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

AIR TRANSPORTATION SAFETY INVESTIGATION REPORT A17Q0030

MID-AIR COLLISION

Cargair Ltd., Cessna 152, C-GPNP
and
Cargair Ltd., Cessna 152, C-FGOI
Montréal/St-Hubert Airport, Quebec, 1.7 nm ESE
17 March 2017

Canada

ABOUT THIS INVESTIGATION REPORT

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.

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

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Executive summary

This investigation examined a mid-air collision between 2 Cessna 152 aircraft (registrations C-GPNP and C-FGOI) that occurred 1.7 nautical miles east-southeast of the Montréal/St-Hubert Airport (CYHU), Quebec, on 17 March 2017. C-GPNP was being operated by a Cargair Ltd. pilot undergoing commercial training who was returning to CYHU from a solo flight in a local training area. C-FGOI was being operated by a student pilot, also training at Cargair Ltd., who was departing CYHU for a solo flight in a local training area. At 1238 Eastern Daylight Time, the 2 aircraft collided at 1500 feet above sea level. C-GPNP was substantially damaged, and its pilot sustained serious injuries. C-FGOI was destroyed, and its student pilot was fatally injured.

Both aircraft were operating under visual flight rules in controlled airspace, and air traffic control had issued altitude restrictions to each aircraft: C-GPNP had been instructed to maintain an altitude of “not below 1600 feet” and C-FGOI had been instructed to maintain an altitude of “not above 1100 feet.” The relative attitudes of the 2 aircraft suggest that when the pilot of C-GPNP became aware of the impending collision with C-FGOI, which was approaching from the left, he made a right turn in an effort to avoid it. Neither pilot saw the other aircraft in time to avoid a mid-air collision, partly owing to the inherent limitations of the see-and-avoid principle.

The investigation found that the density and variety of operations conducted at CYHU increase the complexity of air traffic controller workload. The varying levels of flying skill and language proficiency among the student pilots at the 4 flying schools that are based at CYHU add to the complexity. In addition, inbound and outbound aircraft must follow the visual flight rules (VFR) traffic routes depicted on the VFR terminal procedure charts. The

result is that VFR aircraft pilots with little experience converge with an altitude separation of 500 feet.

In 2008, the International Civil Aviation Organization introduced standards for aviation-specific language proficiency to help ensure that flight crews and controllers were proficient in conducting and comprehending aeronautical radiotelephony communications in English—the language used for aviation communications between aircraft and controllers worldwide. In response, Transport Canada (TC) amended the *Canadian Aviation Regulations* to include a provision on language proficiency, requiring applicants to obtain an operational or expert level in English, French, or both, before being issued a pilot's licence.

The investigation determined that regulatory oversight of TC's aviation language proficiency test (ALPT) program is limited to administrative verifications. With limited regulatory oversight, it is not possible to assess whether and to what extent approved examiners administer the ALPT in a manner that ensures validity, reliability, and standardization nationally.

Following this accident, TC published a Civil Aviation Safety Alert on the risks associated with student pilots conducting solo flights when they have not yet achieved the minimum operational level on the aviation language proficiency test.

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1.0 FACTUAL INFORMATION

1.1 History of the flight

On the morning of 17 March 2017, a Cessna 152 (registration C-GPNP), operated by Cargair Ltd. (Cargair), was scheduled for 2 training flights to be flown out of the Montréal/St-Hubert Airport (CYHU), Quebec. Cargair cancelled the earlier of the 2 flights due to a reported problem with the aircraft's radiocommunication system. Maintenance personnel replaced the NAV/COM very high frequency (VHF) radio, and the aircraft was released for flight.

The pilot of C-GPNP arrived at Cargair at approximately 1030[1] to prepare for the remaining scheduled flight, which was to be flown solo under visual flight rules (VFR) to a local training area. There, the pilot was to practise the exercises required for the flight test toward the issuance of a commercial pilot licence. At 1118, the pilot reported to Cargair dispatch that he was leaving the ramp, and at 1121:08, he contacted the ground controller for taxi instructions and requested an eastbound departure. There was more than one radio transmission at that moment, and the ground controller broadcasted, in French [translation], "Several calls at the same time … uh … over."[2] At 1122:34, following a period of silence on the frequency, the pilot contacted ground control a 2nd time; he was instructed to taxi toward Runway 24L, and did so.

At 1128:50, the tower controller cleared C-GPNP for an eastbound departure, with an altitude restriction of not above 2000 feet above sea level (ASL). At 1134:40, while in flight and approximately 5 nautical miles (nm) east of CYHU, the pilot was cleared to switch to the enroute frequency. He acknowledged receipt of the clearance 4 seconds later, and the flight continued uneventfully for the next 56 minutes.

At approximately 1130, a student pilot arrived at Cargair to prepare for a scheduled VFR solo flight to a local training area, using another Cargair Cessna 152 (registration C-FGOI). The purpose of the flight was to practise the exercises required for the flight test toward a private pilot licence.

The student pilot of C-FGOI reported to Cargair dispatch at 1222 that he was leaving the ramp, and contacted ground control at 1227:22 for taxi instructions, requesting an eastbound departure. Approximately 20 seconds later, the ground controller issued taxi instructions to C-

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[1] All times are Eastern Daylight Time (Coordinated Universal Time minus 4 hours).

[2] The source of all quoted material from radio transmissions in this report is NAV CANADA, St-Hubert Tower frequency audio.

FGOI, and the student pilot asked the controller to repeat them. The student pilot acknowledged the repeated instructions, then taxied to Runway 24L.

At 1230:53, as the pilot of C-GPNP was returning from the training area, he made 3 attempts to contact the tower. His first 2 transmissions had remained unanswered and were not recorded by air traffic control (ATC) audio. After his 3rd transmission had been acknowledged by the tower controller, the pilot of C-GPNP requested clearance to return to CYHU. At 1231:06, the tower controller cleared C-GPNP for a left downwind approach to Runway 24L with an altitude restriction of not below 1600 feet ASL. The pilot acknowledged the instruction 9 seconds later, when C-GPNP was approximately 11.5 nm to the southeast of the airport, by reading back, "Not below one point six."

At 1234:35, the C-FGOI student pilot contacted the tower and stated that he was ready for takeoff. The tower controller initially instructed C-FGOI to line up on Runway 24L, then to "left turn eastbound, not above one thousand one hundred feet, one point one, cleared takeoff runway two four left." As the student pilot of C-FGOI read back the clearance, stating in part "not above one thousand," the tower called another aircraft, interrupting C-FGOI's readback.

C-GPNP entered the control zone from the southeast at 1236, at 2000 feet ASL and approximately 5 nm from CYHU. C-FGOI was still on the runway at that time, preparing for takeoff.

At 1236:18, when C-GPNP was approximately 4.5 nm to the southeast, inbound for CYHU, C-FGOI was airborne off Runway 24L and climbing through 800 feet ASL. Fourteen seconds later, C-FGOI reached its assigned altitude of 1100 feet ASL. The distance between C-GPNP and C-FGOI was approximately 4.3 nm.

At 1237:36, the tower controller provided C-GPNP with traffic information[3] about C-FGOI.[4] The 2 aircraft were approximately 1.8 nm apart; C-GPNP was inbound from the southeast at 1800 feet ASL, and C-FGOI was at 1100 feet ASL on an east-northeast heading (Figure 1). When the controller had heard no acknowledgment from C-GPNP of the traffic information after 11 seconds, the controller repeated the transmission. The distance between the 2 aircraft had narrowed to 1.3 nm: the radar display showed C-GPNP at 1800 feet ASL and C-FGOI at 1100 feet ASL.

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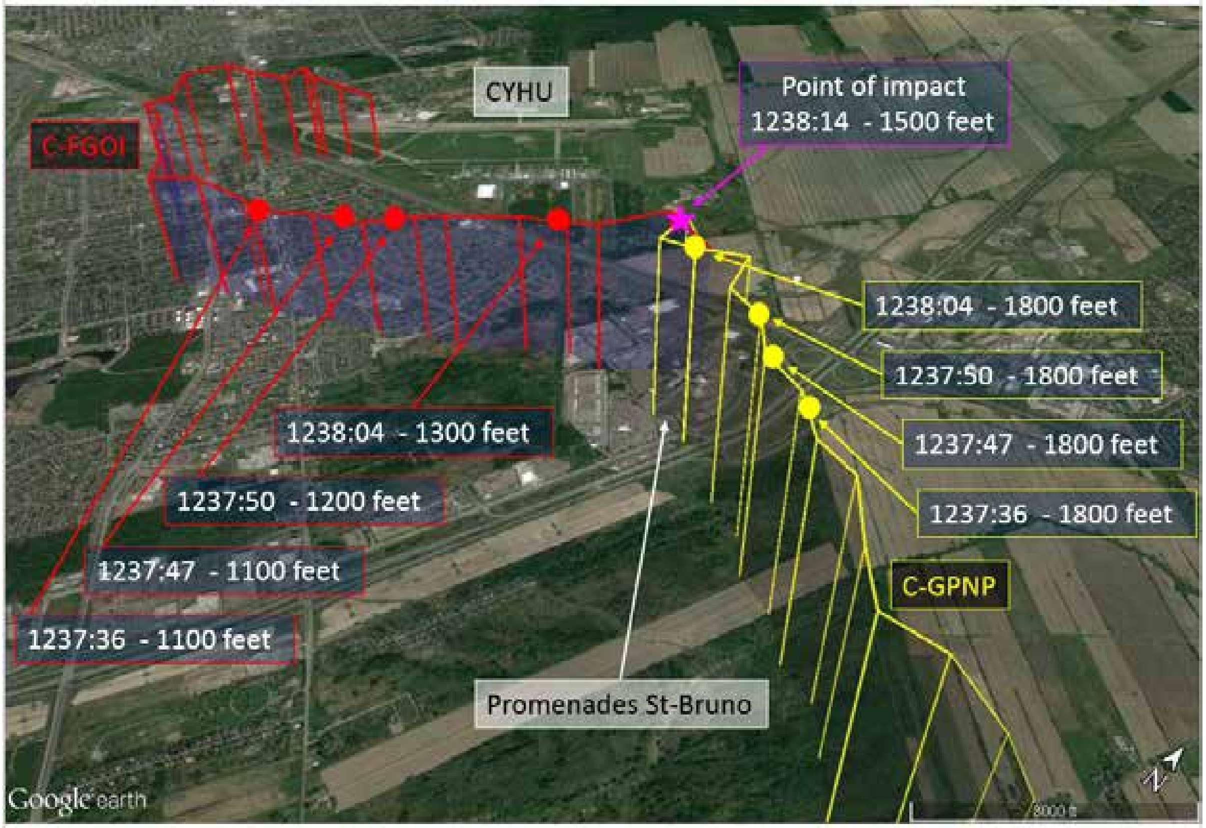
3 Traffic information is "information issued to pilots regarding other known or observed traffic that may be in such proximity to their position or intended route as to warrant their attention." (Source: NAV CANADA, *Manual of Air Traffic Services – Tower* [31 August 2016], Glossary.)

4 "Papa November Papa, make sure you maintain one thousand six hundred feet, traffic ten o'clock one mile, Cessna eastbound one thousand one hundred feet."

Figure 1. Flight paths of C-FGOI and C-GPNP (Source: Google Earth, with TSB annotations)



At 1238:04, the tower controller made a further attempt to communicate with C-GPNP, and again heard no reply. C-GPNP and C-FGOI were now approximately 0.5 nm apart; the radar display showed that C-GPNP was at 1800 feet ASL, while C-FGOI had begun climbing and was at 1300 feet ASL.

When the pilot of C-GPNP realized that the tower controller could not hear his responses, he began to troubleshoot the aircraft's radiocommunication system, and the aircraft descended below 1600 feet. By the time he saw C-FGOI, the impact was imminent and the collision could not be avoided.

Radar altitude readouts for both aircraft were lost at 1238:10; however, their radar targets remained displayed.[5] The tower controller made a final call to C-GPNP at 1238:14, at which time the distance on radar separating C-GPNP and C-FGOI was less than 0.1 nm. The 2 aircraft had already collided at approximately 1500 feet ASL,[6] above the Promenades St-Bruno shopping mall, 1.7 nm east-southeast of CYHU.

C-GPNP became uncontrollable following the collision. Its pilot unlocked the cabin door and assumed a brace position, protecting his head with his arms. The aircraft struck the roof of the shopping mall and came to rest in an upright position on top of a natural gas line on the roof. The pilot sustained serious injuries but was able to partially exit the wreckage.

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5 Radar image refreshes approximately every 3.4 seconds.

6 Equipment limitations correct aircraft altitude to the nearest 100 feet. For example, an aircraft appearing at 1500 feet could be operating between 1450 and 1549 feet.

C-FGOI entered a dive following the collision. It struck the ground in the parking lot near a main entrance of the shopping mall, and came to rest in a nose-down attitude. The aircraft was severely deformed by impact forces, and its engine was lodged beneath the instrument panel. The impact was not survivable; the student pilot of C-FGOI was fatally injured.

The search-and-rescue satellite system did not receive a signal from either aircraft's emergency locator transmitter (ELT).

The ground controller activated emergency procedures at 1238:41, as per those specified in the NAV CANADA *Manual of Air Traffic Services – Tower* (MATS – Tower) and the *Manuel d'exploitation d'unité – Tour de St-Hubert* (the unit operations manual for St-Hubert Tower).

The first of multiple calls to 911 was received at 1239. Emergency services arrived shortly thereafter.

1.2 Injuries to persons

Table 1. Injuries to persons – C-GPNP

Injuries	Pilot	Passengers	Others	Total
Fatal	0	–	–	0
Serious	1	–	–	1
Minor/None	0	–	–	0
Total	1	–	–	1

Table 2. Injuries to persons – C-FGOI

Injuries	Pilot	Passengers	Others	Total
Fatal	1	–	–	1
Serious	0	–	–	0
Minor/None	0	–	–	0
Total	1	–	–	1

1.3 Damage to aircraft

1.3.1 C-GPNP

C-GPNP was substantially damaged by the collision, which caused the outboard section of the left wing and the empennage to separate from the rest of the aircraft. There was no post-impact fire.

1.3.2 C-FGOI

C-FGOI was destroyed when it struck the ground. There was no post-impact fire.

1.4 Other damage

1.4.1 C-GPNP wreckage site

C-GPNP came to rest on the roof of the Promenades St-Bruno shopping mall, on a rooftop gas line feeding the building. There was damage to the roof structure, along with contamination from fuel that leaked from the aircraft. As a precautionary measure, the shopping mall closed immediately after the accident and remained closed on the following day to allow technicians to inspect and replace a section of the damaged gas line. In the days following the accident, as snow on the roof started to melt, some areas of water ingress resulting from the damage were identified and repaired.

1.4.2 C-FGOI wreckage site

C-FGOI came to rest in the parking lot of the same shopping mall, near a main entrance and restaurant. Several cars parked near the wreckage sustained minor damage after being struck by parts of the aircraft that separated from the main wreckage on impact. There were no injuries to bystanders.

1.5 Personnel information

Table 3. Personnel information

	Pilot of C-GPNP	Student pilot of C-FGOI
Pilot licence/permit	Private pilot licence	Student pilot permit
Medical expiry date	01 April 2021	01 September 2021
Total flying hours	135.8	39.5
Flight hours on type	135.8	36.5
Flight hours, dual	66.4	30.7
Flight hours, solo	69.4	8.8
Flight hours in a simulator	12.4	0
English-language proficiency assessment*	Operational	Operational

* See Section 1.18.3 for details about language proficiency.

1.5.1 Pilot of C-GPNP

The pilot of C-GPNP was an international student enrolled in flight training whose first language was neither English nor French. Records indicate that the pilot was certified and qualified for the flight in accordance with existing regulations. The pilot held a current private pilot licence for single-engine land planes and a valid medical certificate. His English-language proficiency had been assessed as operational. Appendix A shows the scale used by Transport Canada (TC) to assess language proficiency.

1.5.1.1 Previous flight experience

The Transportation Safety Board of Canada (TSB) obtained radar and audio data for 4 solo flights that the pilot of C-GPNP had conducted in the training area prior to the occurrence flight. An analysis of the historical flight data showed no events in which the pilot had provided an incorrect readback or was otherwise corrected by ATC, nor did the analysis show any deviations from clearances.

There was no indication that pilot fatigue played a role in the occurrence.

1.5.2 Student pilot of C-FGOI

The student pilot of C-FGOI was an international student enrolled in flight training whose first language was neither English nor French. Records indicated that the student pilot was certified and qualified for the flight in accordance with existing regulations. He held a student pilot permit for single-engine land planes and a valid medical certificate. His English-language proficiency had been assessed as operational. However, before obtaining an operational assessment, the student pilot had been authorized to conduct 3 solo flights.

1.5.2.1 Previous flight experience

Prior to the occurrence flight, the student pilot of C-FGOI had been authorized for, and had flown, 8 solo flights. Of those, 5 had been devoted to flying circuits, and 3 to practising specific exercises in the training area. The TSB obtained radar and audio data for the latter 3 flights. Analysis of the historical data showed that on 2 occasions, while returning from the training area, ATC had given the student pilot an altitude restriction of “not below.” On both occasions, the student pilot had incorrectly read back the altitude restrictions as “not above”; ATC corrected the student pilot, who then read back the correct instruction. The altitude restrictions were part of a standard ATC clearance given to all aircraft returning to the airport from the training area.

In addition, on 2 occasions, the student pilot had deviated from an ATC clearance. On one of those occasions, he had cut in front of an aircraft that he was supposed to follow when approaching the airport, resulting in a subsequent controller instruction to turn right direct to the threshold of Runway 06R. On the other occasion, the student pilot had been cleared for a right-hand downwind approach to Runway 06R; however, when the landing clearance was issued, he was cautioned by the controller that he had extended the base leg too far past the extended centreline of Runway 06R and was actually on final approach to Runway 06L. Such deviations are not unusual, especially with student pilots who have limited solo flight experience.

Departure information was available for 1 of the solo flights to the training area. On that occasion, the student pilot had received a clearance with an altitude restriction of “not above 2000 feet” on departure. The student read back the altitude restriction correctly, and the departure was uneventful.

The historical flight data showed generally that, even when the limitations of the displayed radar altitude were taken into consideration, the student pilot had difficulty levelling off and maintaining a consistent altitude.

There was no indication that pilot fatigue played a role in the occurrence.

1.5.3 St-Hubert Tower air traffic controller

Table 4. Controller information

Licence	Air traffic controller
Medical expiry date	01 September 2017
Language proficiency assessment	Expert
Experience as a controller	6 years
Experience in present unit	6 years
Hours on duty prior to occurrence	7 hours 8 minutes
Hours off duty prior to work period	15 hours 32 minutes

Records indicate that the air traffic controller at the combined tower controller for Tower 1 and Tower 2 position at the time of the occurrence was qualified in accordance with existing regulations. He held a TC-issued air traffic controller licence and a valid medical certificate. His language proficiency had been assessed as expert in English and French, and he had been employed as a controller at CYHU since 2011.

Regular work shifts at the St-Hubert Tower are normally 8 hours and 28 minutes. On the day of the occurrence, which was the controller's 7th consecutive day of work, he had accepted overtime work, starting his shift at 0530. The following day was scheduled as his day of rest.

During a work shift, controllers work in 40-minute blocks, rotating among the ground, tower, and coordinator positions. Their breaks depend on the prevailing volume of traffic and workload. At the time of the occurrence, the controller had been in the tower position for approximately 44 minutes, and was about to be relieved. Prior to assuming the tower controller position, he had performed ground controller duties from 1120 until 1200. The controller's last scheduled break had been from 1040 until 1120.

There was no indication that controller fatigue played a role in the occurrence.

1.6 Aircraft information

The Cessna 152 is a lightweight 2-seat general aviation aircraft that is popular with private owners and flying schools worldwide. The aircraft was type-certificated by the United States Federal Aviation Administration in March 1977.

1.6.1 C-GPNP

Table 5. Aircraft information: C-GPNP

Manufacturer	Cessna Aircraft Company
Type, model, and registration	Cessna 152, C-GPNP
Year of manufacture	1979
Serial number	15284152
Certificate of airworthiness/flight permit issue date	28 July 2016
Total airframe time	10 207
Engine type (number of engines)	Avco Lycoming O-235-L2C (1)
Propeller/Rotor type (number of propellers)	McCauley 1A103/TCM (1)
Maximum allowable takeoff weight	757.5 kg
Recommended fuel type(s)	100/130, 100LL
Fuel type used	100LL

Records indicate that the aircraft was certified, equipped, and maintained in accordance with existing regulations and approved procedures. The aircraft's weight and centre of gravity were within the prescribed limits at the time of the occurrence. No indication was found that an airframe failure or system malfunction had occurred before or during the flight.

1.6.1.1 Push-to-talk switch

The aircraft was equipped with a NAV/COM VHF radio and a panel-mounted intercom system. The push-to-talk (PTT) switch, installed on the pilot (left) side of the aircraft, was mounted on the control yoke and permanently connected to the intercom system via a coiled retractable cord that hung from the control yoke and was routed through the instrument panel.

The pilot of C-GPNP experienced intermittent radiocommunication problems prior to entering the control zone and immediately preceding the collision. Although the pilot was able to receive ATC communications, his communications to ATC were transmitted only intermittently.

1.6.2 C-FGOI

Table 6. Aircraft information: C-FGOI

Manufacturer	Cessna Aircraft Company
Type, model, and registration	Cessna 152, C-FGOI
Year of manufacture	1980
Serial number	15283952
Certificate of airworthiness/flight permit issue date	02 December 2005
Total airframe time	11 751
Engine type (number of engines)	Avco Lycoming O-235-L2C (1)
Propeller/rotor type (number of propellers)	Sensenich 72CKS6-0-54 (1)
Maximum allowable takeoff weight	757.5 kg
Recommended fuel type(s)	100/130, 100LL
Fuel type used	100LL

Records indicate that the aircraft was certified, equipped, and maintained in accordance with existing regulations and approved procedures. The aircraft's weight and centre of gravity were within the prescribed limits at the time of the occurrence. No indication was found that an airframe failure or system malfunction had occurred prior to or during the flight.

1.7 Meteorological information

The reported aerodrome routine meteorological report (METAR) for CYHU at 1200 was as follows:

- Winds 300° true (T) at 3 knots, variable between 210°T and 330°T
- Visibility 9 statute miles
- Sky clear
- Temperature −5 °C; dew point −16 °C
- Altimeter setting 30.20 inHg

The collision occurred at approximately 1238 in clear conditions and good visibility. The weather conditions and position of the sun were not considered to be factors in the accident.

1.8 Aids to navigation

1.8.1 Visual flight rules terminal procedure chart

Aeronautical information required for VFR flight that cannot be depicted on visual aeronautical charts is published in the *Canada Flight Supplement* (CFS).[7] When important information about a given aerodrome within a control zone cannot be adequately described within the sketch or text normally used in the CFS, a VFR terminal procedure chart is published in the CFS.

A VFR terminal procedure chart depicts all VFR call-up points as well as VFR checkpoints, where pilots must report to ATC prior to entry into the control zone area. The chart also depicts fixed-wing VFR routes that are to be followed by VFR aircraft flying in and out of the control zone.

1.9 Communications

At the time of the occurrence, 2 controllers were providing airport control services at CYHU: the ground controller and the combined tower controller for Tower 1 and Tower 2 (see section 1.17.3.1). Both of the aircraft involved in the occurrence had established communication with ATC. However, the pilot of C-GPNP was experiencing difficulties with the aircraft's radio. He was receiving transmissions from ATC, but ATC did not hear several of his transmissions.

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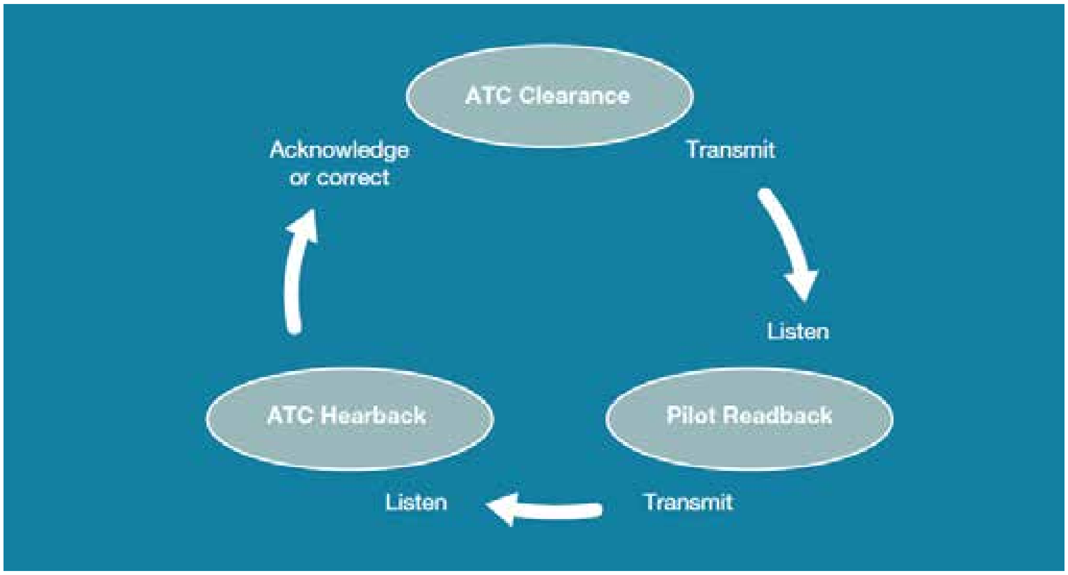
[7] The *Canada Flight Supplement* (CFS), published by NAV CANADA, contains information on all registered aerodromes in Canada; each aerodrome is normally represented by a sketch depicting the aerodrome and its immediate environment as seen from the air.

1.9.1 Hearback and readback

When an air traffic controller issues an instruction, pilots must acknowledge its reception and comply with it. In 2015, NAV CANADA published *VFR Phraseology*, a learning tool and reference guide for all pilots using Canadian airspace, which explains that

> A complete radio transmission is made up of a number of parts and is cyclical in nature. Both persons involved must state their request/intentions, listen for feedback and acknowledge the other person's response. [Figure 2]
>
> The listening portion of the cycle is just as important as the speaking portion. Careful listening (hearback) may prevent errors from occurring.[8]

Figure 2. General format of radiocommunication (Source: NAV CANADA, VFR Phraseology, Version 1 (May 2015), General Format of Radio Communication, p. 14)



In addition, *VFR Phraseology* specifies the following:

> The communications between ATS [air traffic services] and pilots are intended to ensure the safe passage of all aircraft travelling through designated airspace. An important aspect of this communication is hearback/readback. While operating in VFR flight, the pilot is not required to read back each transmission, unless requested by ATS.
>
> **Reading back instructions as well as clearances allows both you and ATS to correct any mistakes in what has been said and heard.**
>
> Some of the most safety-critical clearances and instructions that may be read back are:
>
> - clearance or instruction to enter, land on, take off from, hold short, cross or backtrack on any runway
> - route clearances
> - the runway in use, altimeter settings, level/heading/speed instructions
> - transponder codes[9]

8 NAV CANADA, *VFR Phraseology*, Version 1 (May 2015), General Format of Radio Communication, p. 14.

9 Ibid., p. 15.

1.10 Aerodrome information

CYHU is located in the Saint-Hubert borough of the city of Longueuil, Quebec. It has 3 asphalt runways (Runway 06L/24R, Runway 06R/24L, and Runway 10/28) (Figure 3). At the time of the occurrence, both Runway 24R and Runway 24L were in use.

Figure 3. Montréal/St-Hubert Airport (CYHU) (Source: Développement Aéroport Saint-Hubert de Longueuil [DASH-L], with TSB annotations)

CYHU is a heavily used general aviation airport that receives a high volume of VFR traffic, largely due to the 4 flying schools[10] based there. The airport serves as a large learning centre for Canadian and international pilots, and is also used by small and large aircraft for private, commercial (both scheduled and charter), and military operations. Its mix of VFR and instrument flight rules (IFR) traffic results in high traffic density and complexity.

Given that aircraft are leased to students by the hour, waves of simultaneous departures and arrivals occur. The number of training flights on a given day varies depending on weather conditions.

1.11 Flight recorders

Neither aircraft was equipped with a flight data recorder or a cockpit voice recorder, nor were such recorders required by regulation.

10 The 4 flying schools are Cargair, Air Richelieu, Saint Hubert Flying School, and CPAQ Aéro.

1.12 Wreckage and impact information

1.12.1 General

Both aircraft were examined at the accident site and again at the TSB Engineering Laboratory in Ottawa, Ontario, in the presence of a representative from the manufacturer.

1.12.2 Accident site

1.12.2.1 C-GPNP

The main wreckage of C-GPNP was found on the roof of the Promenades St-Bruno shopping mall, in an upright and approximately level attitude, on top of a yellow gas line (Figure 4). At the time of the occurrence, the roof was covered in snow due to a heavy snowstorm 2 days earlier. There were no signs that the aircraft had skidded in the snow or struck any other area of the roof.

Figure 4. Wreckage of C-GPNP (Source: Service de police de l'agglomération de Longueuil)

The outboard section of the left wing had separated from the aircraft and was found on the roof approximately 249 feet from the main wreckage, indicating that the separation had occurred in the air. The aft section of the fuselage and empennage had separated from the aircraft and were found embedded in C-FGOI's wreckage, also consistent with an in-air separation.

1.12.2.2 C-FGOI

The wreckage of C-FGOI was found in the parking lot, near a main entrance to the shopping mall. The aircraft had come to rest in a nose-down attitude, with the engine lodged beneath the instrument panel. The forward section of the fuselage was severely deformed, consistent with a high-energy collision with the ground along the aircraft's longitudinal axis (Figure 5).

Figure 5. Wreckage of C-FGOI (Source: Nicholas Dumont)

Both wings had struck the ground and were found just in front of the fuselage. The empennage had separated from the airframe and was found behind the aft section of the fuselage, indicating that the separation had occurred on impact with the ground.

1.12.3 Laboratory examination

1.12.3.1 C-GPNP

The laboratory examination established that, as the 2 aircraft collided, C-FGOI's propeller came into contact with the bottom surface of C-GPNP's left wing, rendering 3 cuts to the wing. One cut, made just forward of the left-wing rear spar, near the inboard end of the aileron of C-GPNP, appeared to be the first point of contact between the 2 aircraft. This damage was consistent with a cut from the bottom upward, indicating that C-FGOI approached C-GPNP from below.

Further examination of the fractured end of C-GPNP's left wing indicated that the first propeller strike cut through a substantial portion of the rear spar and aft portion of the wing. This initiated the bending and torsional failure of the wing under aerodynamic load, resulting in separation of that section of the wing from the aircraft.

The left-wing structure aft of the forward spar showed signs of deformation into an arc shape, and bore red-paint transfer markings as well as a number of scratches. That damage was also consistent with a strike from below by C-FGOI.

Black tire marks were found on the left side of C-GPNP's fuselage, just aft of the cargo compartment. The marks were consistent with a strike by C-FGOI's nose wheel to the left side of

C-GPNP's fuselage following the initial impact. C-FGOI then struck the left horizontal stabilizer of C-GPNP, severing its empennage.

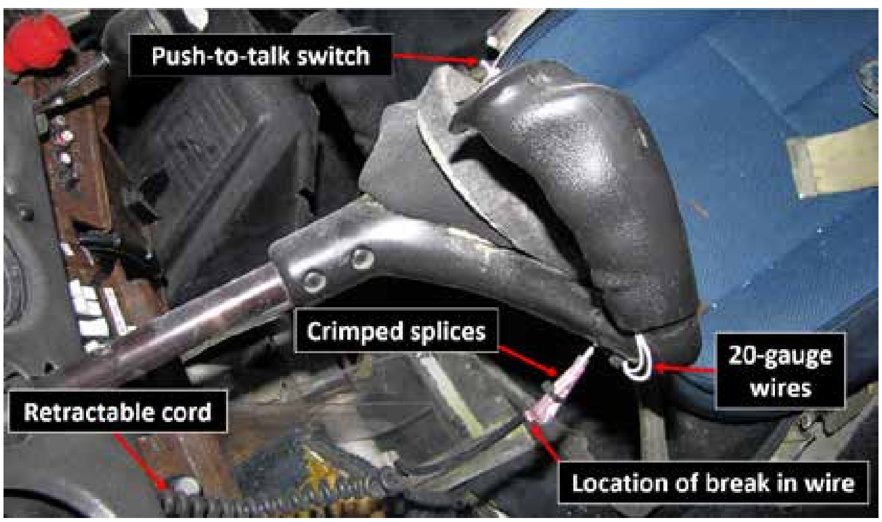
Although there was a small dent on C-GPNP's belly, no scratches were observed. The dent was attributable to the aircraft's contact with the gas line as the aircraft came to rest on the roof of the shopping mall. The small size of the dent and the fact that the gas line, though damaged, was not breached indicated that the aircraft struck the roof at a relatively low speed.

1.12.3.1.1 Push-to-talk switch

The aircraft's NAV/COM VHF transmitter/receiver and accompanying intercom system were examined for defects to determine the cause of the intermittency of the radio's transmissions. The pilot side of the cockpit was fitted with a handset, which was slipped over the aircraft's control yoke and included the intercom's PTT switch at the top. Tests conducted on the pilot PTT switch showed that it was necessary to depress the switch twice for the radio to be triggered into transmission mode. Further, movement of the control yoke caused transmissions to be intermittent.

The examination found that the retractable cord connecting the switch to the intercom was routed through terminals at the back of the pilot-side microphone and headset jack panel. Further examination of the PTT switch revealed a defect that originated from pre-existing crimped wire splices located just forward of the control yoke. The splices connected the wires running from the grip of the control-yoke handset to those in the retractable cord (Figure 6). The wire splices and adjoining wires were unsupported and had been left to hang, and were therefore bearing all motion and tension loads. The retractable cord was not secured to the control yoke.

Figure 6. C-GPNP's push-to-talk switch installation



It was determined that the intermittency of the radio's transmissions was likely caused by the break found in one of the wires of the retractable cord, adjacent to the crimped splice. A detailed examination of the broken wire identified distinct necking (a localized narrowing resulting from reduction in the strand cross-section) at the location of the break. Necking at the point of a rupture is seen when wires have failed in overload due to disproportionately applied tensile loads (Figure 7 and Figure 8).

Figure 7. Computed tomography scan view of the broken wire

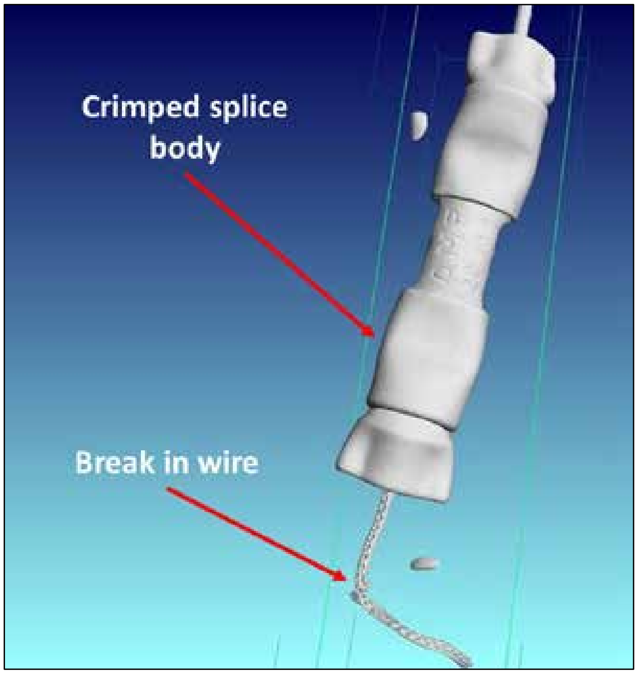
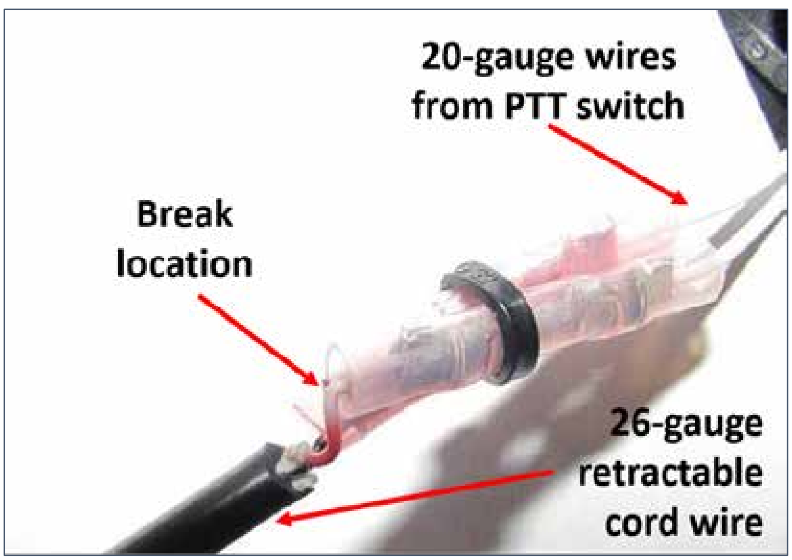


Figure 8. Detailed view of location of break in wire



1.12.3.2 C-FGOI

Examination of C-FGOI's 2-bladed propeller showed impact dents on the leading edges of both blades, near their tips. The dents were consistent with the propeller blades cutting through a strong structure, such as the lower cap of C-GPNP's left-wing rear spar (Figure 9 and Figure 10).

Figure 9. Impact dents on blade 1 of C-FGOI's propeller

Figure 10. Impact dents on blade 2 of C-FGOI's propeller

All 3 landing gear wheels had separated from the aircraft. Examination of the nose landing gear showed rub marks over a large area of its right side, consistent with the nose wheel coming into contact with C-GPNP's fuselage.

The structural damage to C-FGOI was found to be consistent with a nose-down vertical or near-vertical impact with the ground at high speed.

1.12.3.3 Collision sequence

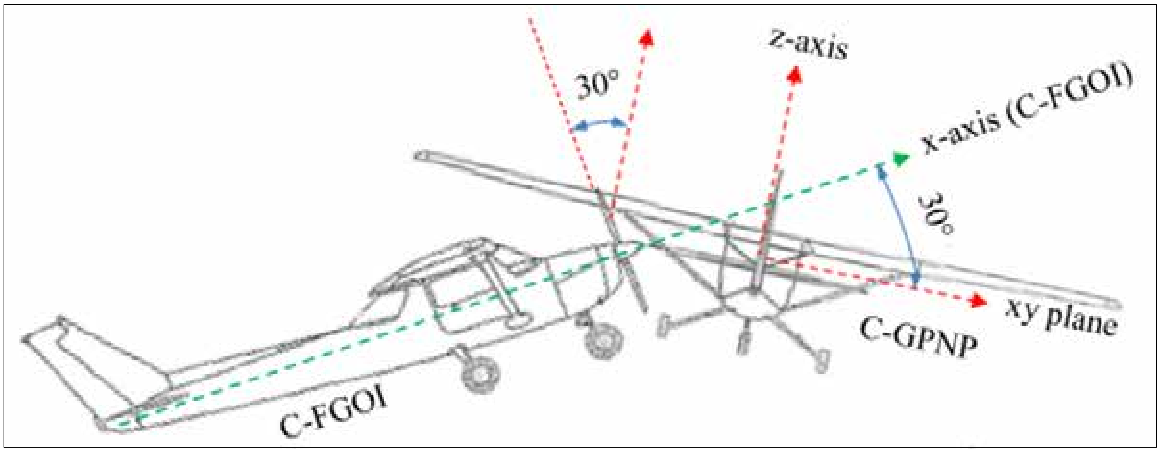
It was determined that C-FGOI had been approaching C-GPNP from the front and to the left at the time of the collision.

Based on the angle of the first cut on C-GPNP's left wing, it was determined that the angle of the comparative attitudes of the 2 aircraft was approximately 30° relative to their vertical axis, which could have resulted from 3 possible scenarios:

- C-FGOI was pitching nose-up to approximately 30° while C-GPNP remained level;
- C-GPNP was banking to the right while C-FGOI remained level; or
- C-FGOI was pitching up while C-GPNP was banking to the right.

Further analysis established that C-FGOI was likely pitching nose-up while C-GPNP made a right banking turn in an effort to avoid the collision (Figure 11).

Figure 11. Illustration of the geometric relationship between the angle of the cut to C-GPNP's wing and the comparative attitudes of the 2 aircraft (relative to C-GPNP's z-axis)



1.13 Medical and pathological information

There were no indications that the performance of either the pilot or the student pilot was degraded by physiological factors.

1.14 Fire

Not applicable.

1.15 Survival aspects

1.15.1 Pilot of C-GPNP

Immediately following the mid-air collision, the pilot of C-GPNP, unaware that the airframe had been damaged, attempted to regain control of the aircraft. On finding that it was not possible to do so, he assumed a brace position. In accordance with the emergency landing procedure checklist, the pilot unlatched the cockpit door before C-GPNP struck the roof of the shopping mall. Unlatching the door helped the pilot partly exit the aircraft once it came to a stop.

The pilot of C-GPNP sustained serious injuries. When shopping mall personnel found him, he was halfway out of the aircraft. Because fuel was leaking from the aircraft, it was decided to move the pilot a safe distance from the wreckage (approximately 20 feet) until emergency services arrived on the scene.

1.15.2 Student pilot of C-FGOI

C-FGOI was destroyed when it struck the ground. The impact was not survivable.

1.15.3 Emergency locator transmitters

C-GPNP and C-FGOI were each equipped with an automatic fixed emergency locator transmitter (ELT)[11] that transmitted on 243 MHz and 406 MHz, respectively, as well as on 121.5 MHz. Both units were sent to the TSB Engineering Laboratory for analysis.

The 3-position control switch on each ELT unit was in the OFF position when the TSB Engineering Laboratory received them. The position of the switch before and immediately following the occurrence could not be determined in either case.

It was determined that the ELTs of C-GPNP and C-FGOI were serviceable in the moments leading up to the occurrence. However, in each case, the collision had caused the unit to become physically separated from the aircraft and forced the coaxial cable of the antenna from the output terminal. It is therefore unlikely that Cospas-Sarsat satellites would have been able to detect ELT distress signals.

1.16 Tests and research

1.16.1 TSB laboratory reports

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

- LP059/2017 – Altimeter Analysis (C-FGOI)
- LP060/2017 – Altimeter Analysis (C-GPNP)
- LP061/2017 – ELT Analysis (C-FGOI)
- LP062/2017 – ELT Analysis (C-GPNP)
- LP063/2017 – Flight Control Analysis (C-FGOI)
- LP064/2017 – Flight Control Analysis (C-GPNP)
- LP065/2017 – GPS Data Retrieval (C-FGOI)
- LP066/2017 – GPS Data Retrieval (C-GPNP)
- LP067/2017 – VHF Analysis (C-GPNP)
- LP071/2017 – Transponder Analysis (C-GPNP)
- LP072/2017 – Transponder Analysis (C-FGOI)
- LP096/2017 – Radar Data Analysis
- LP132/2017 – Wreckage Examination
- LP160/2017 – Cell Phone and Tablet Data Retrieval

1.17 Organizational and management information

1.17.1 Cargair

Cargair is a TC-authorized flight-training unit that holds a valid flight-training unit operator certificate under Subpart 406 of the *Canadian Aviation Regulations* (CARs). At the time of the occurrence, the company operated a fleet of 52 aircraft, including 29 Cessna 152 airplanes.

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11 C-GPNP was equipped with a Dorne & Margolin ELT, model C589511-0117. C-FGOI was equipped with an ACK Technologies ELT, model E-04.

Cargair also holds an approved maintenance organization certificate issued by TC under CARs section 573.02.

Cargair is also authorized by TC to offer an integrated Airline Transport Pilot – Aeroplane (ATP-A) training program[12] under CARs Subpart 406. As a result, Cargair has been chosen by foreign carriers to train selected[13] student pilots. Once they arrive in Canada to start their training, the student pilots are expected to complete their flight training within a period of 12 months. This period can be extended to a maximum of 14 months to allow for unforeseen circumstances, such as weather delays.

1.17.1.1 Authorization and monitoring of solo flights

The Cargair training manual states the following:

> All solo flights must be authorized by the student assigned instructor. If the instructors has [*sic*] planned to not be physically available during the student's solo flight he/she must brief the Chief Flight Instructor of the student's capabilities. The Chief Flight Instructor will then take the decision to authorize the flight or not.
>
> A class 4 instructor must at all times get prior authorization from the Chief Flight Instructor or by a delegate before allowing his/her student to perform a solo flight.[14]

Before a student pilot is authorized for a solo flight, the assigned instructor or the chief flight instructor reviews the weather conditions and circuit procedures with the student, and provides a briefing to discuss which exercises the student is expected to perform.

On the day of the occurrence, the assigned instructor authorized the pilot of C-GPNP to conduct a solo flight. The chief flight instructor, following a briefing from the class 4 instructor, authorized the student pilot of C-FGOI to conduct a solo flight.

1.17.1.2 Safety management system

Cargair is not required by regulation to implement a safety management system (SMS). However, in 2010, the company voluntarily developed an SMS based on TC's guidelines for activities subject to CARs Subpart 705 (Airline Operations).

Under its SMS, Cargair conducts a follow-up when an incident involving one of its aircraft is reported to the company or when it has been advised of an occurrence that could affect safety.

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[12] "Integrated course" means a course of pilot training developed using the principles of instructional systems design, in which all instructional stages are completed as one continuous course and the flight training elements are interrelated and sequenced to provide for the efficient achievement of the learning objective. (Source: Transport Canada, SOR/96-433, *Canadian Aviation Regulations,* Part IV: Personnel Licencing and Training, Division I: General, subsection 400.01(1).)

[13] When an individual has been selected, the parent carrier is responsible for the training costs incurred by the student pilot.

[14] Cargair, Training Manual – Transport Canada Integrated Program (01 December 2014), p. 38.

1.17.2 NAV CANADA

CYHU is a controlled airport, where airport control services[15] are provided by NAV CANADA. The *Manual of Air Traffic Services* (MATS) details the procedures and phraseology that air traffic controllers should use when providing air traffic services. The MATS states the following:

> Issue clearances and instructions[16] as necessary to maintain a safe, orderly, and expeditious flow of traffic under the control of your unit. […] Give priority to providing control service. Provide other services to the fullest possible extent.[17]

Procedures and phraseology to be used by controllers in airport towers are specified in the MATS—Tower[18]; those specific to St-Hubert Tower are set out in St-Hubert Tower's unit operations manual.[19]

1.17.2.1 Airspace

NAV CANADA provides airport control services at CYHU within a 5 nm, irregularly shaped Class C[20] control zone,[21] which extends vertically to an altitude of 2000 feet ASL (Figure 12).

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15 An airport control service is defined as a "control service provided by airport control towers to aircraft and vehicles on the manoeuvring area of an airport and to aircraft operating in the vicinity of an airport." (Source: NAV CANADA, Terminav terminology database, at http://www1.navcanada.ca/logiterm/addon/terminav/termino.php [last accessed on 27 July 2018]).

16 "An ATC clearance or instruction constitutes authority for an aircraft to proceed only as far as known air traffic is concerned and is based solely on the need to safely separate and expedite air traffic." (Source: NAV CANADA, *Manual of Air Traffic Services – Tower* [31 August 2016], Control Service, p. 66.)

17 Ibid., p. 23.

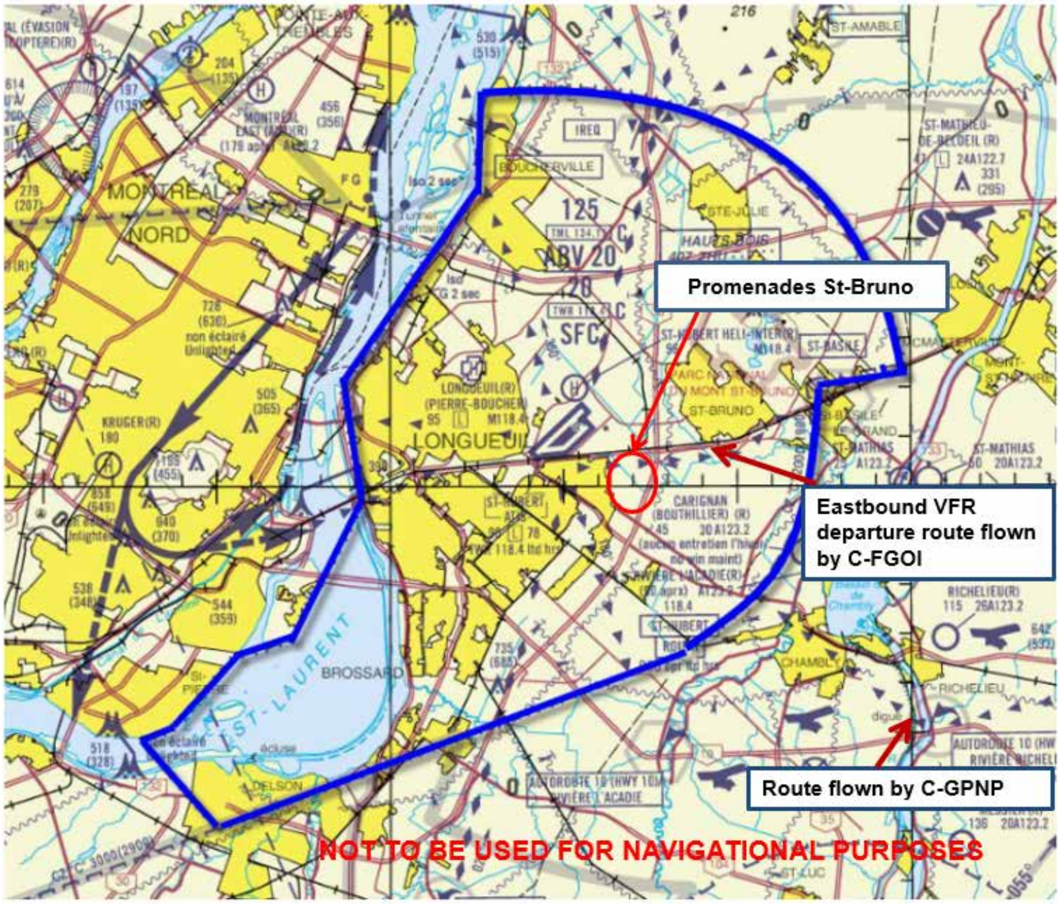
18 NAV CANADA, *Manual of Air Traffic Services – Tower* (31 March 2016).

19 NAV CANADA, *Manuel d'exploitation d'unité – Tour de St-Hubert* (05 December 2016).

20 "CDA [Canadian Domestic Airspace] is divided into seven classes, each identified by a single letter—A, B, C, D, E, F or G." (Source: Transport Canada, *Transport Canada Aeronautical Information Manual* [TC AIM], TP14371, RAC – Rules of the Air and Air Traffic Services [13 October 2016], section 2.8.)

21 A control zone is "a controlled airspace of defined dimensions extending upwards from the surface of the earth up to and including 3 000 [feet above aerodrome elevation (AAE)] unless otherwise specified." (Source: Transport Canada, TP 14371, *Transport Canada Aeronautical Information Manual* [TC AIM], GEN – General [13 October 2016], section 5.1.)

Figure 12. St-Hubert control zone (shown in blue) and surrounding area (Source: NAV CANADA, Manuel d'exploitation d'unité – Tour de St-Hubert, with TSB annotations)



The classification of an airspace determines the operating rules and level of ATC service provision therein, as well as its communication and equipment requirements. Class C airspace is defined as

> a controlled airspace within which both IFR and VFR flights are permitted, but VFR flights require a clearance from ATC to enter. ATC separation is provided between all aircraft operating under IFR and, as necessary to resolve possible conflicts, between VFR and IFR aircraft. Aircraft will be provided with traffic information. Conflict resolution will be provided, upon request, after VFR aircraft is provided with traffic information.[22]

[22] Transport Canada, TP 14371, *Transport Canada Aeronautical Information Manual* (TC AIM), RAC – Rules of the Air and Air Traffic Services (13 October 2016), section 2.8.3.

To enter and fly in Class C airspace under VFR, a pilot must hold a valid pilot's licence or student pilot permit, and the aircraft must be equipped with a functional 2-way radio as well as a serviceable and functioning transponder[23] with mode C[24] capability.[25]

1.17.2.2 Aircraft separation

Authorization by ATC to fly in Class C airspace does not relieve pilots of their responsibility to avoid other aircraft. Several factors, such as traffic volume, multiple communications, lack of communication, and equipment availability, may influence the workload of controllers and their subsequent ability to provide information in a timely manner. However, according to the MATS—Tower, controllers "must provide [traffic information] unless higher-priority duties prevent [them] from doing so."[26]

When separating aircraft, controllers are to do so

> consistently according to these fundamentals of safe, orderly, and expeditious control:
> - Planning: determine the appropriate separation minimum required
> - Executing: implement the selected standard
> - Monitoring: ensure that the planned and executed separation is maintained[27]

1.17.2.2.1 Separation of visual flight rules aircraft

Visual separation is defined as "a means used by controllers to separate aircraft operating in visual meteorological conditions (VMC)."[28] When separating VFR aircraft, if controllers determine that a potential conflict exists, they may issue "clearances, instructions, and/or information as necessary to aid aircraft in establishing visual contact with each other to assist aircraft in avoiding other aircraft."[29] The MATS—Tower provides controllers with the following guidance:

> VFR aircraft are considered separated when they have reported over separate, clearly defined geographical points and their intended routes of flight will not conflict thereafter.
>
> [...]

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23 "A receiver and transmitter that will generate a reply signal upon proper interrogation, the interrogation and reply being on different frequencies." (Source: Transport Canada, Advisory Circular [AC] 100-001: Glossary for Pilots and Air Traffic Services Personnel [effective date 05 June 2016].)

24 "A type of transponder with altitude-encoding capability." (Source: Ibid.)

25 "Transponders substantially increase the capability of radar to detect aircraft. The use of automatic pressure altitude reporting equipment (Mode C) enables controllers to quickly determine where potential conflicts could occur." (Source: Transport Canada, TP 14371, *Transport Canada Aeronautical Information Manual* [TC AIM], COM – Communications, Navigation and Surveillance [13 October 2016], section 8.1.)

26 NAV CANADA, *Manual of Air Traffic Services – Tower*, Traffic Management—Traffic Information (31 March 2016), p. 64.

27 Ibid., Separation Basics, p. 148.

28 Transport Canada, TP 14371, *Transport Canada Aeronautical Information Manual* (TC AIM), GEN – General (13 October 2016), section 5.1.

29 Ibid.

Aircraft are considered visually separated when one of the following applies:
- You can see the aircraft and no conflict exists.
- At least one pilot reports sighting traffic.[30]

1.17.2.2.2 Aircraft conflict resolution

The MATS—Tower contains guidelines for controllers to follow when providing conflict resolution between VFR aircraft. If visual separation cannot be assured, controllers are instructed to apply a "minimum of 500 feet vertical separation, or more if additional separation is required for wake turbulence."[31]

Additionally, the St-Hubert Tower unit operations manual allows air traffic controllers at CYHU to assign altitude restrictions to VFR aircraft.[32]

Aircraft departing from CYHU are assigned an altitude of either not above 1100 feet[33] or not above 2000 feet,[34] depending on expected aircraft arrivals. It is common practice for controllers to provide an altitude restriction of 600 feet ASL to helicopters, not above 1100 feet or not above 2000 feet to aircraft heading from CYHU to the training area, and not below 1600 feet to aircraft returning to CYHU from the training area. The minimum vertical separation of 500 feet must be maintained until 1 of 2 converging aircraft reports having the conflicting traffic in sight or until, in the controller's judgment, the aircraft are no longer in conflict.[35]

1.17.3 St-Hubert Tower

1.17.3.1 Staffing

Depending on the level and complexity of traffic on a given day, up to 4 of the following positions, and 3 frequencies, may be operational at the tower:

- Ground controller—[translation] "provides airport control services for all aircraft and vehicles operating on the manoeuvring area and inactive runways; ensures all traffic remains clear of the active runway; coordinates with the appropriate controller if an aircraft or vehicle will be using or crossing the active runway […]."[36]
- Combined Tower 1 and Tower 2 controller—[translation] "provides airport control services within the entire St-Hubert control zone; provides airport control services for all active runways […]."[37]

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30 NAV CANADA, *Manual of Air Traffic Services – Tower*, Separation – Separation Basics (31 March 2016), p. 148.

31 Ibid., p. 149.

32 NAV CANADA, *Manuel d'exploitation d'unité – Tour de St-Hubert* (05 December 2016), p. 53.

33 Aerodrome circuits are flown at an altitude of 1000 feet above aerodrome elevation. At CYHU, this represents an altitude of 1100 feet ASL.

34 NAV CANADA, *Manuel d'exploitation d'unité – Tour de St-Hubert* (05 December 2016), p. 53.

35 NAV CANADA, *Manual of Air Traffic Services – Tower* (31 August 2016), p. 149.

36 NAV CANADA, *Manuel d'exploitation d'unité – Tour de St-Hubert* (05 December 2016), p. 26.

37 Ibid., p. 27.

- Tower 1 controller—[translation] "provides airport control services within the airspace that does not fall under the jurisdiction of the Tower 2 controller; provides airport control services for all aircraft using Runway 06L/24R […]."[38]
- Tower 2 controller—[translation] "provides airport control services within the airspace used for circuits on Runway 06R/24L; provides airport control services for aircraft using Runway 06R/24L […]."[39]
- Coordinator—[translation] "does not provide control services to aircraft, but does the following: coordinates runway crossings and special situations with the ground controller; coordinates with the Montreal Terminal sector and Montreal Tower; […] assists the tower controller in identifying and managing conflicts […]."[40]

At a minimum, the ground controller and the combined Tower 1 and Tower 2 controller position are operational.

On the day of the occurrence, the tower was considered fully staffed. Four controllers were available to allow for the operation of at least 2 workstations (the minimum required), and another controller was available to operate the Tower 2 (coordinator) position if required. According to the St-Hubert Tower's unit operations manual [translation],

> The coordinator controller must be in the tower and ready to take his/her position when a third aircraft taxis to conduct circuits[41] or if the traffic density justifies it. The coordinator controller must be at his/her workstation when he/she or the Tower 1 controller deem it necessary. The Tower 1 controller and the coordinator will then determine whether the Tower 2 position should be opened.[42]

At the time of the occurrence, runways 24L and 24R were in use, with airport control services available from the ground controller position and the combined Tower 1 and Tower 2 controller position.

1.17.3.2 Workload

On the day of the occurrence, weather conditions were considered ideal for visual flight. A large number of training flights were expected, which would result in high traffic density.

The combined tower controller who was on duty at the time of the occurrence had taken up the position 44 minutes before C-GPNP and C-FGOI collided. In that period, as the number of departures and arrivals rose, the controller's workload and level of work complexity was increasing, and opening the coordinator position was being considered. When the collision occurred, the controller had 13 aircraft under his responsibility.

From the time when C-FGOI requested authorization for takeoff at 1234:35 until the time of the collision at approximately 1238:10, there were 45 transmissions on the tower frequency. Of

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38 Ibid., p. 28.

39 Ibid., p. 29.

40 Ibid., p. 30.

41 The International Civil Aviation Organization terminology for the circuit is "aerodrome traffic circuit." It is defined as "[t]he specified paths to be flown by an aircraft operating in the vicinity of an aerodrome." (Source: Transport Canada, *Aeroplane Flight Training Manual,* 4th edition [2004], Exercise Seventeen: The Circuit.)

42 NAV CANADA, *Manuel d'exploitation d'unité – Tour de St-Hubert* (05 December 2016), p. 30.

those, 23 were transmissions by the controller; the rest were made by the numerous aircraft under his responsibility. The collision occurred approximately 3 minutes and 35 seconds after C-FGOI received takeoff clearance.

In the minutes preceding the occurrence, the controller's attention was directed to solving a conflict involving 3 aircraft to the north of the airport. Between 1236:32 and 1237:28, there were 11 transmissions involving this conflict, 6 of which were transmissions by the controller. To resolve the conflict, the controller issued instructions to 1 of the aircraft so it would avoid another aircraft on approach to Runway 24R.

Once the conflict to the north of the airport had been resolved, the controller turned his attention to the next priority, which was to ensure that the pilots of C-GPNP and C-FGOI were aware of their converging tracks and their proximity to one another. At 1237:36, the controller provided traffic information to C-GPNP regarding a possible conflict with C-FGOI for the first time, instructing the pilot to maintain 1600 feet.[43] At that moment, radar returns indicated that C-GPNP was at 1800 feet ASL and C-FGOI was at 1100 feet ASL. Hearing no reply from C-GPNP, the controller made a 2nd call to C-GPNP at 1237:47. Both calls were in line with normal procedures, as controllers often issue reminders to pilots about altitude restrictions within the busy CYHU environment.

At 1237:55, an unknown aircraft attempted to call the tower, but its transmission was overridden by that of another aircraft calling the tower. The controller instructed the transmitting aircraft to stand by, and the pilot acknowledged the instruction at 1238:01. At 1238:04, the controller made a 3rd call to C-GPNP,[44] then made a 4th and final call at 1238:14. No calls were made to C-FGOI to warn its student pilot of the proximity of C-GPNP. At the time of the first 2 calls, the student pilot of C-FGOI was maintaining 1100 feet. Although it could not be determined whether he heard the transmission between the controller and C-GPNP, the fact that he climbed above 1100 feet suggests that he was not aware of C-GPNP's position.

1.18 Additional information

1.18.1 Limitations of the see-and-avoid principle

The basic method of visual collision avoidance for VFR and IFR flights is the see-and-avoid principle, which is based on active scanning and the ability to detect conflicting aircraft and take appropriate measures to avoid them. There are 2 types of see-and-avoid practice: alerted and unalerted. In a report on the limitations of the see-and-avoid principle, the Australian Transportation Safety Bureau stated that

> [i]t is important to distinguish between unalerted and alerted see-and-avoid. In alerted see-and-avoid, the pilot of an aircraft in controlled airspace is assisted to sight the traffic and an important back up exists because positive control will be provided if the traffic

43 "Papa November Papa, make sure you maintain one thousand six hundred feet, traffic ten o'clock one mile, Cessna eastbound one thousand one hundred feet."

44 "Papa November Papa, are you listening?"

> cannot be sighted. Unalerted see-and-avoid on the other hand, presents a potentially greater safety risk because it relies entirely on the ability of the pilot to sight other aircraft.[45]

A pilot's ability to visually detect another aircraft is affected by many factors, including physiological limitations of human visual and motor-response systems, obstructions to field of view, aircraft conspicuity, pilot scanning techniques, workload, and alerting to the presence of other aircraft. The effective practice of see-and-avoid can be influenced by limitations in what can be seen and by other activities, such as in-flight monitoring of instruments, radiocommunications, flight training exercises and interactions with an instructor, and navigation or conduct of simulated instrument approaches. The pilot's full attention may thus be diverted from active scanning for traffic.

Several published studies and TSB aviation investigation reports[46] have addressed the limitations and shortcomings of the see-and-avoid principle when pilots rely on it as the sole means of collision avoidance. In 1991, the Australian Transportation Safety Bureau produced a report that provided "an overview of the major factors that limit the effectiveness of [the see-and-avoid principle in preventing mid-air collisions]."[47] The report summary, details of which are consistent with known physiological limitations of the human eye, was as follows:

> Cockpit workload and other factors reduce the time that pilots spend in traffic scans. However, even when pilots are looking out, there is no guarantee that other aircraft will be sighted. Most cockpit windscreen configurations severely limit the view available to the pilot. The available view is frequently interrupted by obstructions such as window-posts which totally obscure some parts of the view and make other areas visible to only one eye. Window-posts, windscreen crazing and dirt can act as 'focaltraps' and cause the pilot to involuntarily focus at the very short distance even when attempting to scan for traffic. Direct glare from the sun and veiling glare reflected from windscreens can effectively mask some areas of the view.
>
> Visual scanning involves moving the eyes in order to bring successive areas of the visual field onto the small area of sharp vision in the centre of the eye. The process is frequently unsystematic and may leave large areas of the field of view unsearched. However, a thorough, systematic search is not a solution as in most cases it would take an impractical amount of time.
>
> The physical limitations of the human eye are such that even the most careful search does not guarantee that traffic will be sighted. A significant proportion of the view may be masked by the blind spot in the eye, the eyes may focus at an inappropriate distance due to the effect of obstructions as outlined above or due to empty field myopia in which, in the absence of visual cues, the eyes focus at a resting distance of around half a meter. An object which is smaller than the eye's acuity threshold is unlikely to be detected and even less likely to be identified as an approaching aircraft.

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45 Australian Transportation Safety Bureau, *Limitations of the See-and Avoid Principle* (1991), available at https://www.atsb.gov.au/publications/1991/limit_see_avoid.aspx (last accessed on 27 July 2018), p. 1.

46 TSB aviation investigation reports A99P0056, A99P0108, A99P0168, A00O0164, A06O0206, A09C0114, A12H0001, A12C0053, A13P0127, and A15W0087.

47 Australian Transportation Safety Bureau, *Limitations of the See-and Avoid Principle* (1991), available at https://www.atsb.gov.au/publications/1991/limit_see_avoid.aspx (last accessed on 27 July 2018), p. vii.

> The pilot's functional visual field contracts under conditions of stress or increased workload. The resulting 'tunnel vision' reduces the chance that an approaching aircraft will be seen in peripheral vision.
>
> The human visual system is better at detecting moving targets than stationary targets, yet in most cases, an aircraft on a collision course appears as a stationary target in the pilot's visual field. The contrast between an aircraft and its background can be significantly reduced by atmospheric effects, even in conditions of good visibility.
>
> An approaching aircraft, in many cases, presents a very small angle until a short time before impact. In addition, complex backgrounds such as ground features or clouds hamper the identification of aircraft via a visual effect known as 'contour interaction'. This occurs when background contours interact with the form of the aircraft, producing a less distinct image.
>
> Even when an approaching aircraft has been sighted, there is no guarantee that evasive action will be successful. It takes a significant amount of time to recognise and respond to a collision threat and an inappropriate evasive manoeuvre may serve to increase rather than decrease the chance of a collision.
>
> Because of its many limitations, the see-and-avoid concept should not be expected to fulfil a significant role in future air traffic systems.[48]

1.18.1.1 Response time

Scanning for traffic takes time. Research has demonstrated that the total time it would take the average pilot to see an object, recognize it as an approaching aircraft, realize that the aircraft is on a collision course, decide which way to turn, execute a control movement, and allow time for the pilot's aircraft to respond to the control input is approximately 12.5 seconds.[49]

Therefore, for pilots to have a good chance of avoiding a collision, they must be able to detect a conflicting aircraft at least 12.5 seconds prior to the time of impact. This delay in reaction time can and will vary depending on the pilot's experience, and is likely to be higher than 12.5 seconds.

1.18.2 Airborne collision avoidance systems

Although both C-GPNP and C-FGOI were equipped with Mode C transponders, neither aircraft was equipped with any type of aircraft collision avoidance system technology, and an aircraft collision avoidance system was not required by regulation.

Some proximity-alerting devices for light aircraft are available; their operability depends on whether the aircraft is equipped with a transponder. During its investigation into the August 2006 mid-air collision of 2 aircraft near Caledon, Ontario,[50] the TSB expressed concern regarding the risk of collision between VFR aircraft in congested airspace.

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[48] Ibid., pp. vii–viii.

[49] Federal Aviation Administration, Advisory Circular 90-48D: Pilots' Role in Collision Avoidance (issued 19 April 2016).

[50] TSB Aviation Investigation Report A06O0206.

As a result of that occurrence, the Board issued the following safety concern:

> At the present time, a large number of VFR-only aircraft are not equipped with Mode C transponders, devices that can alert pilots of other aircraft in their vicinity. Furthermore, the lack of other, available, and installed technological methods of alerting VFR pilots to the presence of other aircraft increases the risk of a mid-air collision, especially in congested airspace. A meaningful improvement to the ability to see-and-avoid other VFR aircraft requires a practicable, affordable method of alerting pilots to the proximity of conflicting traffic.
>
> Recent developments in Europe, specifically with respect to low-cost, low-power, lightweight Light Aviation SSR [secondary surveillance radar] Transponder (LAST) technology and collision-protection systems such as FLARM that are compatible with automatic dependent surveillance broadcast (ADS-B), indicate that technological solutions are emerging that can accomplish both of these objectives. These new systems offer a means to reduce the risk of future mid-air collisions, provided they are integrated into the Canadian regulatory, airworthiness, airspace and navigation framework, and supported by general aviation. […]
>
> The Board is concerned that, until technological solutions such as on-board collision-protection systems are mandated, a significant risk of collision between VFR aircraft will continue to exist in congested, high-density airspace areas in Canada. The Board notes that the risk of collision will increase as this traffic continues to grow, and see-and-avoid remains the primary means of defence. In addition, the Board recognizes that technological innovation is creating potential solutions that are both viable and economical.
>
> The Board appreciates that Transport Canada must examine all potential solutions before it can decide how to best recommend or mandate the adoption of one or more systems. On this basis, the Board requests that Transport Canada take a lead role, in cooperation with industry, in examining technological solutions, with the eventual aim of broad-scale adoption.

Following the report on the Caledon occurrence, the Board issued another safety concern in TSB Aviation Investigation Report A12H0001, in which it discussed the need for the practice of the see-and-avoid concept to be augmented by aircraft collision avoidance technology. This discussion, revisited in TSB Aviation Investigation Report A15W0087, stated in part:

> This accident has demonstrated yet again that relying solely on the see-and-avoid principle to avoid collision between aircraft operating under visual flight rules (VFR) in congested airspace is inadequate.
>
> A number of international studies have addressed the overall issue of the effectiveness of the see-and-avoid principle […]. All acknowledged the underlying physiological limitations at play and that, when mid-air collisions occur, "failure to see-and-avoid is due almost entirely to the failure to see."[51] One study stated that "our data suggest that the relatively low (though unacceptable) rate of mid-air collisions in general aviation aircraft not equipped with TCAS [traffic alert and collision avoidance system] is as much

51 W. Graham, *See and Avoid/Cockpit Visibility*, FAA Report DOT/FAA/CT-TN89/18 (October 1989), as quoted in TSB Aviation Investigation Report A12H0001 and TSB Aviation Investigation Report A15W0087.

a function of the 'big sky' as it is of effective visual scanning."[52] A British Royal Air Force study into mid-air collisions, which were deemed to be random, found that the probability of conflict is proportional to the square of the traffic density, and recommended avoiding altitude restrictions that concentrate traffic.[53] Measures such as improving aircraft conspicuity, pilot scanning techniques, and pilot traffic awareness can reduce risks, but they do not overcome the underlying physiological limitations that create the residual risk associated with a see-and-avoid method without alerts.

As VFR traffic increases, additional lines of defence should be considered to reduce the risk of a mid-air collision. These lines of defence could include: changes in airspace classification, increased air traffic control (ATC) intervention, as well as ground-based and on-board technology.

Changes in airspace classification can be implemented to increase the provision of dedicated ATC services, including separation and traffic advisories, to VFR aircraft operating in congested airspace. In such cases, ATC sectorization and controller workload must also be carefully reviewed to ensure that controllers have the appropriate resources to effectively manage air traffic under their jurisdiction.

Controllers can use ATC-based technology to alert pilots of potential conflicts with other aircraft. However, the effectiveness of such systems also depends on controller judgement and workload. The National Transportation Safety Board (NTSB) has previously expressed concern and made recommendations to improve the effectiveness of such conflict warning systems.

A meaningful improvement to the ability to see and avoid other VFR aircraft may require on-board technology capable of directly alerting pilots of the proximity of conflicting traffic. As outlined in this report, a number of viable and economical on-board alerting systems exist or are under development. These technologies also offer the potential to reduce the risk of mid-air collisions.[54]

1.18.3 Language proficiency licensing requirements

1.18.3.1 International Civil Aviation Organization

In 1998, the International Civil Aviation Organization (ICAO) undertook to address the issue of language proficiency among pilots and air traffic controllers. In March 2003, it adopted a comprehensive set of standards and recommended practices aimed at strengthening the language proficiency requirements for pilots and air traffic controllers involved in international operations. In 2008, ICAO introduced standards for aviation-specific language proficiency to help ensure that flight crews and controllers were proficient in conducting and comprehending aeronautical radiotelephony communications in English—the language used for aviation communications between aircraft and controllers worldwide.

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52 K. W. Colvin, R. M. Dodhia, and R. K. Dismukes, "Is Pilots' Visual Scanning Adequate to Avoid Mid-air Collisions?" Proceedings of the 13th International Symposium on Aviation Psychology, Oklahoma City (2005), pp. 104–109, as quoted in TSB Aviation Investigation Report A12H0001 and TSB Aviation Investigation Report A15W0087.

53 J. W. Chappelow and A. J. Belyavin, *Random Mid-Air Collisions in the Low Flying System*, Royal Air Force Institute of Aviation Medicine Report 702 (April 1991), as cited in TSB Aviation Investigation Report A12H0001 and TSB Aviation Investigation Report A15W0087.

54 TSB Aviation Investigation Report A12H0001.

Given that improvements in language comprehension reduce the risk of miscommunications in aviation, a sufficient level of language proficiency among those involved in air operations is essential to enhance safety. To ensure that language proficiency is adequate, ICAO criteria[55] emphasize that language tests must be valid (correctly measuring proficiency) and reliable (consistently measuring this proficiency). The criteria also recommend that a candidate's language proficiency be assessed by a minimum of 2 raters—one with operational expertise and the other a language specialist—to reduce the possibility of examiner error and to ensure that each candidate receives a comprehensive evaluation.[56] If available, the use of a 3rd rater is recommended to resolve differences between the 2 raters' assessments of a candidate.[57]

In addition, ICAO recommends that if "a language TSP [testing service provider] is also a [flight] training provider, there should be a clear and documented separation between the two activities […] in order to avoid a possible conflict of interest."[58]

1.18.3.2 Canadian Aviation Regulations

In response, in 2008, TC amended the CARs to include a provision on language proficiency.[59] The provision stipulates that, before a licence is issued, all new applicants must provide documents establishing that they have demonstrated, "by means of an evaluation, their ability to speak and understand English or French, or both, at the operational or expert level."[60]

Applicants who are assessed as having an operational level of language proficiency (the minimum required to obtain a licence) are required to renew their language proficiency every 5 years. Applicants who are assessed as having an expert level of language proficiency are not required to renew their proficiency.[61]

1.18.3.3 Transport Canada aviation language proficiency testing

TC Advisory Circular 400-002 provided information and guidance on aviation language proficiency requirements.[62] It described the aviation language proficiency test (ALPT) requirements that must be met before any flight crew licence is issued.

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55 International Civil Aviation Organization, *Language Testing Criteria for Global Harmonization*, Circular 318-AN/180 (2009).

56 Ibid., chapter 2, paragraph 3.2, p. 18.

57 Ibid.

58 International Civil Aviation Organization, Document 9835-AN/453, *Manual on the Implementation of ICAO Language Proficiency Requirements*, 2nd edition (2010), chapter 6, paragraph 6.3.7.3, p. 6-23.

59 Transport Canada, SOR/96-433, *Canadian Aviation Regulations*, Part IV, Subpart 1 – Flight Crew Permits, Licences and Ratings, section 401.06.

60 Ibid., paragraph 401.06(1.1)(b).

61 Transport Canada, Advisory Circular 400-002: Aviation Language Proficiency Requirements (Issue 02: 09 August 2010). Note: This Advisory Circular was in effect at the time of the occurrence. On 20 April 2018, it was cancelled and replaced with Advisory Circular No. 401-009: The Conduct of Aviation Language Proficiency Demonstrations.

62 Ibid.

The ALPT assesses a candidate's language proficiency in English, French, or both languages. Flight crew licences are annotated with the holder's language of proficiency (English, French, or English/French), but the level of that proficiency is not noted on the licence. To obtain a flight crew licence, the applicant's language proficiency must meet the requirements of the operational level or above; therefore, a candidate assessed as below operational does not qualify for and will not be issued a Canadian pilot or controller licence.

The ALPT is administered by language proficiency examiners who are approved and trained to do so by TC. The test consists of 20 questions for which a candidate must provide 20 verbal answers in a role-playing scenario. For each question, the examiner evaluates the candidate's response and assigns a score of 1 to 6. The candidate's score corresponds to his or her language proficiency level, as set out in the CARs[63]: expert (score of 6), operational (score of 4), or below operational (score of below 4). The overall score for each answer is the lowest rating for the criteria. To obtain an operational level, a candidate must achieve a score of at least 4 in 14 of the 20 questions. The examiner is not required to record and retain a copy of the ALPT.

Although TC conducts administrative verifications of its approved language-proficiency examiners, it does not conduct operational verifications of the ALPT (such as listening to audio samplings to assess whether individual examiners are using the rating scale correctly when evaluating candidates' language proficiency) to ensure standardization across Canada.

Candidates applying for a student pilot permit are not subject to the requirement to demonstrate language proficiency. Therefore, a student pilot does not have to demonstrate achievement of an operational level of proficiency in English before conducting a supervised solo flight. In a Transportation Appeal Tribunal of Canada decision[64] involving the ALPT, the Tribunal noted that "as a safety consideration in congested airspace, student pilots should be required to have at least Level 4 — Operational proficiency in English prior to flying solo."[65]

In recent years, flight-training units in Canada experienced an increase in the number of international students training in a number of locations across the country. As a result, a number of airports have seen an increase in the number of aircraft movements, raising concerns about international students meeting an acceptable level of English-language proficiency prior to being authorized to conduct solo flights.

When the ALPT program was introduced, its aim was to address the issue of professional pilots flying internationally with below-operational levels of English. The program does not address situations involving international student pilots who undertake pilot training at a Canadian flight-training unit and who do not meet the requirement for an operational level of English proficiency.

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63 Transport Canada, SOR/96-433, *Canadian Aviation Regulations*, Standard 421: Flight Crew Permits, Licences and Ratings, section 421.06.

64 Canada Transportation Appeal Tribunal Decision, *Douglas v. Canada (Minister of Transport), [2017] C.T.A.T.D. No. 12*, MoT File No. 5802-259342 (TAR) (Heard: 26 January 2017; Decision: 13 April 2017), p. 11.

65 Ibid., paragraph 55.

1.18.3.4 Cargair language proficiency training program

Cargair has had an integrated English training program for Canadian and international student pilots for over 10 years. The approved examiner, who conducted the ALPT for Cargair student pilots as well as student pilots from other training units, also held the positions of director of integrated training and training supervisor for the private pilot licence/commercial pilot licence programs at Cargair.

The responsibilities of the director of integrated training and training supervisor include ensuring that all students are progressing in the private pilot licence and commercial pilot licence programs and attending ground school classes, evaluating the quality of ground school instruction, updating the ground school content, enrolling students in integrated training with TC, complying with the rules set out by TC for integrated training, and assessing students' readiness to write the mandatory TC exams.

The approved examiner is not directly involved in the English courses. All ALPT records are kept separate from other Cargair flight-training activities. TC has conducted several administrative verifications of Cargair's ALPT program and files, and noted a few administrative issues, which were subsequently corrected. However, TC does not conduct operational oversight of the evaluation of ALPT results.

Given that student pilots are not required to complete the ALPT before obtaining a student pilot permit, they are authorized to conduct solo flights once Cargair assesses them as having achieved a sufficient language proficiency level.[66]

1.18.3.5 Operational context at Montréal/St-Hubert Airport

The operation of several flight schools out of Montréal/St-Hubert Airport adds complexity to controller workload, because it results in airspace with high numbers of student pilots whose skill levels vary and whose first language is often neither English nor French. Generally, air traffic controllers are highly attentive when communicating with student pilots. When ATC is aware of an aircraft piloted by international students with limited English-language proficiency, the level of attention required is further heightened, and the result is an increase in controller workload.

To prevent the need to repeat instructions or clearances, controllers generally use routine, standard phraseology that is familiar to student pilots. However, when a complex instruction or clearance is required, repetition becomes necessary. This increases both the controller's workload and the congestion on the transmission frequency.

When dealing with reportable events,[67] ATC may immediately communicate with the pilot involved, contact the company, follow up when possible with the pilot after the incident, formally report the incident, and conduct an investigation. When an incident is non-reportable, ATC may communicate with the pilot involved and will conduct a post-incident follow-up when possible. On occasion, ATC follows up directly with the company involved. There were no reported incidents involving the pilot of C-GPNP or the student pilot of C-FGOI.

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66 Ground school and flight training is conducted exclusively in English. The assessment is therefore informal and based on the chief, ground, and flight instructors' daily interaction with a student.

67 NAV CANADA, *Aviation Occurrence Reporting Procedures*, version 6 (05 May 2017).

1.18.4 Transport Canada flight test standards

TC publishes various flight test guides to help student pilots prepare for their flight tests, including guides for the commercial pilot licence and the private pilot licence. These guides set out

> the techniques, procedures and the marking criteria that will be used by Civil Aviation Inspectors and delegated Pilot Examiners for the conduct of the flight test required to demonstrate the skill requirements for the issuance of the [applicable licence].[68,69]

The guides describe the exercises that will be performed and list the performance criteria on which the assessment will be based. One typical performance criterion used by examiners to assess candidates is their proficiency to maintain their altitude within ±100 feet of the assigned altitude.

1.19 Useful or effective investigation techniques

Not applicable.

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[68] Transport Canada, TP 13723, *Flight Test Guide, Private Pilot Licence – Aeroplane*, Fourth Edition (April 2016).

[69] Transport Canada, TP 13462, *Flight Test Guide, Commercial Pilot Licence – Aeroplane*, Fourth Edition (April 2016), p. i.

2.0 ANALYSIS

The pilot and the student pilot involved in this occurrence were certified and qualified for their respective flights in accordance with regulations, and there were no indications that either the pilot's or the student pilot's performance was in any way degraded due to physiological factors, such as fatigue. The air traffic controller was certified and qualified to perform the duties associated with the combined tower controller position in accordance with regulations, and there were no indications that the controller's performance was in any way degraded by physiological factors, including fatigue. Both of the aircraft involved in the occurrence were serviceable, and the prevailing weather conditions were suitable for visual flight rules (VFR) flight.

The analysis will focus on why the 2 aircraft collided while operating under VFR in controlled airspace, despite the controller's repeated calls to C-GPNP to inform its pilot about its convergence with C-FGOI. The role of air traffic control (ATC), the impact of communications and aviation language proficiency, the limitations of the see-and-avoid principle, and the availability of airborne collision avoidance systems will be discussed.

2.1 Collision between C-GPNP and C-FGOI

Analysis of the damage to the aircraft indicated that C-FGOI was climbing at the time of the collision. The relative attitudes of the 2 aircraft suggest that when the pilot of C-GPNP became aware of the impending collision with C-FGOI, which was approaching from the left, he made a right turn in an effort to avoid it.

ATC had issued both aircraft an altitude restriction; C-GPNP had been instructed to maintain an altitude of "not below 1600 feet," and C-FGOI to maintain an altitude of "not above 1100 feet." However, the student pilot of C-FGOI climbed 400 feet above his altitude restriction of 1100 feet and struck C-GPNP from below. The 2 aircraft collided at an altitude of approximately 1500 feet; as a result of the collision, both aircraft sustained significant damage and were rendered uncontrollable.

The examination of C-GPNP's radiocommunication system demonstrated that the pilot-side (left) push-to-talk (PTT) switch had to be depressed twice to key the radio into transmission mode, and that movement of the control yoke caused transmissions to be intermittent. This was found to originate from pre-existing wire splices located just forward of the control yoke.

Further examination revealed a break in a wire within the retractable cord of the pilot's PTT. It was also determined that the support provided to the wire splices and adjacent wires was inadequate for their location and intended use, and likely contributed to the break. A broken wire caused the PTT keying signal on C-GPNP's radiocommunication system to transmit intermittently prior to entering the control zone and immediately preceding the collision.

Cockpit workload and other factors can reduce the time that pilots spend actively scanning for traffic. The pilot of C-GPNP experienced intermittent problems transmitting with the aircraft's radiocommunication system prior to the collision. When the pilot of C-GPNP realized that the tower controller could not hear his responses to the controller's repeated calls about C-FGOI's proximity, he began troubleshooting the aircraft's radiocommunication problem. Troubleshooting the aircraft's radiocommunication problem distracted the pilot of C-GPNP; the pilot thus inadvertently allowed the aircraft to descend 100 feet below his altitude restriction of 1600 feet.

With his attention focused inside the cockpit, the pilot of C-GPNP did not see C-FGOI in time to avoid a collision.

2.2 Saint-Hubert airspace

The airspace surrounding the Montréal/St-Hubert Airport (CYHU) is complex, in large part because of the variety of the operations conducted at the airport. The presence of the 4 flying schools based there increases the complexity of air traffic controller workload, given the varying levels of flying skill and language proficiency among the student pilots. The mix of VFR and instrument flight rules traffic, small and large aircraft, and military and civilian operations in the CYHU control zone adds to traffic density and complexity.

The English-language proficiency for both the pilot and the student pilot had been assessed as operational; when pilots have only the minimum level of language proficiency required, the air traffic controller's workload may increase, because instructions and clearances may need to be repeated or may be misunderstood. This situation may also lead to congestion of the radio transmission frequency. If pilots have only the minimum required proficiency in the language used with ATC, there is a greater risk of miscommunication between the pilots and controllers, and of misunderstanding critical information.

Aircraft departing from CYHU are assigned an altitude of either not above 1100 feet or not above 2000 feet, depending on expected aircraft arrivals. Given the 2000-foot ceiling of the CYHU control zone, when arrivals are expected, controllers generally assign 1 of 3 altitude levels to aircraft: 600 feet above sea level (ASL) to helicopters, 1100 feet ASL to aircraft departing the circuit, and 1600 feet ASL to aircraft joining the circuit. Using these altitude levels ensures a vertical separation of 500 feet between aircraft in the event that conflict resolution becomes necessary. Inbound and outbound aircraft must follow the VFR traffic routes depicted on the VFR terminal procedure charts. The result is that low-experience pilots of VFR aircraft converge with an altitude separation of 500 feet.

If airspace design relies on limited vertical separation between converging tracks in congested airspace that is mainly used by pilots whose flight skill levels and language proficiency vary, there is an increased risk of traffic conflicts.

2.3 St-Hubert Tower

2.3.1 Staffing and workload

On the day of the occurrence, as the number of departures and arrivals rose, the complexity of the combined tower controller's workload was increasing.

From the time of C-FGOI's request for takeoff authorization at 1234:35 to the time of the collision at approximately 1238:10, there were 45 transmissions on the tower frequency. Of these, 23 were transmissions by the controller; the rest originated from the many aircraft under his responsibility.

To alleviate the increasing workload, the controller had 2 options: open the coordinator position or open the Tower 2 position.

The St-Hubert Tower's unit operations manual requires that a controller be in the tower and ready to assume responsibility for the coordinator position in the following circumstances:

- when a 3rd aircraft taxis for the purpose of conducting circuits;
- if required based on the traffic density; or
- when either the Tower 1 controller or the coordinator deems it necessary.

The manual does not, however, provide explicit guidance regarding the conditions that constitute a situation in which traffic density requires that the coordinator or Tower 2 position be opened. That decision is at the discretion of the individual controller, who, in a high-workload situation, may not be in a position to assess whether the limit of traffic volume that can be safely and efficiently controlled has been reached.

If ATC tower unit operations manuals do not provide explicit directives on staffing and workload, controller workload in high-traffic situations may exceed controller staffing levels, increasing the risk of ineffective air traffic control.

2.3.2 Air traffic control communication

In accordance with NAV CANADA's *Manual of Air Traffic Services*, air traffic controllers are responsible for identifying and correcting "any errors in readbacks, clearances, and instructions."[70] The *Canadian Aviation Regulations* (CARs)[71] stipulate that when an air traffic controller issues an instruction, pilots must acknowledge and comply with the instruction, unless a collision avoidance manoeuvre is necessary.

In his takeoff clearance, ATC issued an altitude restriction to C-FGOI of not above 1100 feet ASL. In the readback, the student pilot was heard saying "not above one thousand," when the controller prematurely transmitted over the last portion of the readback. Although the student pilot of C-FGOI did initially maintain an altitude of 1100 feet, the investigation could not determine why he climbed above 1100 feet.

If air traffic controllers do not allow sufficient time to obtain a complete readback of instructions, there is a risk that errors in pilot readbacks may go unnoticed and uncorrected.

2.3.3 Traffic information

If controllers determine that a potential conflict exists between 2 or more aircraft, they must, as necessary, issue a clearance, an instruction, or information to aid an aircraft either in establishing visual contact with or in avoiding a conflicting aircraft, unless a higher priority prevents them from doing so.

In this occurrence, the controller provided traffic information to C-GPNP on 2 occasions (at 1237:36 and 1237:47) regarding a possible conflict with C-FGOI and instructed the pilot to maintain 1600 feet both times. These calls were in line with normal procedures, as controllers

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70 NAV CANADA, *Manual of Air Traffic Services – Tower* (31 August 2016), p. 58.

71 Transport Canada, SOR/96-433, *Canadian Aviation Regulations*, Part VI, Subpart 2 – Operating and Flight Rules, section 602.31.

often issue reminders to pilots about altitude restrictions within the busy CYHU environment. Since C-FGOI was level at 1100 feet and C-GPNP was at 1800 feet, above his altitude restriction of 1600 feet, it was reasonable to conclude that C-GPNP would resume his descent to 1600 feet. C-GPNP thus became a priority for the controller. By the time C-FGOI's climb became evident, only 10 seconds remained prior to impact. Hearing no reply from C-GPNP, the controller made a 3rd and 4th call, at 1238:04 and 1238:14 respectively.

The student pilot of C-FGOI was not provided with a traffic advisory regarding C-GPNP's position and altitude. The investigation determined that providing the traffic advisory to C-FGOI was the controller's next priority; however, the collision occurred before the traffic information could be passed on. If all involved pilots are not provided with information regarding conflicting traffic, there is an increased risk that use of the see-and-avoid principle will not be optimized.

2.4 Aviation language proficiency

2.4.1 Transport Canada language proficiency testing

As part of their training toward obtaining a private pilot licence, student pilots must conduct solo training flights. Currently, neither the CARs nor Transport Canada's (TC's) aviation language proficiency test (ALPT) require that student pilots successfully demonstrate an operational level of language proficiency before obtaining a student pilot permit and receiving authorization for solo flights.

The chief flight instructor of a flight-training unit is responsible for ensuring that all solo flights are properly authorized; however, there are no specific requirements for language proficiency. Therefore, it is possible for a flight-training unit to allow student pilots with limited proficiency in English to perform solo flights before obtaining an operational level of language proficiency on the ALPT. As highlighted in the Transportation Appeal Tribunal of Canada decision involving ALPT, "as a safety consideration in congested airspace, student pilots should be required to have at least Level 4 — Operational proficiency in English prior to flying solo."[72]

The ALPT is designed to assess language proficiency in accordance with the scale set out in the CARs. The use of alternate measures by flight training units to assess students' language proficiency before authorizing solo training flights may result in student pilots not meeting the requirements of the ALPT. If student pilots are authorized to conduct solo flights before they have successfully demonstrated an operational level of language proficiency in accordance with the proficiency scale set out in the CARs, there is an increased risk of miscommunication.

2.4.2 Language proficiency testing oversight

There is no requirement for TC-approved examiners to record the ALPT, and TC does not observe while an approved examiner administers the test. As a result, TC conducts no operational oversight to verify that the language proficiency scale set out in the CARs is applied correctly. The investigation determined that regulatory oversight of the ALPT program is

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72 Canada Transportation Appeal Tribunal Decision, *Douglas v. Canada (Minister of Transport), [2017] C.T.A.T.D. No. 12*, MoT File No. 5802-259342 (TAR) (Heard: 26 January 2017; Decision: 13 April 2017), p. 11.

limited to administrative verifications, whereby licensing agents ensure that the paperwork submitted by approved examiners follows the guidelines set out in the examiner's manual.

With only limited regulatory oversight, it is not possible to assess whether and to what extent approved examiners administer the ALPT in a manner that ensures validity, reliability, and standardization nationally. If TC only conducts limited oversight of language proficiency testing, there is a risk that designated examiners will not apply the CARs language proficiency scale as intended to ensure that applicants demonstrate the required ability to speak and understand at an operational or expert level.

2.4.3 Language testing service provider

The approved examiner who administered ALPT examinations for Cargair students also held the positions of director of integrated training and training supervisor for the private pilot licence/commercial pilot licence programs at Cargair.

In its documentation of the issue, the International Civil Aviation Organization (ICAO) highlights the reliance of language proficiency evaluations on subjective judgments by raters. As a mitigation, ICAO recommends that such evaluations be carried out by a minimum of 2 raters, and that a 3rd rater be consulted if the 2 scores diverge.

Further, ICAO recognizes the possibility of conflict of interest when a language testing service provider is also the flight-training provider. The issue of concern is not that the flight-training unit may have an integrated language-training program combined with a flight-training program. Rather, the issue is whether language proficiency testing could be conducted objectively, without a real or perceived conflict of interest on the part of the approved examiner. It is advisable to retain an approved examiner who is external to a flight-training unit for the administration of language proficiency testing. Without a clear separation between a language-testing service provider and a flight-training provider, there is potential for a real or perceived conflict of interest.

2.4.4 Flight data

Data from the occurrence flight indicated that the student pilot of C-FGOI was given an altitude restriction of "not above 1100 feet" following departure. This restriction differed from that in the historical flight data, which showed that the student pilot had previously been restricted to "not above 2000 feet." After C-FGOI's departure, radar data showed that the aircraft initially maintained its assigned altitude of not above 1100 feet for just over 1 minute, but began to climb just after the controller's 2nd attempt to pass on traffic information to C-GPNP.

Historical flight data also showed that on 2 occasions, when given an altitude restriction of "not below" by ATC, the student pilot of C-FGOI incorrectly read it back as "not above." ATC then corrected him, and he subsequently read back the correct instruction. The altitude restriction was part of a standard ATC clearance given to all aircraft returning to the airport from the training area.

In addition, analysis of historical flight data for the student pilot of C-FGOI showed that he had difficulty levelling off at, and maintaining, a consistent altitude at times, and had deviated from ATC clearances on other solo flights.

It could not be determined why the student pilot of C-FGOI climbed after levelling off at his assigned altitude.

2.5 The see-and-avoid principle

2.5.1 Alerted see-and-avoid principle

Authorization from ATC to fly in Class C airspace does not relieve pilots of their responsibility to avoid other aircraft; each person operating an aircraft must maintain vigilance to see and avoid other aircraft. Pilots can contribute to collision avoidance by being alert and scanning. This is particularly true near an airport.

In Class C airspace, ATC can provide aircraft with traffic information to prevent collisions; however, for flights operated under VFR, the see-and-avoid principle remains the basic rule. The information that ATC provides to a pilot is only the traffic information known to the controller, and does not constitute clearance with respect to other aircraft. If pilots operating under VFR rely solely on information from air traffic controllers to avoid other aircraft, there is an increased risk of collision in controlled airspace.

2.5.2 Response time

Research has determined that for pilots to have sufficient opportunity to avoid a collision, they must be able to detect a conflicting aircraft a minimum of 12.5 seconds prior to the time of impact. This delay in reaction time can and does vary depending on pilot experience, and is likely to exceed 12.5 seconds. When the pilot of C-GPNP became aware of the impending collision with C-FGOI, it was too late to avoid it. It could not be determined whether the student pilot of C-FGOI realized his proximity to and converging track with C-GPNP.

2.5.3 Limitations of the see-and-avoid principle

Several published studies and TSB aviation investigation reports have addressed the limitations and shortcomings of the see-and-avoid principle when it is relied upon as the sole means of collision avoidance.

In this occurrence, the 2 aircraft were operating under VFR in controlled airspace. Neither pilot saw the other aircraft in time to avoid a mid-air collision, partly owing to the inherent limitations of the see-and-avoid principle.

This accident has demonstrated that, because of its limitations, the see-and-avoid principle cannot be used as the sole means of preventing aircraft collisions when operating under VFR.

2.6 Airborne collision avoidance systems

Neither aircraft was equipped with any type of aircraft collision avoidance system (ACAS), nor was an ACAS required by regulation. As discussed above, the see-and-avoid principle has inherent limitations when used as a primary method of maintaining aircraft separation. An ACAS provides pilots with additional information to increase their awareness of nearby aircraft and to reduce the risk of a mid-air collision.

As established by the TSB in previous reports,[73] a number of viable and economical on-board alerting systems exist or are under development. These technologies offer the potential to significantly reduce the risk of mid-air collisions.

73 TSB aviation investigation reports A06O0206, A12H0001, and A15W0087.

3.0 FINDINGS

3.1 Findings as to causes and contributing factors

1. The student pilot of C-FGOI climbed 400 feet above his altitude restriction of 1100 feet and struck C-GPNP from below.

2. The 2 aircraft collided at an altitude of approximately 1500 feet; as a result of the collision, both aircraft sustained significant damage and were rendered uncontrollable.

3. A broken wire caused the push-to-talk keying signal on C-GPNP's radiocommunication system to transmit intermittently prior to entering the control zone and immediately preceding the collision.

4. Troubleshooting the aircraft's radiocommunication problem distracted the pilot of C-GPNP; the pilot thus inadvertently allowed the aircraft to descend 100 feet below his altitude restriction of 1600 feet.

5. With his attention focused inside the cockpit, the pilot of C-GPNP did not see C-FGOI in time to avoid a collision.

6. It could not be determined why the student pilot of C-FGOI climbed after levelling off at his assigned altitude.

7. Neither pilot saw the other aircraft in time to avoid a mid-air collision, partly owing to the inherent limitations of the see-and-avoid principle.

3.2 Findings as to risk

1. If pilots have only the minimum required proficiency in the language used with air traffic control, there is a greater risk of miscommunication between the pilots and controllers, and of misunderstanding critical information.

2. If airspace design relies on limited vertical separation between converging tracks in congested airspace that is mainly used by pilots whose flight skill levels and language proficiency vary, there is an increased risk of traffic conflicts.

3. If air traffic control tower unit operations manuals do not provide explicit directives on staffing and workload, controller workload in high-traffic situations may exceed controller staffing levels, increasing the risk of ineffective air traffic control.

4. If air traffic controllers do not allow sufficient time to obtain a complete readback of instructions, there is a risk that errors in pilot readbacks may go unnoticed and uncorrected.

5. If all involved pilots are not provided with information regarding conflicting traffic, there is an increased risk that use of the see-and-avoid principle will not be optimized.

6. If student pilots are authorized to conduct solo flights before they have successfully demonstrated an operational level of language proficiency in accordance with the proficiency scale set out in the *Canadian Aviation Regulations*, there is an increased risk of miscommunication.

7. If Transport Canada only conducts limited oversight of language proficiency testing, there is a risk that designated examiners will not apply the *Canadian Aviation Regulations* language proficiency scale as intended to ensure that applicants demonstrate the required ability to speak and understand at an operational or expert level.

8. If pilots operating under visual flight rules rely solely on information from air traffic controllers to avoid other aircraft, there is an increased risk of collision in controlled airspace.

3.3 Other findings

1. Without a clear separation between a language-testing service provider and a flight-training provider, there is potential for a real or perceived conflict of interest.

2. Because of its limitations, the see-and-avoid principle cannot be used as the sole means of preventing aircraft collisions when operating under visual flight rules.

3. As established by the TSB in previous reports, a number of viable and economical on-board alerting systems exist or are under development. These technologies offer the potential to significantly reduce the risk of mid-air collisions.

4.0 SAFETY ACTION

4.1 Safety action taken

4.1.1 Transport Canada

In June 2017, Transport Canada published a Civil Aviation Safety Alert (CASA) highlighting "the risks associated to sending student pilots on solo flights prior to the demonstration of an operational level on the aviation language proficiency test."[74] The CASA noted the following:

> Some flight-training units that are using training flights as a means to acquire an operational level of language proficiency are postponing the language proficiency test until the end of the training and are releasing on solo flights student pilots that have not yet reached an operational level of language proficiency.
>
> There have been many instances where student pilots that do not have an operational language proficiency level have misunderstood instructions, have caused unnecessary repeats of communications, have been unable to provide accurate position reports, have been unable to acknowledge or understand reports of conflicting traffic.
>
> Inadequate level of language proficiency results in additional workload for air traffic controllers and increases risks associated to diminished situational awareness.[75]

The CASA also "recommended that flight training units ensure that student pilots have been awarded an operational level of language proficiency in accordance with the language proficiency scale set out in […] the personnel licensing standards prior to first solo flight."[76]

This report concludes the Transportation Safety Board of Canada's investigation into this occurrence. The Board authorized the release of this report on 09 August 2018. It was officially released on 05 September 2018.

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.

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74 Transport Canada, Civil Aviation Safety Alert No. 2017-04, Operational Level of Language Proficiency Prior to First Solo (23 June 2017), at https://www.tc.gc.ca/eng/civilaviation/opssvs/managementservices-referencecentre-2250.html (last accessed on 27 July 2018). Note: This CASA was cancelled and replaced by CASA No. 2017-08, Operational level of language proficiency prior to engaging in radiotelephony communications (08 December 2017), at https://www.tc.gc.ca/eng/civilaviation/opssvs/casa-2017-08.html (last accessed 27 July 2018).

75 Ibid.

76 Ibid.

APPENDICES

Appendix A – Language Proficiency Scale: Expert, Operational, and Below Operational Levels

The following table appears in Standard 421, Flight Crew Permits, Licences and Ratings, of the *Canadian Aviation Regulations*.

Level	Pronunciation	Structure	Vocabulary	Fluency	Comprehension	Interaction
Expert Level describes proficiency more advanced than the minimum required standard	Pronunciation, stress, rhythm, and intonation infrequently are influenced by the first language or regional variation, but almost never interfere with ease of understanding.	Both basic and complex grammatical structures and sentence patterns are consistently well controlled.	Vocabulary range and accuracy are sufficient to communicate effectively on a wide variety of familiar and unfamiliar topics. Vocabulary is idiomatic, nuanced, and sensitive to register.	Able to speak at length with a natural, effortless flow. Varies speech flow for stylistic effect, e.g. to emphasize a point. Uses appropriate discourse markers and connectors.	Comprehension is consistently accurate in nearly all contexts and includes comprehension of linguistic and cultural subtleties.	Interacts with ease in nearly all situations. Is sensitive to verbal and non-verbal cues and responds to them appropriately.
Operational Level describes the minimum proficiency acceptable for radiotelephony communication	Pronunciation, stress, rhythm, and intonation are influenced by the first language or regional variation, to the extent that they sometimes interfere with ease of understanding.	Basic grammatical structures and sentence patterns are used creatively and are usually well controlled. Errors may occur, particularly in unusual or unexpected circumstances, but rarely interfere with meaning.	Vocabulary range and accuracy are usually sufficient to communicate effectively on common, concrete, and work-related topics. Can often paraphrase successfully when lacking vocabulary in unusual or unexpected circumstances.	Produces stretches of language at an appropriate tempo. There may be occasional loss of fluency on transition from rehearsed or formulaic speech to spontaneous interaction, but this does not prevent effective communication. Can make limited use of discourse markers or connectors. Fillers are not distracting.	Comprehension is mostly accurate on common, concrete, and work-related topics when the accent or variety used is sufficiently intelligible for an international community of users. When the speaker is confronted with a linguistic or situational complication or an unexpected turn of events, comprehension may be slower or require clarification strategies.	Responses are usually immediate, appropriate, and informative. Initiates and maintains exchanges even when dealing with an unexpected turn of events. Deals adequately with apparent misunderstandings by checking, confirming, or clarifying.

Level	Pronunciation	Structure	Vocabulary	Fluency	Comprehension	Interaction
Below Operational Level describes a level of proficiency below the level required	Pronunciation, stress, rhythm, and intonation are influenced by the first language or regional variation, to the extent that they frequently interfere with ease of understanding.	Basic grammatical structures and sentence patterns associated with predictable situations are not always well controlled. Errors frequently interfere with meaning.	Vocabulary range and accuracy are limited and the word choice often inappropriate. Often unable to paraphrase successfully when lacking vocabulary.	Produces stretches of language, but phrasing and pausing are often inappropriate. Hesitations or slowness in language processing may prevent effective communication. Fillers are sometimes distracting.	Comprehension is often accurate on common, concrete and work-related topics when the accent or variety used is sufficiently intelligible for an international community of users. May fail to understand a linguistic [or] situational complication or an unexpected turn of events.	Can initiate and maintain exchanges with reasonable ease on familiar topics and in predictable situations. Generally inadequate when dealing with an unexpected turn of events.

The following note is included below the table (emphasis in original):

> ***Information Note:***
>
> *Language proficiency in English or English and French will be annotated on the licence, however, the level of proficiency will not be indicated.*
>
> (amended 2008/04/17)[77]

77 Transport Canada, SOR/96-433, *Canadian Aviation Regulations*, Standard 421, Division I – General, subsection 421.06(4): Language Proficiency Scale.