° and 13°. At 0955:50, the pitch angle began to increase while the flight path angle began to decrease, which meant that the angle of attack was increasing. [11] At 0955:54, the pitch angle reached a maximum of 17° and the flight path angle was between 1° and 2°. After 0955:54, the pitch angle and flight path dropped rapidly, which indicated an increase in the angle of attack from 10° to 30°. The behaviour of the data suggested that the aircraft was in a stall 5 seconds before the end of data. A diagram of the calculated flight path is shown in Appendix H.

The values of speed and distance at lift-off for the occurrence aircraft were compared to the parameters provided in the take-off performance data. The APE II documentation included take-off performance data. Review of the aircraft engine parameters during the occurrence take-off were consistent with the requirements listed in the take-off performance data, which meant that comparison of the occurrence performance and the take-off performance data was valid. The AFM performance data was taken for a temperature of 0°C, pressure altitude of 800 feet, and weight of 9062 pounds. The comparison of the take-off distances and lift-off speeds is shown in Table 2.

Table 2. Take-off distance and speed comparison

Parameter	Occurrence	STC flaps 0	STC flaps 20
Take-off roll (feet)	2215	2190	1495
Lift-off CAS (knots)	78	83	70-75

STC = supplemental type certificate
CAS = calibrated airspeed

The aircraft manufacturer, Cessna, provided data for climb-out, but added that the aircraft was equipped with an STC that modified the performance of the aircraft, which may make its analysis not applicable.

The Chelton-calculated aircraft ground speed, contained in Appendix F, indicates that about 20 seconds before the end of the data, there are 7 one-second data points, indicating a spike of

---

11 “Angle of attack (AOA) is the angle between the oncoming air or relative wind and a reference line on the airplane or wing. […] AOA is sometimes confused with pitch angle or flight path angle. Pitch angle (attitude) is the angle between the longitudinal axis (where the airplane is pointed) and the horizon. This angle is displayed on the attitude indicator or artificial horizon. Flight path angle is defined … as the angle between the flight path vector and the horizon, also known as the climb (or descent) angle.” Source: Boeing [online], *Aero* magazine, no. 12, What is angle of attack?, available at http://www.boeing.com/commercial/aeromagazine/aero_12/attack_whatisaoa.html (last accessed on 14 April 2014)

about 10 knots in the ground speed. The spike is followed by oscillations in the aircraft's pitch angles continuing to the end of the data, as noted in the aircraft's calculated pitch angles (Appendix G). No change in the engine parameters were noted at that time. A ground speed spike can result from a shift in wind speed or direction aloft, or from retraction of the aircraft's wing flaps, or from global positioning system (GPS) anomalies. About 10 seconds after the spike in ground speed, there is an increase in aircraft pitch angle and several subsequent oscillations in pitch, and a decrease in speed and altitude consistent with an aircraft stall.

1.12 Wreckage and impact information

The aircraft struck the ground on a heading of 210°, approximately 0.9 nm off the end and approximately 70 meters to the right of an extended centreline of Runway 21. The aircraft descended through approximately 30-foot trees in a slight nose-down attitude. The wings were damaged from tree contact, and the outboard portion of the right horizontal stabilizer and elevator were torn off and remained in the trees. The aircraft struck the ground on a gentle up-slope, causing a sudden stoppage. The aircraft's nosewheel and belly pod were torn off, the main landing gear was splayed outwards, and the aircraft's nose and floor structure were buckled. All of these factors helped reduce the impact loading to the occupants. The aircraft yawed to the right and slid approximately 30 feet before coming to rest. The aircraft's descent angle and short ground slide were consistent with a low-airspeed stall condition before tree contact.

The propeller and reduction gearbox were torn free from the engine, and a small post-crash fire ensued in the forward part of the engine. Fuel was released from both of the aircraft's wing fuel cells on impact, but did not ignite. The wreckage was examined, and flight control continuity was established. The flap system was found in the flap-up 0° position. Damage to the propeller indicated that the engine was developing substantial power at impact. No pre-existing malfunctions or defects with the aircraft or engine were found.

Approximately 3 hours after the occurrence, rime ice was found adhering to the leading edge of the vertical stabilizer. Most of the leading edges of the wings and horizontal stabilizers were too severely damaged to retain any evidence of ice.

1.13 Medical and pathological information

The investigation determined that there was nothing to indicate that the pilot's performance was degraded by physiological factors.

1.14 Fire

The aircraft's battery is mounted on the engine firewall and is designed with a swing-hinge arrangement for easy removal and installation. Upon impact, the battery swung forward around its swing hinge and was thrown free of the wreckage, eliminating the source of electrical power. The aircraft's propeller and part of the reduction gearbox were broken from the engine on impact. Engine oil in the reduction gearbox was released and ignited on contact with hot engine / exhaust components. The fire self-extinguished after several minutes when its fuel source (engine oil) was depleted, and did not adversely affect the survivability of the occupants after the occurrence.

1.15 Survival aspects

1.15.1 Rescue

The aircraft was equipped with a 406-MHz emergency locater transmitter (ELT), which activated on impact. The Joint Rescue Coordination Centre dispatched a CC-130 Hercules search aircraft from Winnipeg. Due to weather conditions at Snow Lake, the search and rescue technicians (SARTECs) on board were not able to parachute to the site.

Several of the passengers were able to communicate with first responders by cell phone. Response to the site was delayed by approximately 3 hours, because of uncertainty as to the exact location of the site and difficulty in moving vehicles through the rocky and wooded terrain.

The pilot and the front right seat passenger were wearing 5-point harnesses. Both sustained injuries from contact with their respective control yoke and instrument panel. The front right seat passenger had injuries resulting from the impact and contact with the right control yoke, instrument panel, and glare shield, and was knocked unconscious for several minutes. The passengers had varying degrees of injury as a result of impact forces, and 5 were able to exit the wreckage by the rear exit door. One of the rear seat passengers was trapped in the seat and couldn't move. Both remained in the aircraft until emergency services arrived. The survivors were taken to the Snow Lake Hospital for medical attention and were later evacuated by aircraft.

1.15.2 Aircraft structure

The Cessna 208 Caravan is designed to attenuate occupant crash loads through the absorption of impact loads by the landing gear system, through controlled yielding of the aircraft subfloor structure, through occupant restraint systems, and through energy-absorbing crew seats with a vertical-stroking seat pedestal. These factors were reviewed to assess the survivability aspect for the occupants. Although the impact was at a relatively low airspeed, the initial contact with the up-sloping ground would have induced a greater deceleration force and a higher occupant *g* [12] loading.

Examination of the aircraft subfloor structure showed that the floor had buckled and yielded beneath the crew seats, and the front of the aircraft and instrument panel had flexed and compressed rearward. Both of these aspects combined to reduce the head-to-panel clearance of the front seat occupants. The pilot and co-pilot 5-point restraint systems were examined, and no defects or failures of the belt webbing, retract harness, or seat buckles were found. The crew seats are designed to reduce vertical impact loads to the occupants by a series of collapsible C-tubes, crush-tubes, and seat-pan deformation. Examination of both seats found that the collapsible seat mechanisms were deformed to their maximum crush capabilities, indicating that the impact was beyond the design limit of the seat. The seats remained attached to the seat rails. The co-pilot seat was positioned at its aft stop limit; the pilot seat was positioned 9 inches forward of the aft stop position. The investigation concluded that the impact forces exceeded the crashworthy design limits of the aircraft. The buckling or compression of the subfloor

---

[12] The accelerating force of gravity

structure, along with the flexing or movement of the instrument panel, and the collapsing and forward positioning of the pilot's seat, reduced the livable space for the pilot to the degree that the accident was non-survivable. The front seat passenger was knocked unconscious, but likely survived due to the aft-most positioning of that seat.

The passengers in the cabin area suffered varying degrees of injury. The cabin's livable space remained intact, and all occupied seats were deformed to varying degrees from crash loading. A video clip that was taken while the aircraft was taxiing before take-off showed that several of the occupants were not wearing their available lap belts or shoulder harnesses. One of the unrestrained passengers was on the bench seat at the rear of the aircraft, and another passenger was in a prone position with seat-back fully reclined and feet up on the seat rest directly in front. During impact, the unrestrained passengers were thrown forward, contacting the seats and aircraft structure ahead of them, increasing the injuries to themselves and other passengers.

CARs 703.39 and the COM (Chapter 3, Annex B) specify that all passengers are to be provided with a passenger briefing before departure. The briefing is to advise passengers of the requirement to be seated and to wear the available passenger restraint equipment for departure. Such a briefing was not provided to the passengers.

1.16 Tests and research

Not applicable.

1.17 Organizational and management information

1.17.1 Gogal Air Services Limited

Gogal is authorized to conduct domestic non-scheduled day visual flight rules (VFR) air transport operations under CARs Subpart 702 and Subpart 703 between points in Canada and abroad. The operations manager was also the chief pilot and the person responsible for maintenance (PRM). The accident pilot flew the company's sole Cessna 208B and coordinated its handling and maintenance.

The COM (Chapter 1.3) indicates that "[t]he operations manager is responsible for safe flight operations. In particular the responsibilities of the position include (A) control of operations and operational standards, of all aeroplanes operated." [13] Chapter 2 of the COM specifies that "[a]ll flights must be authorized before departure by the Operations Manager or Chief Pilot. Operational control of a flight is delegated to the pilot-in-command by the operations manager who retains responsibility for the day-to-day conduct of flight operations." [14] Section 2.1.2 of the COM states:

> A flight release will be given when the pilot-in-command has determined that:

[13] Gogal Air Services Limited, *Gogal Air Services Limited Operations Manual* (amendment 7-29: October 2003), Chapter 1.3

[14] Ibid., Chapter 2

(a) The flight may be conducted in accordance with the Air Operator Certificate, Operations Specifications, issued to the company, and with all Canadian Aviation Regulations and Standards;

(b) The validity of all required licences, permits, certificates, has been verified;

(c) All required aircraft maintenance work has been completed (aircraft is airworthy) and sufficient flying time remains on the aircraft before any scheduled maintenance; and

(d) An Operational Flight Plan / Flight Plan / Flight Itinerary has been completed as appropriate. [15]

The COM goes on to stipulate that male winter passenger weights shall be calculated as 206 pounds and that aircraft take-off and landing weights shall comply with the limits in the applicable AFMs. The weights for aviation gasoline (AVGAS) and oil were specified, but no standard weight for Jet A fuel was provided. The investigation used standard weights from the Canada Flight Supplement.

Information provided indicated that the accident flight was operating on a flight itinerary. The flight itinerary was provided to and authorized by the company president and the operations manager along with the flight manifest. The operations manager was the pilot of the company's Piper PA-31-350 aircraft that carried out the other flight to Winnipeg on the morning of the accident.

1.17.2 Transport Canada oversight

Section 720.01 of the *Commercial Air Service Standards* (CASS) defines a scheduled air service as a publicly available air transport service that provides transportation for passengers between points and serves those points in accordance with a published schedule at a charge per seat. If an air operator makes an application for its air operator certificate (AOC) to contain a scheduled point, TC assesses the applicant's ability to meet the CASS for the operation as required by CARs 703.07(1)(e). The operation between Winnipeg and Snow Lake was not structured as a scheduled service, but rather as a charter. The company's flight operations relative to moving the staff of the local mine operations were recurring, but did not have the other features of a scheduled air service mentioned in CASS 720. As such, there is no regulatory requirement to apply for a scheduled AOC.

Scheduled operations incur additional risks for their operators, as compared to non-scheduled operations, in that there is a public expectation for the flight to proceed. However, the Gogal operation was not a scheduled air operation under current TC regulations. Therefore, even though the flight was run on a recurring basis, TC did not provide the same degree of oversight as it does for a scheduled operator.

Transport Canada's policy is to visit every CARs 702 and 703 operator every 5 years at minimum, to conduct a program validation inspection (PVI). After that, a risk matrix is developed and operators are rated as to their relative risk, and more frequent PVIs are scheduled depending on the risk factor.

---

15 Ibid., section 2.12

Transport Canada did not visit Gogal during the year before the occurrence; the previous visits occurred in March 2010, and before that, in June 2009.

A summary of the findings of the March 2010 visit included 1 finding of noncompliance with the CASS and 1 finding of noncompliance with the company's maintenance control manual (MCM):

- Operational Control – 703.105(1): Contents of Company Operations Manual (A company operations manual, which may be issued in separate parts corresponding to specific aspects of an operation, shall include the instructions and information necessary to enable the personnel concerned to perform their duties safely and shall contain the information required by the *Commercial Air Service Standards*.) Examples of noncompliance included "flight/duty and rest period requires updating to CASS standard and electronic form in use", and "incomplete documentation for rotorcraft servicing and ground handling training". [16]
- Quality System (Evaluation Program) – 706.07(1): Quality Assurance Program (An air operator shall, in order to ensure that its maintenance control system and all of the included maintenance schedules continue to be effective and to comply with these Regulations, establish and maintain a quality assurance program that (a) is under the sole control of the person responsible for the maintenance control system appointed under paragraph 706.03(1)(a); and (b) meets the requirements of section 726.07 of Standard 726 — Air Operator Maintenance of the Commercial Air Service Standards.) Examples of noncompliance included [17] the following:
    - Records of compliance for multiple areas audited were undocumented and/or could not be substantiated. It was impossible to determine if sampling rate was commensurate with the company activities.
    - The maintenance planning documented did not capture/track the required calendar life inspections for 12-month chip detector, 3-year bearing lubrication, 12-year inspection, and limited overhaul and corrosion inspection for the cargo hook.
    - Internal audit check sheets identified that no aircraft were sampled in the 2009 and 2010 audit cycles, due to their unavailability.

The examples of noncompliance also identified that a required MCM amendment was not submitted to Transport Canada, and this finding was not administratively re-opened for action in the 2010 audit cycle. The 2010 pre-audit check sheets also identified a required change to the amendment procedure.

Transport Canada conducted a PVI of Gogal following the accident during the period from 03 December 2012 to 07 December 2012. The purpose of the inspection was to determine whether Gogal had an effective quality assurance (QA) program and an operational control system. The PVI was conducted to determine the level of conformance to the CARs and to company manuals and documents. The inspection determined that Gogal did not fully meet the regulatory requirements. The non-conformances included the following:

---

[16] Transport Canada, Records Documents Information Management System (RDIMS)

[17] Ibid.

- Three company pilots had not completed company indoctrination training in accordance with CARs 703.99(1)(c).
- Gogal had failed to retain a copy of the most recent written examination completed by each pilot for each aircraft for which the pilot was qualified, in accordance with CARs 703.99(3).
- Gogal had not notified the Minister of Transport within 10 working days that it had ceased to operate a Maule ML4 and de Havilland DHC-2 aircraft, as required by Gogal's operations certificate.
- Gogal's COM did not contain a description of its type D operational control system.
- The defect reporting system contained in the COM was not consistent with those found in the MCM.
- The COM made reference to 24-month validity periods for pilot proficiency checks, although the validity is 12 months.
- The company's internal audit system had required several amendments to the MCM related to aircraft maintenance records, and those amendments had not been completed.
- The company's approved maintenance organization (AMO) had not completed a required amendment to the aircraft equipment list.
- Gogal's chief pilot (CP) had not entered known defects into the logbook of aircraft C-GBAO as required by the CARs, and subsequently flew the aircraft before the defects were rectified.
- Several mandatory maintenance items referring to aircraft C-GBAO were not completed when they came due.

Gogal submitted a corrective action plan on 29 January 2013 to address these issues, and the issues were addressed. A follow-up inspection was conducted from 10 June 2013 to 14 June 2013, and the corrective measures were verified to be complete.

1.18 Additional information

1.18.1 Previous Transportation Safety Board Recommendation: Lightweight flight-recording systems

In June 2012, there were 6957 commercially registered aircraft listed on the Canadian Civil Aircraft Register, of which 5453 (78.4%) weighed less than 5700 kg. Most commercial aircraft weighing less than 5700 kg are operated under CARs Subpart 702 (Aerial Work) and CARs Subpart 703 (Air Taxi Operations). These operations accounted for 88% of all accidents, 87% of all fatalities, and 82% of all serious injuries involving Canadian registered commercial aircraft in the past 10 years. If accidents involving commuter operations under CARs Subpart 704 are added, the number of commercial air accidents jumps to 91% and the number of commercial air fatalities to 93%. Many of the aircraft operated by these companies are not required to be fitted with any type of flight recorder.

These smaller operators face challenging conditions, such as difficult terrain, and typically operate into smaller, more remote airports with less infrastructure. They often fly smaller, older aircraft with less sophisticated navigation and warning systems, which cause higher workloads for crew. Flight crews working for these operators are often working their way up in the system; they may have less training and experience, and often do not benefit from mentors able to pass on their experience.

In contrast, from 2001 to 2012, Canada's large carriers operating under CARs Subpart 705 have had only 1 fatal accident. [18] These large commercial carriers are required to have safety management systems (SMS), cockpit voice recorders, and flight data recorders. Many of these operators routinely download their flight data to conduct flight data monitoring (FDM) of normal operations. Air carriers with flight data monitoring programs have used flight data to identify problems such as unstabilized approaches and rushed approaches, exceedance of flap limit speeds, excessive bank angles after take-off, engine over-temperature events, exceedance of recommended speed thresholds, ground-proximity warning systems (GPWS) or terrain awareness and warning system (TAWS) warnings, onset of stall conditions, excessive rates of rotation, glide path excursions, and vertical acceleration. [19]

FDM has been implemented in many countries, and it is widely recognized as a cost-effective tool for improving safety. In the United States and Europe—thanks to the International Civil Aviation Organization (ICAO)—many carriers have had the program for years. Some helicopter operators have it already, and the FAA has recommended it.

Worldwide, FDM has proven to benefit safety by giving operators the tools to look carefully at individual flights and ultimately at the operation of their fleets over time. This review of objective data, especially as an integral component of a company safety management system, has proven beneficial in the proactive identification and correction of safety deficiencies and the prevention of accidents.

Several stand-alone lightweight flight-recording systems, which can record combined aircraft parametric data, cockpit audio data, airborne images, and/or data-link messages, are currently being manufactured. ED-155: Minimal Operational Performance Specification for Lightweight Recording Systems, published by the European Organization for Civil Aviation Equipment (EUROCAE), defines the minimum specifications to be met for aircraft required to carry lightweight flight-recording systems. While performance standards and TSOs exist, there is no requirement for aircraft not governed by CARs 605.33 to be fitted with any type of flight recorder, and Transport Canada does not intend to extend those requirements to smaller aircraft.

The development of lightweight flight-recording system technology presents an opportunity to extend FDM approaches to smaller operations. Using this technology and FDM, these operations will be able to monitor standard operating procedure compliance, pilot decision making, and adherence to operational limitations, among other things. Review of this information will allow operators to identify problems in their operations and initiate corrective actions before an accident takes place. In short, a whole new and promising avenue is now available to improve operational control and safety beyond CARs Subpart 705 operations. In

---

18 TSB Aviation Investigation Report A11H0002

19 Flight Safety Foundation, Wealth of Guidance and Experience Encourage Wider Adoption of FOQA, *Flight Safety Digest*, June–July 2004

Canada, some companies have already decided to fit their aircraft with lightweight flight-recording systems.

The Board acknowledges that there are issues that will need to be resolved to facilitate the effective use of recordings from lightweight flight-recording systems, including questions about the integration of this equipment in an aircraft, human resource management, and legal issues such as the restriction on the use of cockpit voice and video recordings. Nevertheless, given the potential for this technology, combined with FDM, to significantly improve safety, the Board believes that no effort should be spared to overcome these obstacles.

Given the combined accident statistics for CARs Subparts 702, 703, and 704 operations, there is a compelling case for industry and the regulator to proactively identify hazards and manage the risks inherent in these operations. To manage risk effectively, they need to know why incidents happen and what the contributing safety deficiencies may be. Moreover, routine monitoring of normal operations can help these operators both improve the efficiency of their operations and identify safety deficiencies before they result in an accident. In the event that an accident does occur, recordings from lightweight flight-recording systems will provide useful information to enhance the identification of safety deficiencies in the investigation.

Therefore, the Board recommended that:

> The Department of Transport work with industry to remove obstacles to and develop recommended practices for the implementation of flight data monitoring and the installation of lightweight flight recording systems by commercial operators not currently required to carry these systems.
>
> A13-01

1.18.2 Transportation Safety Board Aviation Safety Study 90-SP002

The aim of the aviation safety study was to examine the contributing factors to accidents that involved initiation or continuation of flight under VFR despite adverse weather conditions. The conclusion of the study stated, in part, that VFR flights that are continued into instrument meteorological conditions (IMC) experience an increased risk of collision with terrain and loss of control, and account for a number of fatalities each year. The causes and contributing factors of these accidents have recurring themes. They include inappropriate pilot qualifications or proficiency for the conditions encountered, and shortcomings in pilot training and in pilot licence privileges. In some cases, current industry practices and limitations in aircraft equipment and weather briefing facilities exacerbated the circumstances leading up to the accidents.

1.19 Useful or effective investigation techniques

Information was retrieved from the onboard Chelton EFIS and converted to time-location data points. The data points were organized and compared to forecast winds aloft to derive ground speed, and the resulting flight path was displayed using Google Earth (Appendix H).

2.0 Analysis

2.1 General

The aircraft's engine and propeller functioned as specified, and no pre-impact defects in the aircraft were identified. The analysis will concentrate on the aircraft's loading and performance, weather conditions, icing, and operational control issues.

2.2 Fuel

The aircraft's fuelling information for the accident flight and for previous flights was stored on a cell phone and was not recovered, and damage to the aircraft prevented a measurement of the fuel load on board after the occurrence. As a result, the amount of the fuel load had to be reconstructed. The flight manifest prepared for the flight listed a fuel load of 2000 pounds, subsequently changed to 1800 pounds. The Jet A resettable fuel storage tank meter reading after the occurrence indicated 955 litres, or approximately 1814 pounds. Information recovered from the aircraft's Chelton electronic flight instrument system (EFIS) showed an initial fuel load of 366 pounds, which changed to 2220 pounds, indicating that the amount of 2220 had been entered manually or that the pilot had selected the FULL FUEL button. A fuel load of 2220 pounds is the most likely fuel load, because it is consistent with the amount of fuel indicated by the pump meter reading, together with the calculated fuel remaining at the conclusion of the previous flight and the reading on the Chelton EFIS.

2.3 Weight and balance

The passenger weights combine with the baggage and fuel weights to produce a gross weight, on departure from Snow Lake, of approximately 9655 pounds, using a fuel load of 2220 pounds. This amount is approximately 600 pounds over the aircraft's maximum gross weight limit of 9062 pounds as extended by the aircraft payload extender (APE) II STC.

2.4 Weather and icing

The weather conditions on the day before the accident were conducive to the accumulation of rime ice in cloud. The aircraft had an accumulation of rime ice on its wing and tail leading edges, left from the incoming flight to Snow Lake on the day before the accident. The ice had most likely accumulated during the previous day's flight in icing conditions. Although the pilot made an attempt to remove the ice before flight, a significant amount of it remained on the aircraft. The aircraft's gross weight at take-off exceeded the aircraft's allowable gross weight in icing conditions of 8550 pounds by about 1100 pounds.

The ice on the leading edges of aircraft's wings and tail would have reduced available lift, added extra weight, increased aerodynamic drag, and thereby reduced its take-off and climb performance, increased its stall speed, and impaired the protection afforded by its stall warning system, which is activated at a pre-set angle of attack based on a clean wing.

The rime ice on the leading edge indicates that the aircraft had likely not encountered the patchy areas of clear icing forecast for the southern area of the flight on 17 November 2012.

2.5 Operational control and oversight

The accident flight was operating on a flight itinerary, which the pilot provided to the company president and the operations manager along with the flight manifest, as required by the company operations manual (COM). However, the aircraft departed significantly overweight and with ice on its critical surfaces, indicating that the company's operational control procedures were not effective in ensuring that the flight would be operated in accordance with the *Canadian Aviation Regulations* (CARs) and the COM.

The company dispatched flights of over 300 nautical miles (nm) in length on both the day before the accident and the day of the accident along a route of flight with forecast icing conditions in cloud. Although Gogal's operating certificate authorizes visual flight rules (VFR) flight only, the rime ice on the aircraft's leading edge before the accident flight indicates that it was likely flown in cloud on the previous flight, and the accumulated ice was not removed before the flight on the morning of the accident flight. The accident flight was dispatched into ceilings lower than those prevailing on the inbound flight on the previous day, so it is at least as likely that part of the accident flight would have been conducted in instrument meteorological conditions (IMC) as well. The company was not authorized to operate in IMC, and the flights were at an increased risk as a result.

The company's flight operations relative to moving the staff of the local mine had some of the features of a repetitive charter operation. Repetitive charters incur additional risks, such as the expectation of performance in various operating weather conditions for which the operator is not certified, as compared to non-scheduled operations. However, they are not considered to be scheduled air operators under current Transport Canada (TC) regulations. Therefore, even though such charter operators provide a service with many of the features of a scheduled service, TC does not provide the same degree of oversight as it does for a scheduled operator.

TC conducted program validation inspections (PVIs) at Gogal based on its risk matrix. Gogal had been visited by TC during the years before the occurrence. During the visits, PVIs were conducted, findings were made, and corrective action was undertaken. However, Gogal's operation on the day of the accident, and on the previous day, indicated that it had undertaken risks outside of the areas certified by TC. For example, the aircraft arrived at Snow Lake on the previous flight with an accumulation of ice on the wings, which indicates that the aircraft had operated in IMC, for which the operator was not certified.

2.6 Qualifications

The pilot was certified and qualified for VFR flight in accordance with existing regulations, but did not have an instrument rating. The presence of ice on the aircraft's leading edges after the inbound flight the previous day indicates a likelihood that part of the flight was conducted in IMC, for which the pilot was not qualified, which increased the risk of loss of control and collision with terrain during that flight.

2.7 Flight procedures

The investigation determined that the flaps were up when the aircraft struck the ground. However, information was inconclusive as to the position of the flaps at take-off. The 2 most likely flap positions at take-off are those mentioned in the airplane flight manual (AFM): 0° or 20°. The occurrence aircraft take-off distance was most similar to a flaps 0 take-off configuration. This similarity seems to correlate with evidence at the accident site where the flap lever was in the 0° position. However, it conflicted with information regarding the operator's procedures, which indicated that the standard procedure was to use 20° of flap for take-off. The gravel runway surface, runway upslope and higher aircraft operating weight could account for the longer take-off distance with the flaps selected to 0°. The 78-knot calibrated airspeed (CAS) lift-off speed recovered from the EFIS is lower than the 0˚ flap speed of 83 knots as recommended in the AFM for an aircraft with de-icing fluid on its wings, and higher than the 20˚ flap lift-off speed of between 70 and 75 knots.

The spike in the Chelton-calculated aircraft ground speed, noted toward the end of the flight, could have resulted from a change in wind speed or direction aloft, from a retraction of the flaps in flight, or from global positioning system (GPS) anomalies. If the pilot departed with flaps configured to 0°, the spike in the aircraft ground speed likely resulted from a change in wind speed or direction aloft, and would have temporarily reduced the aircraft's airspeed. The target climb CAS of 104 knots in 0° flap configuration, however, was never reached. If the pilot departed with flaps at 20°, then at some point after departure, the flaps were retracted to 0°. The normal procedure is to select 10° flap upon reaching 85 knots, and not to retract the flaps fully until reaching 95 knots. The maximum CAS the aircraft reached was 90 knots, which would indicate that the flaps should have been at the 10° position. The flaps at 0° in this scenario would indicate that the flaps had been selected fully up either prematurely or inadvertently upon reaching 85 knots. In either case, the sudden change in wind speed, direction aloft, or flap position would have reduced the available lift, likely to the point of wing stall. The aircraft's performance was reduced, and its stall speed was increased, by its overweight condition and by ice contamination on its wing and tail leading edge surfaces, and it likely stalled with little warning to the pilot.

The AFM recommends that if pre-stall buffet or uncommanded pitch oscillations are encountered, the aircraft's pitch attitude be reduced while increasing engine power to the maximum continuous setting and extending the flaps to 10° to help stabilize the airplane. The information recovered from the EFIS indicated that after the spike in aircraft ground speed occurred, the pitch angle began to oscillate. The pitch angle did not decrease, but instead increased to a maximum of 17° before the pitch angle and flight path dropped rapidly, indicating a stalled condition. The increase in pitch attitude, the 0° position of the flaps, and the steady engine power state indicate that the AFM pre-stall recovery procedures were not effectively followed. Although the engine power was increased before impact, the power was applied too late and at too low of an aircraft altitude to conduct an effective recovery.

2.8 Survival aspects

The passengers did not receive a passenger briefing before take-off. Passenger briefings are required so that all passengers are seated and restrained as required. Some passengers' seats were partly reclined, and some passengers were not wearing their lap belts or shoulder harnesses as required for the passenger restraint systems to work as designed. On impact, the aircraft's seats and cabin deformed as designed and partially attenuated the impact forces. However, the improperly seated and restrained passengers were at increased risk of incurring injuries and increased risk of injuring the other occupants.

3.0 Findings

3.1 Findings as to causes and contributing factors

1. The aircraft departed Snow Lake overweight and with an accumulation of ice on the leading edges of its wings and tail from the previous flight. As a result, the aircraft had reduced take-off and climb performance and increased stall speed, and the protection afforded by its stall warning system was impaired.

2. A breakdown in the company's operational control resulted in the flight not operating in accordance with the *Canadian Aviation Regulations* and the company operations manual.

3. As a result, shortly after departure, the aircraft stalled at an altitude from which recovery was not possible.

3.2 Findings as to risk

1. If companies operate in instrument meteorological conditions for which they are not authorized, there is an increased risk that accidents may occur.

2. If Transport Canada does not provide the same degree of oversight for repetitive charter operations as it does for a scheduled operator, the risks in the operator's activities may not be fully evaluated.

3. If passenger briefings are not provided and passengers are not properly seated and restrained, there is an increased risk of injuries to those passengers and the other occupants in the event of an accident.

4. If flights are conducted without ensuring an ice-free airframe, there is a risk of decreased aircraft performance and of loss of control and collision with terrain.

3.3 Other findings

1. On impact, the aircraft's seats and cabin deformed as designed, and this deformation partially attenuated the impact forces.

This report concludes the Transportation Safety Board's investigation into this occurrence. The Board authorized the release of this report on 16 April 2014. It was officially released on 15 May 2014.

Visit the Transportation Safety Board's website (www.bst-tsb.gc.ca) for information about the Transportation Safety Board and its products and services. You will also find the Watchlist, which identifies the transportation safety issues that pose the greatest risk to Canadians. 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

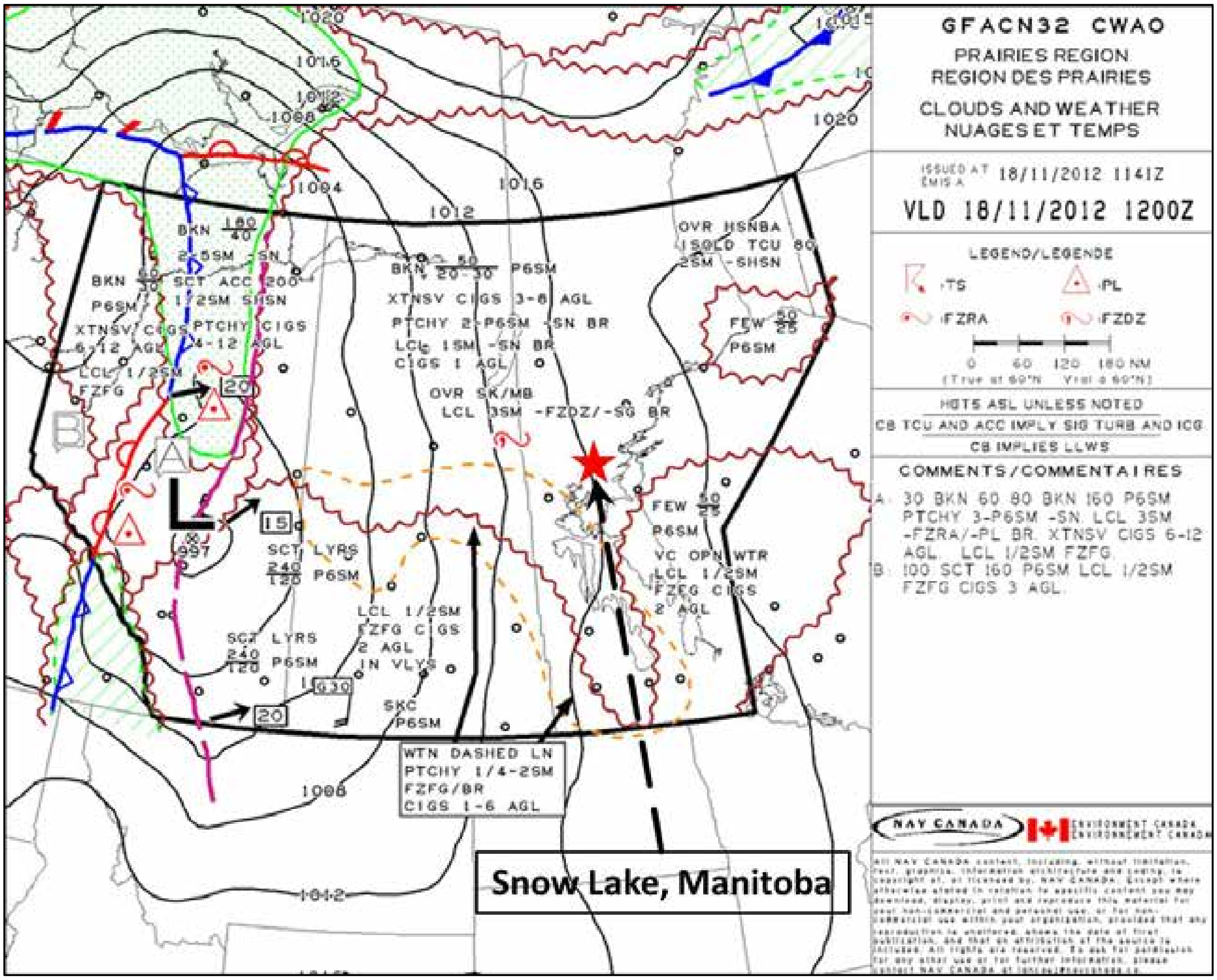
Appendix A – List of Transportation Safety Board Laboratory reports

The following Transportation Safety Board Laboratory reports were completed:

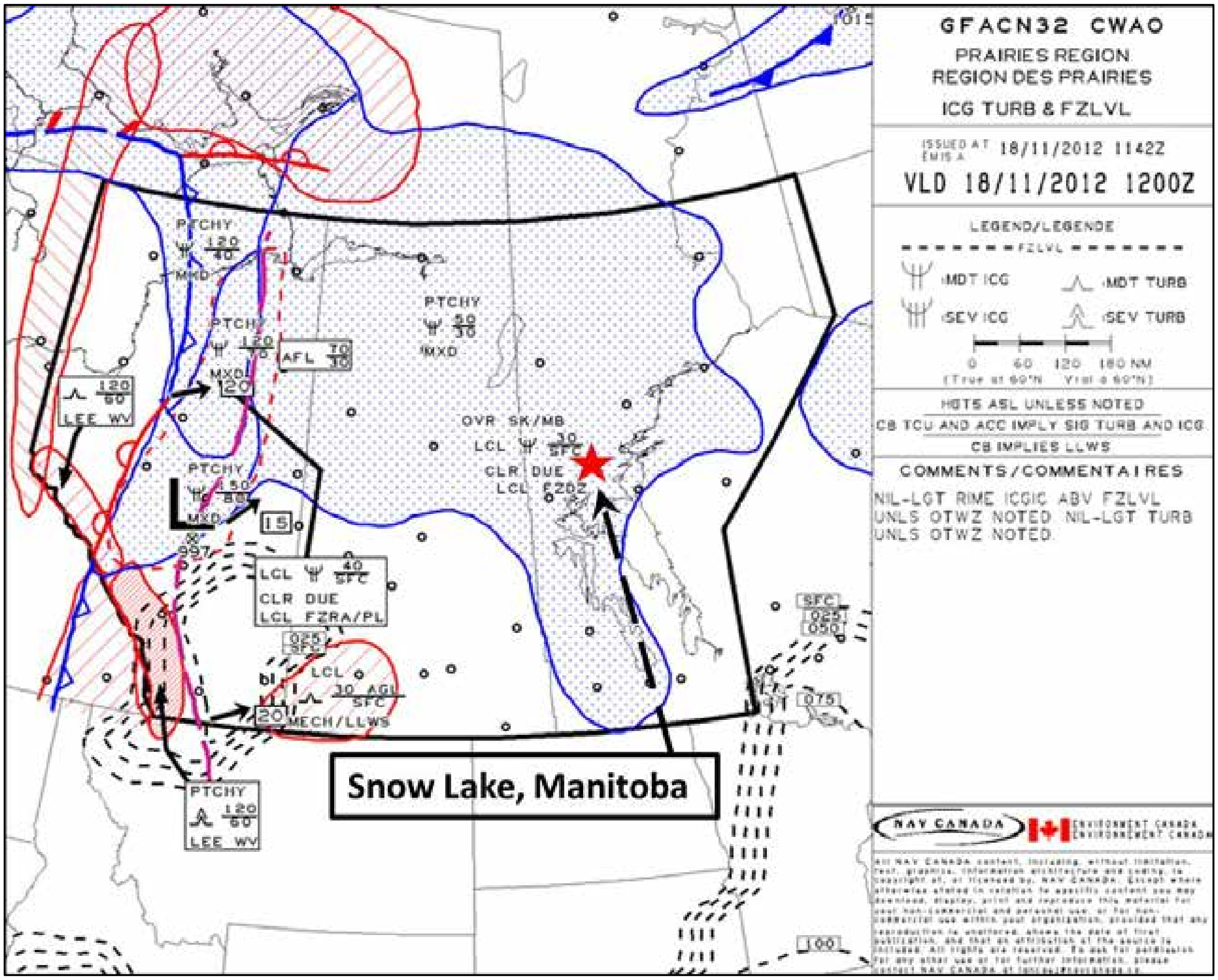
- LP021/2013 – Aircraft Performance Analysis
- LP243/2012 – Instruments and Lamp Analysis

These reports are available from the Transportation Safety Board of Canada upon request.

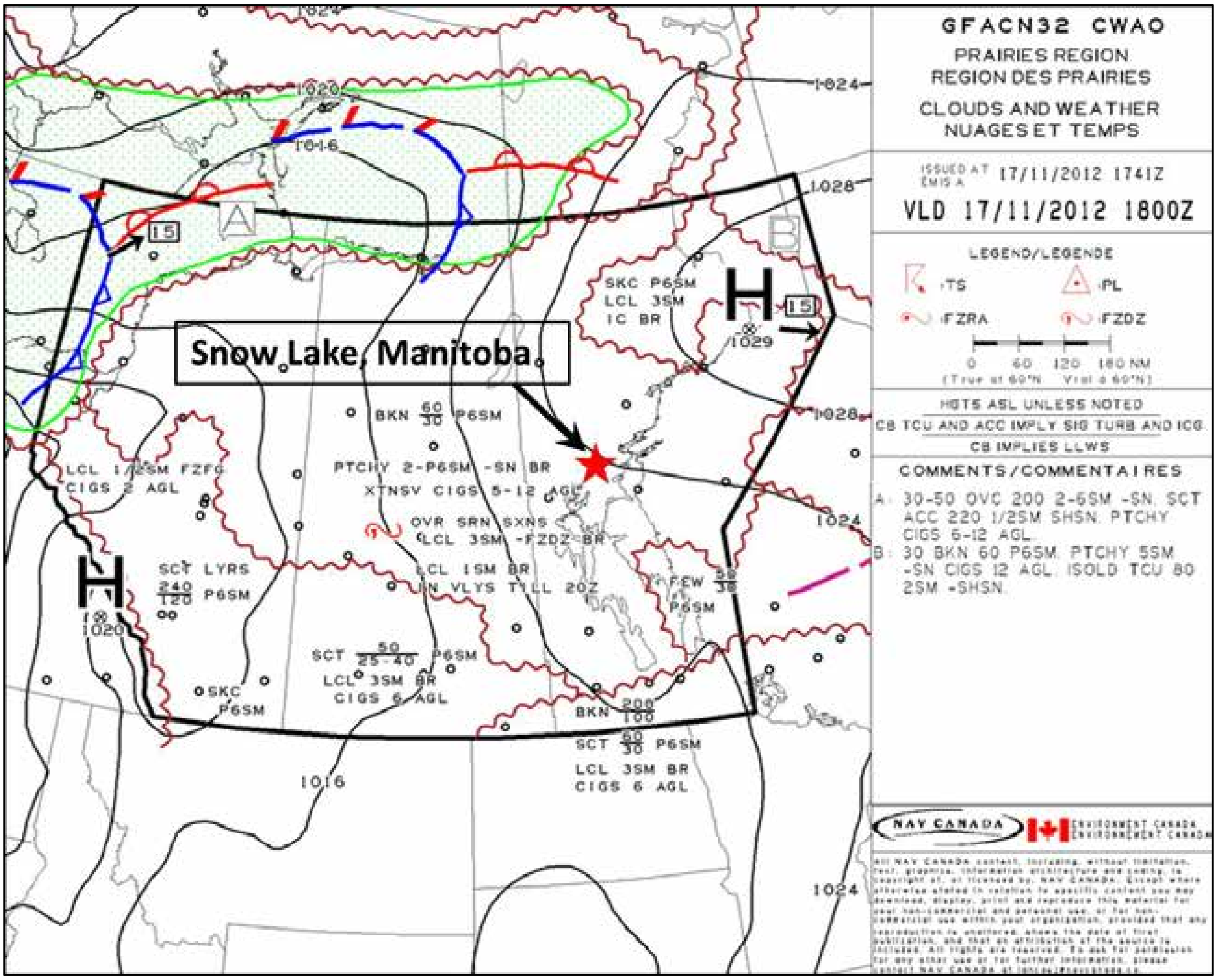
Appendix B – Graphic area forecast: clouds and weather for 18 November 2012 at 12Z



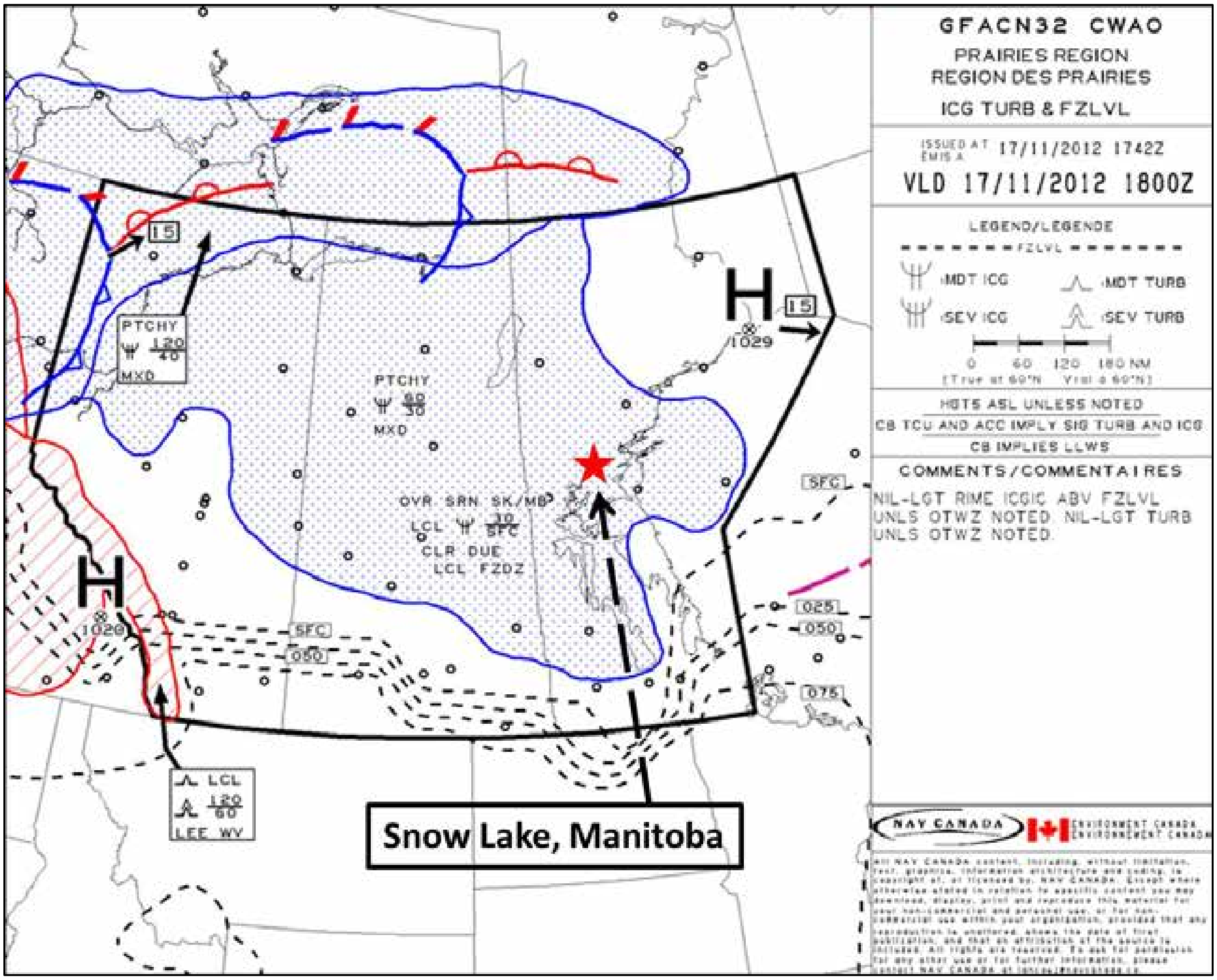
Appendix C – Graphic area forecast: icing and turbulence for 18 November 2012 at 12Z



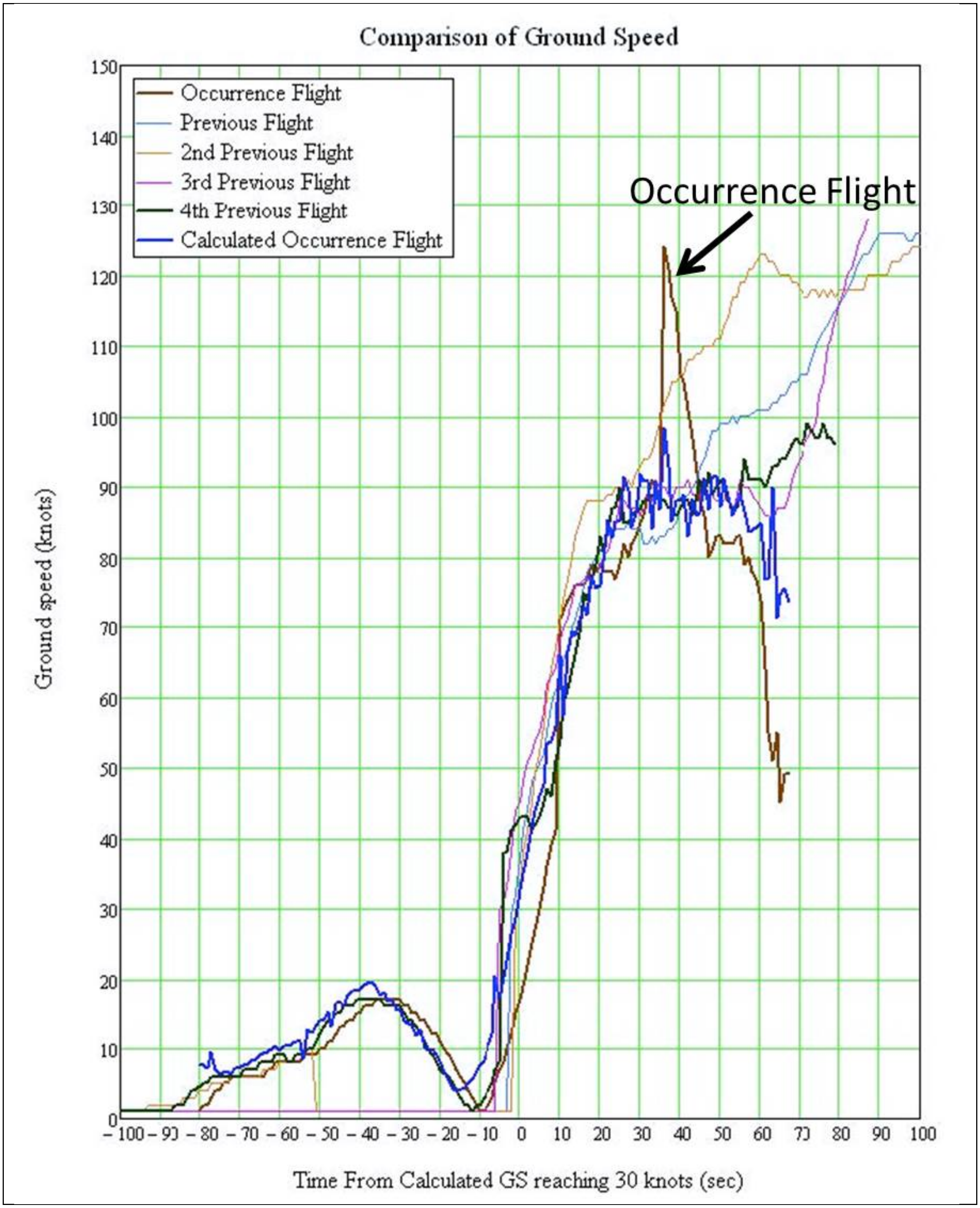
Appendix D – Graphic area forecast: clouds and weather for 17 November 2012 at 18Z



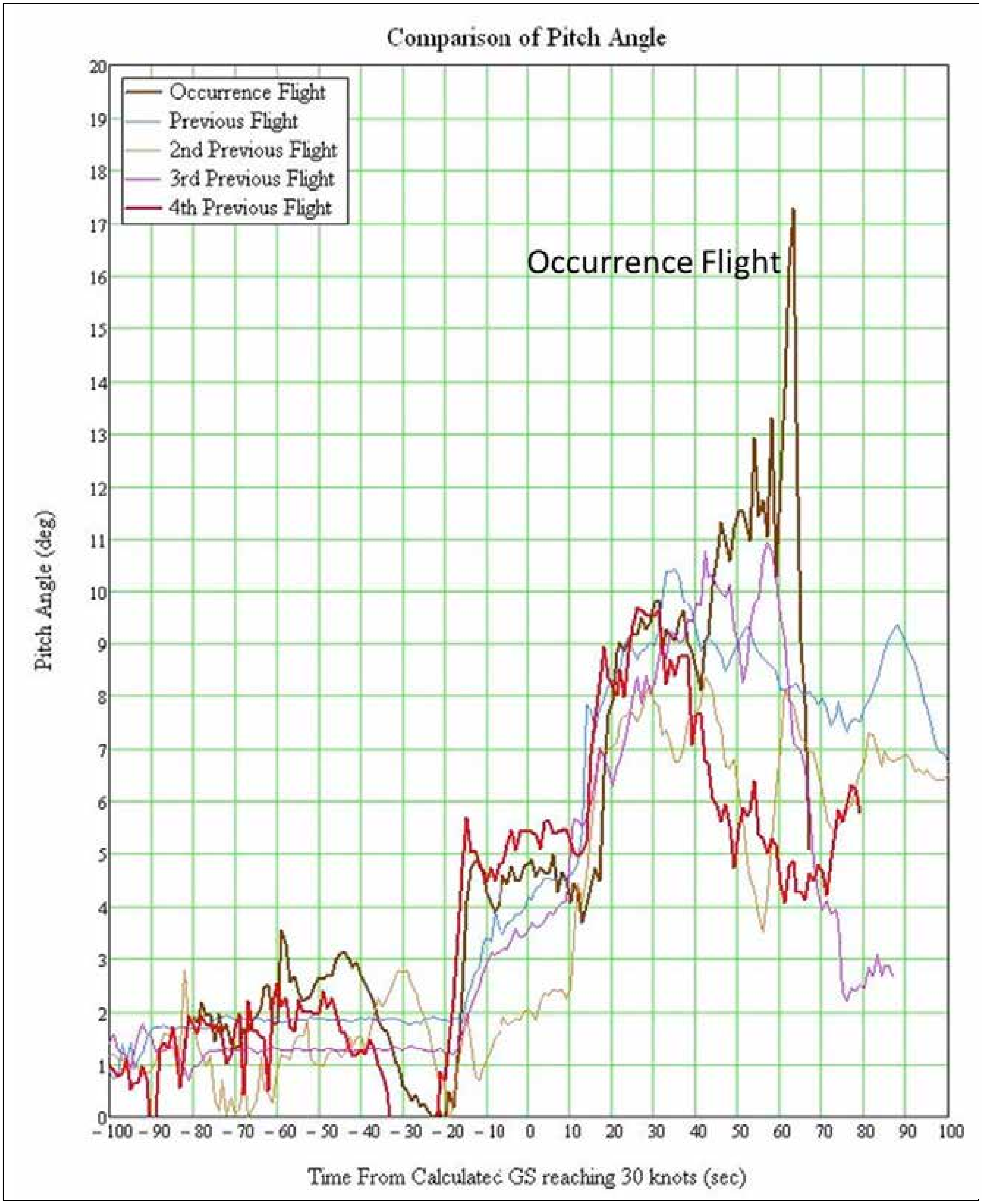
Appendix E – Graphic area forecast: icing and turbulence for 17 November 2012 at 18Z



Appendix F – Comparison of ground speed on the accident flight and four previous flights



Appendix G – Comparison of pitch angle



Appendix H – Flight path of accident flight