Transportation Safety Board of Canada

Bureau de la sécurité des transports du Canada

AVIATION INVESTIGATION REPORT
A04H0001

LOSS OF CONTROL

GEORGIAN EXPRESS LTD.
CESSNA 208B CARAVAN C-FAGA
PELEE ISLAND, ONTARIO
17 JANUARY 2004

Canada

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

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

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Synopsis

The Georgian Express Ltd. Cessna 208B Caravan (registration C-FAGA, serial number 208B0658) operating as GGN126 was on a flight from Pelee Island, Ontario, to Windsor, Ontario, with one pilot and nine passengers on board. The aircraft took off from Runway 27 at approximately 1638 eastern standard time and used most of the 3300-foot runway for the take-off run. It then climbed out at a very shallow angle while turning north over the frozen surface of Lake Erie toward Windsor. The aircraft struck the surface of the lake approximately 1.6 nautical miles from the departure end of the runway. All 10 persons on board were fatally injured.

Ce rapport est également disponible en français.

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1.0 Factual Information

1.1 History of the Flight

On 17 January 2004, the occurrence pilot started his workday in Toronto, Ontario, reporting for duty at 0445 eastern standard time.[1] In the morning, he completed flights in the Cessna 208B Caravan from Toronto to Windsor, Ontario, Windsor to Pelee Island, Ontario, and then Pelee Island to Windsor where the aircraft landed at 0916.

At approximately 1500, the pilot received local weather and passenger information by telephone from the Pelee Island office personnel. The 1430 weather was reported as follows: ceiling 500 feet obscured, visibility two miles. There were eight male passengers for pick up at Pelee Island. One additional passenger was travelling with the pilot. There was no discussion concerning the amount of cargo to be carried or the passenger weights. At 1508, the pilot received a faxed weather package that he had requested from the Flight Information Centre (FIC)[2] in London, Ontario.

At 1523, the aircraft was refuelled in preparation for the scheduled 1600 departure to Pelee Island. The passengers were loaded earlier than usual to allow time for aircraft de-icing, as wet snow had accumulated on the fuselage and wings since the previous flight. At 1555, the aircraft was de-iced with Type 1 de-icing fluid, and it departed for Pelee Island at 1605 on an instrument flight rules (IFR) flight plan as Flight GGN125 (see Appendix A).

At 1615, the pilot advised the Cleveland Control Centre, Ohio, United States, that he had Pelee Island in sight, was cancelling IFR, and was descending out of 5000 feet. The pilot also advised Cleveland that he would be departing IFR out of Pelee Island in about 20 minutes as GGN126 and asked if a transponder code could be issued. The Cleveland controller issued a transponder code and requested a call when GGN126 became airborne. The pilot advised that the flight would depart on Runway 27 then turn north. These were the last recorded transmissions from the aircraft.

The aircraft landed at 1620. While on the ramp, two individuals voiced concern to the pilot that there was ice on the wing. Freezing precipitation was falling. The pilot was observed to visually check the leading edge of the wing; however, he did not voice any concern and proceeded with loading the passengers and cargo.

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[1] All times are eastern standard time (Coordinated Universal Time minus five hours).

[2] See Glossary at Appendix H for all abbreviations and acronyms.

At approximately 1638, GGN126 departed Pelee Island for Windsor. After using most of the runway length for take-off, the aircraft climbed out at a very shallow angle. No one on the ground observed the aircraft once it turned toward the north; however, witnesses who were not at the airport reported that they heard the sound of a crash, then no engine noise.

A normal flight from Pelee Island to Windsor in the Cessna Caravan takes 15 to 20 minutes. Shortly after the aircraft departed, the ticket agent in Windsor received a call from Pelee Island reporting that a crash had been heard. At 1705, when the aircraft had not arrived, the ticket agent called Windsor tower. The pilot had not made contact with any air traffic services (ATS) facility immediately before or after departure, so there was nothing in the ATS system to indicate that the aircraft had taken off. It was, therefore, unaccounted for.

There was no signal heard from the emergency locator transmitter (ELT). At 1710, the Windsor tower controller contacted the Rescue Coordination Centre in Trenton, Ontario, and a search was initiated. At 1908, the aircraft empennage and debris were spotted by a United States Coast Guard (USCG) helicopter on the frozen surface of the lake, about 1.6 nautical miles (nm) from the departure end of the runway. There were no survivors. The empennage sank beneath the surface some four hours later. The wreckage recovery was not fully completed until 13 days later (see Appendix D).

1.2 *Injuries to Persons*

	Crew	Passengers	Others	Total
Fatal	1	9	–	10
Serious	–	–	–	–
Minor/None	–	–	–	–
Total	1	9	–	10

1.3 *Personnel Information*

1.3.1 *General*

The occurrence pilot held a valid airline transport pilot licence (ATPL) and had been employed by Georgian Express Ltd. since November 2000. He flew as a first officer on the Beech 1900 until being upgraded to captain on the Cessna Caravan in the fall of 2003. The pilot had previously flown the Cessna Caravan with another employer, where he had accumulated 859 hours on type. He was familiar with self-dispatch operations in remote locations. The pilot received the complete Georgian Express Ltd. ground school and flight training program, which included a three-hour lecture on winter operations. Line indoctrination training was completed on 29 November 2003 and the pilot proficiency check (PPC) was passed on November 30. The pilot commenced passenger flights to Pelee Island, using the Cessna Caravan, when the air operator obtained the contract for such flights from Owen Sound Transportation Company (OSTC)[3] on 13 December 2003.

A review of the pilot's history and information provided by co-workers indicates that the pilot had a reputation for being conscientious and professional in his work. No one reported anything to contradict this view.

	Pilot
Pilot Licence	ATPL
Medical Expiry Date	31 May 2004
Total Flying Hours	3465
Hours on Type	957
Hours Last 90 Days	128
Hours on Type Last 90 Days	94
Hours on Duty Prior to Occurrence	12
Days Off Duty Prior to Work Period	4 days

1.3.2 Pilot's Seventy-Two Hour History

On 13 January 2003, the occurrence pilot flew as a passenger to Los Angeles, California, United States, and returned to Toronto on January 16, the day before the accident flight, arriving at the Toronto Airport at 2047. This travel was unrelated to his duties at Georgian Express Ltd. Using conservative estimates for the time it would take to process through the airport and drive home, it is unlikely that the pilot could have been in bed before 2230. He arrived at work the following morning at 0445, which would have required a wake-up at approximately 0345. This allowed for approximately five hours of potential sleep time the night before the accident flight. The pilot was accompanied on the return flight from Los Angeles by a companion who flew with him in the Cessna Caravan to Windsor and was also a passenger on the accident flight. The pilot did not fill out the Jump Seat Approval form for carrying a jump seat passenger, nor was anybody with the company made aware of a jump seat passenger's presence.

On January 17, the pilot flew the Cessna Caravan from Toronto to Windsor, departing Toronto at 0558. He arrived in Windsor at 0710, and had the aircraft re-configured for passenger service. At 0831, the pilot departed Windsor for a flight to Pelee Island and return, landing back in Windsor at 0916. After the passengers deplaned, the pilot repositioned the aircraft to free up the

[3] The OSTC operates the ferry service between Pelee Island and the mainland. It contracts for an air service when Lake Erie is frozen.

gate. He then went to the hotel and spent the next few hours in his room awaiting the afternoon flights. The pilot left the hotel briefly around noon to eat a meal.

At 1445, he returned to the Windsor Airport, and at 1500, he called company flight-following in Toronto to confirm his pending departure for Pelee Island. At 1523, the aircraft was refuelled for the 1600 flight. The accident flight was his last scheduled duty until the next afternoon.

1.4 Aircraft Information

1.4.1 General

Manufacturer	Cessna
Type and Model	208B Caravan
Year of Manufacture	1998
Serial Number	208B0658
Certificate of Airworthiness	23 February 1998
Total Airframe Time	7809 hours
Engine Type (number of)	PT6A-114A (1)
Propeller/Rotor Type (number of)	McCauley 3GFR34C703-B/A106GA-0 (1)
Maximum Allowable Take-off Weight	8750 lbs, 8550 lbs in known icing conditions
Recommended Fuel Type(s)	Jet A, Jet A-1, Jet B
Fuel Type Used	Jet A-1

Maintenance records indicate that the aircraft was being maintained in accordance with the approved maintenance control manual.

The engine and propeller were examined at the TSB Engineering Laboratory, and no discrepancies were identified that would have prevented normal operation. The engine had rotational signatures on several components that were consistent with an engine developing power at impact. All propeller damage was consistent with a propeller being driven by high engine power at impact.

Although it was not possible to extract fuel samples from the aircraft, fuel samples were taken from the refuelling truck at the airport and tested. The fuel met the specifications for Jet A-1 fuel.

1.4.2 *Weight and Balance*

Under the pilot self-dispatch system approved for the air operator, the pilot was responsible for completing weight and balance computations before each flight. No such computations for the accident flight were found.

The aircraft had 800 pounds of fuel on landing in Windsor after the morning flight from Pelee Island. This was sufficient for the afternoon's flights, with the alternates of Windsor for Pelee and Detroit, Michigan, United States, for Windsor. After his passenger load (eight men) for the return flight from Pelee was confirmed, the pilot loaded an additional 1000 pounds of fuel before departing for Pelee Island.

Post-accident computations showed that there were 1835 pounds of fuel on board the aircraft before it departed from Windsor for Pelee Island, approximately 1735 pounds on board when it landed at Pelee Island, and an estimated 1700 pounds when it took off on the accident flight. The cargo load was 589 pounds.

Using standard weights from *Aeronautical Information Publication* (A.I.P. Canada) Section RAC 3.5, the weight of the occupants would be 1833 pounds. This includes an allowance for clothing and carry-on baggage. Using the actual passenger weights, the total weight of the occupants was about 2400 pounds; a difference of about 570 pounds. There were also two dogs on the aircraft, estimated at 70 pounds each.

The maximum allowable take-off weight for the Cessna Caravan is 8750 pounds (cargo pod installed); 8550 pounds if flying into known icing conditions. On the occurrence flight, using the actual weight of the occupants, the calculated take-off weight was 9820 pounds, 1270 pounds over the maximum allowable weight in icing conditions. This represents an overweight condition of about 15 per cent. Even if standard A.I.P. Canada weights were used for the passengers, the aircraft would have been 703 pounds over the maximum allowable weight. Regulations prohibit the operation of an aircraft unless its weight and centre of gravity conform to the limitations specified in the aircraft manual (Canadian Aviation Regulations [CARs] 703.37, 704.32, and 705.39). Table 1 summarizes the weight and balance calculations for the accident flight using both actual weights and standard A.I.P. Canada weights.

Table 1. Calculated Take-off Weight Using Actual and A.I.P. Canada Weights

	Actual Weight (lbs)	A.I.P. Canada Weight (lbs)
Basic empty weight	4991	4991
Fuel weight on ramp	1735	1735
Cargo	589	589
Occupants (9 men, 1 woman)	2400	1833*
Dogs (2)	140	140
Fuel consumed for start/taxi	-35	-35
Gross weight on take-off	9820	9253
Maximum take-off weight (for flight into known icing conditions)	8550	8550
Amount overweight	1270	703

* This total passenger weight was calculated using 188 pounds for men and 141 pounds for women.

1.5 *Meteorological Information*

1.5.1 *General*

On the day of the occurrence, southwestern Ontario was under the influence of two low-pressure systems with a trough of low pressure extending from a low over northern Ontario to a second low over northern Texas, United States. The trough exhibited an eastward motion throughout the period.

An area of cloud and snow ahead of the trough moved into southwestern Ontario during the morning and persisted for several hours. Widespread instrument meteorological conditions (IMC) were observed as the area of snow crossed the region. During the day, as indicated by the atmospheric soundings at Pittsburgh, New Hampshire, United States, and Detroit, a layer of warmer air aloft began to override the colder air at the surface. Near the trough and just ahead of it, this warmer layer was sufficient to produce widespread icing conditions and an area of freezing precipitation at the surface. Freezing rain and/or freezing drizzle were reported by several stations in northern Pennsylvania, Ohio, and Michigan, United States, and in southwestern Ontario.

1.5.2 *Forecast Weather*

The graphic area forecast (GFA) for the region of the occurrence, valid from 1300 on January 17, was as follows: overcast layers based at 3000 feet and topped at 18 000 feet; visibility of 1 to 3 statute miles (sm) in light snow; and moderate mixed icing in cloud between 3000 and 12 000 feet (see Appendix C). The area forecast indicated scattered embedded alto cumulus castellanus cloud to 20 000 feet, visibilities of ½ sm in snow, and extensive ceilings at 500 feet above ground level (agl).

The latest terminal aerodrome forecast (TAF) available for Windsor (CYQG) before departure from Windsor at 1600 was the forecast issued at 1230 on January 17 valid from 1300 January 17 to 1300 on 18 January. The forecast was as follows: surface wind 160° true (T) at 10 knots, visibility ¾ sm in light snow, overcast at 1000 feet agl; temporarily from 1300 to 1900, visibility 3 sm in light snow, scattered clouds at 1500 feet agl, overcast at 3000 feet agl. From 1900, surface wind 210°T at 10 knots, visibility greater than 6 sm, overcast at 1200 feet agl; temporarily from 1900 to 0300, visibility 2 sm in light freezing drizzle, light snow and mist, overcast at 600 feet agl; becoming between 2200 and 2400, surface wind 270°T at 12 knots gusting to 22 knots.

Another TAF for Windsor was issued at 1615 and was valid between 1600 on January 17 to 1300 on January 18. It read as follows: surface wind 180°T at 8 knots, visibility 1½ sm in light snow, overcast at 800 feet agl; temporarily from 1600 to 1900, visibility 3 sm in light snow, scattered clouds at 1500 feet agl, overcast at 3000 feet agl. Probability 40 per cent, from 1600 to 1900, visibility 2 sm in freezing rain and mist; overcast at 600 feet agl.

The latest available TAF for Detroit Metro Airport (KDTW) was the one issued at 1232 on January 17 valid between 1300 on January 17 and 1300 on January 18. After 1500, the forecast was as follows: surface wind 180°T at 8 knots, visibility 4 sm in mist, overcast at 1400 feet agl; temporarily from 1500 to 1700, visibility 1 sm in light freezing drizzle and mist.

The latest available TAF for Toledo, Ohio, United States, was issued at 1238 on January 17 and valid between 1300 on January 17 and 1300 on January 18. After 1600, the forecast was as follows: surface wind 170°T at 8 knots, visibility 1½ sm in mist, overcast at 700 feet agl; temporarily from 1600 to 1800, visibility ¾ sm in light freezing rain, snow, and mist, overcast at 300 feet agl.

1.5.3 *Observed Weather*

The actual weather at Windsor Airport for 1600 was as follows: surface wind 180°T at 6 knots; visibility 1¾ sm in light snow; overcast at 800 feet agl; temperature -5°C; dew point -7°C; altimeter setting 29.82. A special observation taken at Windsor at 1641, approximately three minutes after the reported take-off time of GGN126 from Pelee Island, was as follows: special, surface wind 190°T at 6 knots, visibility 2 sm in light snow, light freezing rain and mist, overcast at 500 feet agl. Freezing rain started to be reported in the actual weather observations at Detroit Metro Airport at 1519.

Shortly after 1700 on the day of the occurrence, an air operator who landed at Put-in-Bay, Ohio, United States, approximately 10 sm to the southwest of Pelee Island, reported that light freezing drizzle was encountered, and that the aircraft had picked up approximately ¼ inch of clear ice.

Before take-off from Windsor, the occurrence pilot called the airport manager at Pelee Island to inquire about the weather. Although the airport manager is not a qualified weather observer, he had provided this service in the past. He reported that the ceiling was approximately 500 feet with a visibility of 2 miles. He also estimated that the conditions remained the same when the aircraft was departing on the accident flight. Many witnesses reported freezing precipitation at the Pelee Airport starting at about 1600.

Like many airports of similar category, Pelee Island does not have weather reporting capability. Pilots are responsible for ensuring that weather conditions are suitable for their type of operation. Pelee Island is located in the middle of the western end of Lake Erie and is relatively exposed to weather systems moving across the lake.

1.5.4 Weather Briefing

The occurrence pilot called London FIC to obtain a faxed weather package for the area of the proposed flight. The London FIC briefing log indicated that a package of weather information was faxed to the pilot at 1508. The contents of the package were found in the cockpit of the aircraft during recovery. The five-page package contained weather and NOTAM (Notice to Airmen) information for Windsor (METAR [aviation routine weather report] issued at 1500 and TAF issued at 1230), Detroit Metro (METAR issued at 1445 and TAF issued at 1232), Toledo (METAR issued at 1452 and TAF issued at 1238), and London (METAR issued at 1500 and TAF issued at 1230). It did not include a GFA for southwestern Ontario.

1.5.5 Alternate Forecast Weather

Sarnia, Ontario, was designated as the alternate airport on the centre stored flight plan for the accident flight; however, the flight plan found in the aircraft indicated that Detroit was the intended alternate. A review of air traffic control (ATC) transcripts revealed that the pilot had not advised ATC of the change of alternate from Sarnia to Detroit.

At the time of the accident, official weather observations and forecasts for Sarnia terminated at 1400. Sarnia was served by the same GFA as the region of the occurrence, with visibilities of ½ sm in snow with extensive ceiling at 500 feet agl.

Section RAC 3.14.1 of A.I.P. Canada defines the alternate aerodrome weather minima requirements for an airport served by a GFA as follows: no cloud lower than 1000 feet above the lowest approach height above touchdown/height above airport, no cumulonimbus cloud, and visibility not less than 3 miles. According to these criteria, Sarnia did not meet the alternate requirements. Detroit Metro would have met the alternate weather requirements, notwithstanding the freezing precipitation between 1500 and 1700.

1.6 *Aircraft Performance*

1.6.1 *Take-off Procedure*

The Georgian Express Ltd. standard operating procedures (SOPs) described normal take-off parameters as follows: flaps 20°, take-off power, rotate at the calculated reference speed, climb at 83 knots until clear of obstacles, accelerate to 110 to 120 knots, retract flaps to 10° after reaching 85 knots and 400 feet above ground, and flaps 0° after reaching 95 knots and a minimum of 400 feet above ground. Turns will be done with no more than 30° of bank and normally initiated at a minimum altitude of 400 feet above ground.

The above SOPs differ somewhat from the normal take-off procedure described in the Cessna Caravan pilot operating handbook (POH), which states: flaps 20°, take-off power, rotate at 70 to 75 knots, climb speed 85 to 95 knots, retract flaps to 10° after reaching 85 knots and to 0° after reaching 95 knots.

1.6.2 *Flight Performance*

The performance charts in the Cessna Caravan POH do not allow for calculations above the certified maximum gross weight of 8750 pounds (pod installed). Investigators calculated stall speeds for the Cessna Caravan at weights above 8750 pounds, based on the maximum lift coefficient derived from Cessna flight test data.[4] Table 2 shows the stall speeds of the aircraft in various flap configurations without any ice contamination on the lifting surfaces. The indicated airspeed (KIAS) was derived from the calculated calibrated airspeed (KCAS), which is given in parentheses. The following speeds were calculated solely to analyse the sequence of events in this occurrence; they have not been validated. For flights in icing conditions above the maximum gross take-off weight, stall and controllability speeds are unknown and unpredictable.

[4] Much of the information in this section was extracted from TSB Engineering Laboratory report LP 036/04, Aircraft Performance Analysis Report, which is available upon request.

Table 2. Approximate Aircraft Stall Speed KIAS with Computed KCAS in Parentheses

Aircraft Weight (lbs)	Flaps 20°	Flaps 10°	Flaps 0°
8550*	52 (62.6)	57 (67.7)	63 (77.5)
8750	53 (63.3)	58 (68.4)	64 (78.4)
9820**	**59** (67.1)	**64** (72.5)	**75** (83.1)
10 100***	61 (68.1)	65 (73.5)	77 (84.3)

* Authorized maximum take-off weight for flight into icing conditions
** Actual take-off weight
*** Actual take-off weight plus estimated freezing precipitation accumulation

Ice accumulation on an aircraft wing decreases lift, increases drag, and reduces the angle of attack (AOA) at which the maximum lift coefficient occurs. The aircraft will stall at a lower AOA, and the stall warning system will provide a reduced margin of safety compared to the margin of safety with a clean wing. The magnitude of the loss of lift will be airfoil dependent. The Cessna Caravan airfoil has been shown to be very sensitive to ice accumulation, and the loss of lift can exceed 50 per cent. In order to consider the possibility of ice accumulation on the upper wing surface, conservative reductions of 20 per cent and 30 per cent were applied to the maximum lift coefficient (C_{Lmax}) values and the stall speeds were recalculated (see Table 3).

Table 3. Stall Speeds with Reduced C_{Lmax}, Approximate KIAS with Computed KCAS in Parentheses

	20 per cent Reduction in C_{Lmax}			**30 per cent Reduction in C_{Lmax}**		
Aircraft Weight (lbs)	Flaps			Flaps		
	20°	10°	0°	20°	10°	0°
8550*	64 (70.0)	69 (75.6)	83 (86.7)	71 (74.8)	78 (80.9)	90 (92.6)
8750	65 (70.8)	71 (76.5)	84 (87.9)	73 (75.7)	79 (81.8)	93 (93.7)
9820**	**71** (75.0)	**78** (81.1)	**91** (92.9)	**79** (80.2)	**84** (86.7)	**99** (99.3)
10 100***	73 (76.1)	79 (82.2)	92 (94.2)	80 (81.3)	86 (87.9)	100 (100.7)

* Authorized maximum take-off weight for flight into icing conditions
** Actual take-off weight
*** Actual take-off weight plus estimated freezing precipitation accumulation

According to observers, the aircraft may have accumulated as much as ⅛ inch of ice from the freezing precipitation. Based on the plan form area of the upper surface of the wing, horizontal tail and fuselage, it was estimated that the ice could have added another 280 pounds to the take-off weight. This in turn would further increase the stall speeds of the aircraft. Another increase in stall speed would also occur if the aircraft was in a turn. As indicated in Section 1.6.1 of this report, a pilot following normal procedures would retract flaps from 10° to 0° at a minimum airspeed of 95 KIAS. The calculated stall speed at a weight of 10 100 pounds (9820 pounds plus 280 pounds), with a 20 per cent reduction due to ice, was approximately 92 KIAS (94.2 KCAS). This would indicate that, if the flaps were retracted to 0° at 95 KIAS, there would have been little or no stall margin, particularly if the aircraft was in a turn.

Because the aircraft weight exceeded the maximum allowable gross take-off weight, the POH could not be used to calculate take-off distances. However, alternate means of calculation demonstrated that the ground roll for an aircraft with a weight of 10 100 pounds and a 20 per cent lift reduction would exceed the Pelee Island runway length of 3300 feet unless 20° of flaps were used.

1.7 *Aircraft Icing*

1.7.1 *Aircraft Certification*

The Cessna 208 demonstrated compliance with the ice protection requirements of Federal Aviation Regulation (FAR) 23.1419 when the ice protection equipment was installed in accordance with the aircraft equipment list. C-FAGA was equipped with the Cessna 208 ice protection equipment package. Part of this package includes pneumatic de-icing boots on the wings, wing struts, main landing gear struts, cargo pod nose cap (if installed), and the horizontal and vertical stabilizer leading edges. Also included are electrically heated propeller blade anti-ice boots and a detachable electric windshield anti-ice panel. The ice protection certification allows flight in icing conditions as defined by FAR 25 Appendix C envelopes for continuous maximum and intermittent maximum icing when the aircraft is operated in accordance with the POH and the Federal Aviation Administration (FAA)–approved aircraft flight manual.

1.7.2 *Cessna 208 Flight Manual Icing Information*

The Cessna Caravan POH also states in Supplement 1 that the aircraft should not depart from or be flown into an airport where freezing rain or drizzle conditions are being reported. It also states that the minimum speed during flight in icing conditions with the flaps up is 105 knots. The POH supplement also mentions that, with inoperative de-icing boots, the aural stall warning horn may not function and there may be little or no pre-stall buffet with heavy ice loads on the wing leading edges. It also states that cycling the de-icing boots increases stall speeds by up to 10 knots. The high wing configuration of the Cessna Caravan makes it difficult for the pilot to determine if ice is forming aft of the de-icing boots on the top of the wing, which is more detrimental to lift than if it forms on the bottom of the wing.

The Cessna Caravan POH states in Supplement 1 that the in-flight ice protection equipment is not designed to remove ice, snow, or frost accumulations on a parked aircraft sufficiently to ensure a safe take-off or subsequent flight. Other means (such as a heated hangar or approved de-icing fluids) must be used to ensure that all wing, wing strut, landing gear, cargo pod, tail, control, propeller and windshield surfaces, and the fuel vents are free of ice, snow, and frost accumulations before take-off. Cessna has included a warning in the supplement: "If these requirements are not accomplished, aircraft performance will be degraded to a point where a safe take-off and climb out may not be possible." Cessna has also produced a seminar for its Cessna Caravan customers that highlights the effects of icing on aircraft.

The emergency section of the Cessna Caravan POH gives several cautions about using flaps when encountering severe icing. These cautions were required by Airworthiness Directive (AD) 96-09-15, paragraph (a)(2).

> Do not extend flaps during extended operation in icing conditions. Operation with flaps extended can result in a reduced wing angle of attack, with the possibility of ice forming on the upper surface further aft on the wing than normal, possibly aft of the protected area.
>
> If the flaps are extended, do not retract them until the airframe is clear of ice.

The POH also gives several cautions about using flaps for inadvertent icing encounters.

> Use a minimum approach speed of 105 knots, select the minimum flap setting required.
>
> Do not extend flaps beyond 20° for landing.
>
> With heavy ice accumulations on the horizontal stabiliser leading edge, do not extend flaps while en route or holding.
>
> Do not retract flaps once extended, unless required for a go-around. Then retract flaps in increments while maintaining 5-10 knots extra airspeed.

1.7.3 *Company Direction on Icing*

The company provided initial and recurrent training on surface contamination–airborne icing for its pilots. This included, among other topics, discussions of aerodynamic effects, icing encounter tactics, use of aircraft equipment, and company directives and SOPs. The training lecture and SOPs specifically address the "inadvertent icing encounter" considerations, but the SOPs do not include the "procedures for exiting severe icing environment" as described in the POH, Section 3, Emergency Procedures. The accident pilot had received this training on 26 November 2003.

1.7.4 *Canadian Regulatory Policy Regarding Aircraft Icing*

There is considerable regulatory structure specific to aircraft operations in icing conditions. CAR 602.11(2) states, "No person shall conduct or attempt to conduct a take-off in an aircraft that has frost, ice or snow adhering to any of its critical surfaces." General Operating and Flight Rules Standard 622.11 describes the content requirements for an air operator's ground icing operations program. It is a comprehensive set of guidelines covering the management plan, de-icing and anti-icing procedures, hold-over timetables, inspection and reporting procedures, and training and testing parameters. Commercial Air Service Standard 723.105(t) describes the requirement for the company operations manual to include procedures for ice, frost, and snow critical surface contamination.

1.7.5 *Historical Data on Cessna 208 Icing Accidents*

The number of Cessna Caravan accidents involving icing conditions has raised enough concern in the United States that a study was recently conducted by the Remaining Risk Joint Safety Analysis Team composed of representatives from the FAA, the National Aeronautics and Space Administration (NASA), and industry. The results of this study have yet to be released, but issues under examination include regulations, training, and equipment.

The National Transportation Safety Board (NTSB) is reviewing Cessna Caravan icing-related accidents to determine if there is a systemic problem either with the aircraft or the operation of the aircraft. There have been four accidents in Canada involving Cessna Caravan aircraft in icing conditions.

1.7.6 *National Transportation Safety Board Actions Regarding Cessna 208 Aircraft Icing*

In late 2003, the NTSB initiated an in-depth assessment of 26 ice-related events involving the Cessna 208 aircraft. The assessment revealed that 10 of the 26 events involved inadequate removal of ice that had accumulated while the aircraft was on the ground before take-off. It also offered a possible explanation in that the aircraft's high-wing design makes thorough visual inspection of the wing's upper surface more physically challenging than a similar inspection on an aircraft with a low-wing design. It also stated that, during the FAA's 2002 safety evaluation of the Cessna 208, FAA inspectors asked pilots if they could take off in the Cessna 208 with polished frost, snow, or ice on the wings or stabilizer surfaces. Eight of 22 pilots interviewed thought that such an operation was approved, or were unsure. As a result, on 15 December 2004, the NTSB recommended that the FAA expeditiously do the following:

> Require all pilots and operators of Cessna 208 series airplanes equipped for flight into known icing conditions to undergo seasonal training for ground deicing and flight into icing conditions on an annual basis. This seasonal training should be timed to precede the operator's cold weather operations and should specifically address (1) the limitations of the Cessna 208 in icing situations; (2) the Cessna 208 deice and anti-icing systems and controls and their use; (3) pilot actions during cold weather ground operations, with emphasis on the need for careful visual and tactile examination of wing and horizontal stabilizer upper surfaces during the preflight inspection to ensure that they are free of ice before takeoff; (4) pilot actions during cold weather flight operations, with emphasis on the timely recognition of potentially dangerous accumulations of ice and the importance of having an appropriate strategy for escaping the icing conditions and acting on that strategy promptly; (5) the hazards of performance degradation caused by ice that remains after activation of the deice boots; and (6) Cessna 208 Pilot Operating Handbook icing-related limitations, warnings, and notes. (A-04-64)
>
> Require Cessna Aircraft Company, working with Cessna 208 operators, to develop effective operational strategies (for example, cold weather preflight strategies in remote locations, viable methods of collecting icing-related weather information before and during flight, ice detection and monitoring cues, optimal use of anti-ice and deice systems, minimum airspeeds for all phases of flight, proper use of flaps and engine power in icing conditions, and development of ice accumulation limitations and exit strategies for pilots in icing conditions) and related guidance materials to minimize the chance of Cessna 208 ground and in-flight icing accidents or incidents; the FAA should then verify that these strategies and guidance materials are incorporated into Cessna 208 operator manuals and training programs in a timely manner. (A-04-65)
>
> Require all pilots and operators of Cessna 208 series airplanes to conduct a visual and tactile examination of the wing and horizontal stabilizer leading edges and upper surfaces to ensure that those surfaces are free of ice and/or snow contamination before any flight from a location at which the temperatures are conducive to frost or ground icing. (A-04-66)

> Evaluate its current procedures for surveillance of operators of Cessna 208 series airplanes equipped for flight into known icing conditions to determine whether the surveillance effectively ensures that these operators are in compliance with Federal deicing requirements and, if necessary, modify the surveillance procedures to ensure such compliance. (A-04-67)

On 29 December 2004, the NTSB issued an Alert to Pilots on wing upper surface ice accumulation, which stated the following:

> According to wind tunnel data, a wing upper surface roughness caused by particles of only 1-2 mm (millimeter) diameter (the size of a grain of table salt), at a density of about one particle per square centimeter, can cause lift losses of about 22 and 33 percent, in ground effect and free air, respectively. Research has shown that almost imperceptible amounts of ice on an airplane's wing upper surface during takeoff can result in significant performance degradation.

1.7.7 Aircraft De-icing Boot Activation

The Cessna 208B wing uses a NACA 23000 series airfoil. At wing station 35.0 (wing root), the airfoil is a NACA 23017, which changes in a continuous transition to a NACA 23012 at wing station 306.0 (wing tip). Experimental studies[5] have investigated the effects of residual and intercycle ice accretions. These ice accretions result from the cyclic operation of aircraft de-icing systems. Residual ice is defined as the ice accretion present on the de-icer surface immediately after the de-icer is activated. Intercycle ice is defined as the ice accretion present immediately before the de-icer activation.

The studies reported that the NACA 23012 airfoil has been found to be very sensitive to leading edge ice accretions. Compared to other general aviation airfoils, the NACA 23012 has the most severe performance loss. The results of the studies found that the intercycle icing caused significant performance degradation. The maximum lift coefficient was reduced from 1.8 (clean)

[5]
- American Institute of Aeronautics and Astronautics (AIAA) 2003-0728, *Effect of Airfoil Geometry on Performance with Simulated Intercycle Ice Accretions*, M.B. Bragg and A.P. Broeren;
- AIAA 2002-0240, *Effects of Intercycle Ice Accretions on Airfoil Performance*, M.B. Bragg et al;
- AIAA 99-0092, *Effects of Simulated – Spanwise Ice Steps on Airfoils, Experimental Investigation*, S. Lee and M.B. Bragg;
- DOT/FAA/AR-02/68, dated May 2002, *Effects of Residual and Intercycle Ice Accretions on Airfoil Performance*.

to 0.7 (iced) and the stall angles were reduced from 17° (clean) to 9° (iced). The DOT/FAA/AR-02/68 report dated May 2002 also tested different cycle times (one and three minutes) and the performance degradation was reduced with one-minute cycle times.

During the testing, it was determined that the de-icing boots were equally effective when activated at 11 seconds after ice accretion started as compared to waiting until ¼ inch of ice had accreted. Accumulations of more than ¼ inch of ice resulted in significant performance degradation. The Cessna Caravan POH (S1-22) recommends that ½ to ¾ inch of rime ice should be allowed to accumulate before activating the boots, but only ¼ to ⅜ of clear ice to be allowed to form before activating the boots.

The May 2002 report concludes that initiating the boot operation as soon as icing was detected and using a one-minute cycle was most effective in limiting intercycle ice accretions. The report also recommends an "early and often" approach to the operation of de-icing boots, and further consideration and possible in-flight testing because of the limited number of test cases. In spring 2005, Cessna conducted flight evaluations of the "early and often" de-icing boot operation technique. In addition, the FAA conducted wind tunnel testing on the Cessna Caravan airfoil in 2005. The results of these studies have yet to be published.

1.7.8 Cessna 208 De-icing Boot Coverage

The American Institute of Aeronautics and Astronautics (AIAA) 99-0092 report investigated the effects of spanwise-step ice shapes on various airfoil sections. Again, the NACA 23012 airfoil was found to have more severe performance degradation compared with other general aviation airfoils. The spanwise-step type of ice accumulation can occur on an aircraft when ice accretes behind the leading edge de-icing boot.

The testing of spanwise-step shapes considered various chordwise locations to determine the most critical location. For the NACA 23012 airfoil, the most critical location was near 12 per cent chord. The Cessna 208B de-icing boots, at wing station 306.0, extend aft to 5 per cent chord on the wing upper surface. The most critical location is not covered by the de-icing boots, so if ice were to accrete aft of the de-icing boots, there would be a significant performance degradation. The magnitude of the lift loss would depend on the height of the ice accumulation.

1.8 Aids to Navigation

Pelee Island Airport is served by non-directional beacon (NDB) PT that provides guidance for an NDB/VOR or NDB RWY 09 approach and RWY 27 approach. The NAV CANADA flight check organization performed the last flight check of the PT NDB on 30 May 2003 and reported it acceptable.

1.9 Aerodrome Information

Pelee Island Airport is approximately 31 nm south of Windsor, at an elevation of 571 feet above sea level (asl). Cleveland air route traffic control centre provides air traffic services to IFR aircraft in the area of southern Ontario in which flight GGN125/126 operated. The airport's main runway is 09/27. It is 3300 feet long, 75 feet wide, with an asphalt surface. Pelee Island Airport is a certified airport, licensed and regulated by Transport Canada (TC).

The airport manager had plowed the runway and ramp area before GGN125 arrived. The runway surface at the time GGN125/126 landed and took off was 70 per cent snow covered.

On the day of the accident, NOTAM 040006 for Pelee Island Airport was in effect advising that the aerodrome rotating beacon and the runway identification lights were unserviceable. Neither the wind indicator, the altimeter, nor the UNICOM radio were serviceable. The possible lack of UNICOM radio and altimeter information is addressed in the instructions contained in the *Canada Air Pilot*. There is no indication that the pilot of GGN125/126 attempted communication with the airport through the UNICOM frequency. These circumstances had no impact on the conduct of flights GGN125 and GGN126.

1.10 Flight Recorders

The aircraft was not equipped with any on-board recording devices nor was it required to be by regulations. The determination of the occurrence events was hampered by the lack of on-board recording equipment.

1.11 Aircraft Wreckage and Impact Information

The aircraft was destroyed on impact with the ice (see Appendix E). The aircraft was found on the bottom of the lake, in approximately 27 feet of water, in an upright position, listing to the left and pointing westerly. Much of the aircraft was only loosely held together. The engine appeared to be attached by only cables and wires. There was severe damage to the front of the fuselage, extending back to the trailing edge of the wings. The forward part of the fuselage was fully open at the front end and split open along the sides in several places. The wing carry-through area was torn out of the top of the fuselage and only partially attached at the side. Both wings were partially detached, with extensive compression damage along their leading edges. The left wing was bent aft. The tail section was relatively undamaged. All the observed fractures throughout the aircraft structure were considered to have been the result of either impact damage or cuts made during salvage. There was no indication of structural failure before impact.

The structural damage indicates that the aircraft struck the ice in a steep, nose-down attitude with the left wing down. Examination of the aircraft instruments indicated that, at the time of impact, the aircraft was banked approximately 80° left wing down and pitched approximately 35° nose down. The airspeed was approximately 128 knots and the vertical speed was approximately 2250 feet per minute.

The flight control system was examined, and all fractures were determined to be either salvage cuts or overstress fractures. No indications were found of any pre-existing discontinuity in the flight control system. Examination of the flap system indicates that both flaps were at, or very near, the up position at the time of impact.

1.12 Medical Information

The pilot had a valid civil aviation medical certificate. There was no indication of a pre-existing medical condition that could have affected his performance.

1.13 Survival Aspects

1.13.1 General

All occupants aboard the aircraft died from multiple blunt trauma consistent with a major force impact. The impact force was in excess of 16 g, which exceeded the 9.0 g aircraft design requirements. All the occupant seats had fractured and were at least partially separated from the floor. The aft right passenger door was still serviceable and available for emergency egress, despite the severity of the impact.

1.13.2 Door Placards and Safety Features Card

The interior and exterior placards on the upper panel of the aft right door were not the correct placards (see Appendix F). The inside placard indicated that, to open the upper panel of the door, the operating handle had to be rotated counter-clockwise when in fact it had to be rotated clockwise. The part number for the incorrect placard was 2605013-1. It should have been part number 2605013-2. The outside placard did not contain all the steps required to open the door from the outside and was for another type of door, a crew door. The part number of the incorrect placard was 2605012-18. It should have been part number 2605012-14.

The investigation could not determine when these incorrect placards were installed on the aircraft. However, the aircraft was last painted at the aircraft manufacturer’s plant. Examination of other Cessna Caravans indicates this to have been an isolated case. Notwithstanding, the internal/external placards depicting how to open the aircraft doors were not designed to be visible in darkness, nor is there a regulatory requirement for such. However, FAR 23.807 states that emergency exits must be arranged and marked for easy location and operation, even in darkness.

TC reviewed a Georgian Express Ltd. safety features card in June 2000 and issued a “meets standards” letter to Georgian Express Ltd. However, the safety features card retrieved from the occurrence aircraft was an Air Georgian safety features card. This card was reviewed by TSB investigators against TC’s Commercial Air Service Standard 723.39(4) for content, accuracy, and clarity. Some required safety information was missing, specifically information about stowing carry-on baggage and about brace positions for adults holding infants. In addition, pictorial instructions regarding the passenger restraint systems and the operation of the emergency exits were unclear and difficult to understand.

Although this was not a survivable accident, the inadequate information and instructions provided by the safety features cards and placards could impede a timely and safe evacuation in an emergency situation.

1.13.3 Animal Restraints

Although the OSTC brochure states that Georgian Express Ltd. has a policy with respect to restraining animals on its aircraft, no such policy could be found in the Georgian Express Ltd. documentation. CAR 602.86(1)(b) addresses the need to secure carry-on baggage, equipment, or cargo. Animals, other than service animals, are expected to be transported in secure cages. When caged, they are considered to be either carry-on baggage or cargo, which must be restrained. The dogs on the occurrence aircraft were not restrained. In an aircraft accident with g forces, any heavy unsecured item can become a projectile and may injure passengers and crew. Moreover, unrestrained animals may impede access to an emergency exit and slow evacuation, thereby prolonging exposure to a potentially lethal environment.

1.13.4 Emergency Locator Transmitter

The ELT was retrieved from the wreckage. It was tested and found to be serviceable. It is likely that the ELT activated at impact. However, as most of the aircraft was under water after impact, the signal strength would have been sufficiently attenuated to render it undetectable.

1.14 Company Oversight

Georgian Express Ltd. had previously provided winter air service to Pelee Island from 2000 to 2002. A different company won the contract in 2002. While the contract was awarded for two years, this company was unable to fulfill the second year of the contract. Georgian Express Ltd. won the contract for 2003-2004, when it was re-tendered in October 2003, and operations commenced on 13 December 2003. The operations manager travelled on the first flight to check on operational concerns such as fuelling and aircraft servicing contracts, ramp access, passenger agents, and billing arrangements.

CAR 723.07(3) states that it is the company's responsibility to coordinate the provision of aircraft services such as fuel, de-icing, and passenger agents. The company base in Toronto had provided de-icing fluid in small containers (about two gallons) similar to a gardener's spray can that crews could carry on board for use in remote locations. No de-icing fluid can was found in the wreckage. There were no facilities on Pelee Island to de-ice the aircraft, and there was no means to inspect the top of the wings and fuselage, such as a ladder.

Georgian Express Ltd. flights are operated as pilot self dispatch. Operational control is delegated to the pilot-in-command of a flight by the operations manager who retains responsibility for the day-to-day conduct of flight operations. This means that the pilot is responsible for obtaining and assessing weather information, flight planning, aircraft configuration management, and load control. The operational flight plan is used by the company to document flight parameters, and weight and balance information. According to the company operations manual, the buff copy of the flight plan must be left with a responsible person for search and rescue (SAR) response. The top copy is not delivered to company operations until the end of the day or when the pilot returns to Toronto.

For Pelee Island operations, the buff copy was to be left with the passenger agent in either Windsor or Pelee Island. This practice was not being followed. Although the chief pilot had repeatedly reminded the pilots to complete their paperwork, for the Pelee Island operation, there were many instances when the required forms either were not properly completed or were not completed at all.

At Pelee Island, the company's flight-scheduled turnaround time was 10 minutes. During the turnaround, pilots were responsible for completing the passenger and cargo offload and upload (including the weight and balance calculation), completing the aircraft inspection, checking the weather, and amending the flight plan as required.

1.15 Regulatory Oversight

1.15.1 Oversight Process

TC's Commercial and Business Aviation (CBA) Division is responsible for the oversight of commercial air operations that fall under CAR 700. The CBA has Certification and Operations sub-divisions. The Certification Sub-division handles applications for new operations and for changes to existing operations. It also ensures that air operators meet the required standards in *Commercial Air Service Standards* (CASS). The Operations Sub-division monitors day-to-day operations to ensure that the company is conducting business in accordance with its Air Operator Certificate (AOC). The Certification and Operations sub-divisions exchange information on related issues as required.

The Operations Sub-division effects oversight through formal audits, inspections, PPCs, ramp inspections, and in-flight inspections. Each air operator has an assigned principal operations inspector (POI) who monitors the company's operations. The activities of the POI are governed by the *Air Carrier Inspector Manual* (ACIM), TP 3783.

Section 3.2 of the ACIM indicates that the in-flight inspection program consists of routine monitoring and special purpose inspections. Routine monitoring covers all route segments and stations in an air operator's service pattern, and all stations within an area of operations for non-scheduled air operators. Special purpose inspections take priority over routine monitoring and are carried out when there are significant or unusual changes in an air operator's operations.

TC assigned a POI for Georgian Express Ltd. in 2001 from the Toronto Operations Sub-division. The POI carried out the regulatory oversight of the company through e-mails, telephone conversations, and routine visits to the air operator's Toronto facilities. Before the Pelee Island accident, the POI's assessment of the company was that there were no serious problems with company operations. The POI did not conduct any visits or inspections specific to the Pelee Island contract because he was unaware that the company had undertaken this operation. There was no regulatory requirement for the company to advise TC of the Pelee Island operation.

TC's Certification Sub-division in Toronto was aware that Georgian Express Ltd. was about to embark on a passenger charter service to Pelee Island. This was indicated by written correspondence between TC and the OSTC dated 11 December 2003. This letter, from the Director of CBA in Ottawa, clarified for OSTC that the responsibility for an AOC rested with Georgian Express Ltd. This letter was also addressed to the TC Certification Sub-division in Toronto, but not to the Operations Sub-division. Since the OSTC does not hold an AOC, there was no requirement for the Operations Sub-division to be included in the distribution of the letter.

1.15.2 Frequency of Inspections

TC's *Frequency of Inspection Policy Document* (TP 12840) sets guidelines for various types of inspections and audits, and any follow-up action requirements. It states that the selection of companies to be audited in a given year will be based on an assessment of the risk factors outlined in the *Manual of Regulatory Audit*. A TC background document regarding the frequency of inspection policy (10 August 2004) states the following:

> Audits and inspections are normally conducted on a cycle ranging from 6 to 36 months. This cycle can be extended or shortened depending on a number of factors. These include the strength of a company's internal audit program, its regulatory record, its history of compliance with previous regulatory findings, and other risk indicators identified by the department.

Section 2.10.3 of the ACIM states that a regional inspection plan must be prepared, maintained, and reported on. The plan must relate to each air operator under regional jurisdiction, identify the target population for the task, indicate the planned inspection frequency for each air operator, and identify the air operators where the inspection frequency is more or less than the established level.

1.15.3 Georgian Express Ltd. Audit History

Georgian Express Ltd. was formed in 2000 when Air Georgian separated its cargo and passenger carrier operations. Although Georgian Express Ltd. was primarily a cargo-carrying operation, a charter contract for passenger service to Pelee Island was added for the winter of 2003-2004.

The first formal TC audit of Georgian Express Ltd. was scheduled for 11 to 14 September 2001. The audit was cut short on September 11, following the terrorist events in New York and Washington, United States. As a consequence, no in-flight inspections or ramp checks were conducted. The audit manager therefore recommended that the next company audit should concentrate on training records, and in-flight and ramp inspections. At the time of the accident, 28 months had elapsed since that abbreviated audit.

The POI for Georgian Express Ltd. had conducted no fewer than 20 regulatory oversight events with the company in 2003 and did not express a safety concern with the company. Correspondence from TC and a review of the Regional Inspection Plan for Ontario indicate that an audit of Georgian Express Ltd. was scheduled for September 2004. The decision to reschedule the Georgian Express Ltd. audit to September 2004 was based on an assessment of the risks in the operation, which were assessed as low.

1.15.4 Scheduled versus Chartered Service

Section 720.01 of the CASS defines a scheduled air service as a publicly available air transport service that provides transportation for passengers between points and serves those points in accordance with a published schedule at a charge per seat. If an air operator makes an application for its AOC to contain a scheduled point, TC assesses the applicant's ability to meet the CASS for the operation as required by CAR 703.07(1)(e). The OSTC contracted Georgian Express Ltd. to fly between Windsor and Pelee Island at a rate per trip. Therefore, by definition, it was not a scheduled service, but a charter. As such, there is no regulatory requirement to apply for an AOC. Since Georgian Express Ltd. did not apply to TC for an AOC with Pelee Island as a scheduled point, the POI did not know about the service to Pelee Island.

The tender for the Pelee Island contract described the service as "A scheduled service under a subsidy arrangement between the Township of Pelee and the provincial Ministry of Transport." There was no requirement for the provincial Ministry to advise TC of the air service, and no such notice was given.

1.16 Simulator Training Requirement

The occurrence pilot attended Cessna Caravan simulator training at the Flight Safety International facility in Wichita, Texas, United States, in May 1999 as part of his initial training on type with a previous employer. His PPC on the Cessna Caravan had expired in September 2000, more than 24 months before he resumed Cessna Caravan duty with Georgian Express Ltd. The pilot completed the initial ground school and flight training with Georgian Express Ltd. in November 2003, but did not undertake any simulator training.

CASS 723.98(24) requires pilots to complete ground training, flight training, and six hours of simulator training as part of their initial training course if they are to carry passengers in a single-engine aircraft during night visual flight rules (VFR) conditions or IFR conditions. The pilot met these requirements in May 1999.

CASS 723.98(13)(c) states that, where a PPC has expired for a period greater than 24 months, a complete initial aeroplane type training course shall be carried out. This is reflected in the Georgian Express Ltd. company operations manual, Section 5.28.3.

However, CASS 723.91(2) only requires the flight crew member to complete the air operator's initial aeroplane ground and flight training when the PPC or competency check has expired for a period of 24 months or more. This section of CASS does not clearly indicate whether there is a requirement for simulator training following PPC expiration.

An overall review of the CARs concerning the simulator issue suggests that there may be no requirement to conduct recurrent simulator training if currency and/or PPC do not lapse.

1.17 Standard Passenger Weights

Regulations prohibit the operation of an aircraft unless the weight and centre of gravity of the aircraft conform to the limitations specified in the aircraft manual (CARs 703.37, 704.32, and 705.39). For passenger-carrying operations, the calculation of passenger weight is one of the primary determinants of total aircraft weight. Air operators have three options for calculating passenger weight: use the passengers' actual weights, use standard weights as published in

A.I.P. Canada Section RAC 3.5, or use standard weights obtained through an air operator survey. Section RAC 3.5 emphasizes that actual weights should be used, but where these are not available, then the values in Table 4 (arrived at by an airline/TC survey) may be applied. In Canadian aviation, the A.I.P. Canada standard weights are commonly used to determine passenger weight. These numbers include the passengers' clothing and carry-on baggage. This procedure is a universally accepted practice and is commonly used throughout the aviation industry.

Table 4. A.I.P. Canada Section RAC 3.5: Published Standard Weights

	Summer	Winter
Males (12 yrs and up)*	182 lbs	188 lbs
Females (12 yrs and up)	135 lbs	141 lbs
Children (2-11 yrs)	75 lbs	75 lbs
Infants (0 to less than 2 yrs)**	30 lbs	30 lbs

* A group of large men, such as a football team, are to be accounted for separately at not less than 215 pounds each.

** Infant weights are to be added in when the number of infants exceeds 10 per cent of the number of adults.

Note: where no carry-on baggage is permitted or involved, the weights for men and women may be reduced by 8 pounds.

On 27 January 2003, the FAA issued Notice N8400.40, which required operators of aircraft with 10 to 19 seats to conduct a survey to validate average passenger weights. The results of the survey (FAA N8300.12) indicated that the standard weight values contained in FAA Advisory Circular 120-27C (11 July 1995) underestimate the average weight of passengers by 20.63 pounds and underestimate the average weight of carry-on baggage by 5.72 pounds.

Recent studies in Canada and the United States also show that these values for standard passenger weights are no longer representative of the general population.

A review of the Pelee Island operation revealed that standard weights were being used to calculate passenger weight for 155 of the 165 flights. In this accident, the difference between the actual weight and the standard weight of passengers was about 570 pounds.

A comparison of various aircraft types indicates that the ratio of passenger weight to overall aircraft weight is inversely proportional to the size of the aircraft. For example, in a Boeing 747, the passenger weight represents approximately 9 per cent of the aircraft's weight, whereas the passenger weight in a Cessna Caravan can represent approximately 22 per cent of the aircraft's weight. For aircraft such as the Cessna Caravan, there can be significant deviations from the published standard passenger weights because of the smaller number (9 or fewer) of passengers carried. This deviation error is further amplified in small aircraft because the passenger weight represents a higher percentage of the total aircraft weight.

There have been numerous accidents in Canada related to overweight aircraft. At least five of these accidents involved small aircraft where discrepancies between the standard and actual weight of passengers contributed to the aircraft's overweight condition and to the accident. Four of these accidents were fatal, involving 24 fatalities. There are 3564 commercial aircraft in the small aircraft category (less than 12 500 pounds) operating in Canada. These aircraft conduct thousands of flights daily.

The NTSB has published numerous recommendations relating to the calculation of aircraft weight. Several of these recommendations dealt specifically with aircraft under 12 500 pounds and the issue of standard versus actual weight. In response to these recommendations, the FAA released an Advisory Circular (120-27C, dated 11 July 1995) outlining a new policy on aircraft weight and balance control. This document states that actual weights for passengers are to be used for aircraft carrying nine passengers or less.

1.18 Fatigue and Stress

The occurrence pilot experienced two circadian rhythm disruptions between 13 and 16 January 2004 when he flew as a passenger from Toronto to Los Angeles and return, with three time zone changes each way. Circadian rhythm disruptions can result in fatigue[6] if adequate adjustment periods are not available.[7] Travelling from Toronto to Los Angeles and back would typically require an adjustment period of three days[8] or more[9] after the round trip. When the accident occurred, the adjustment time available to the pilot had been less than one day (20 hours). It is therefore likely that the pilot was exposed to an increased risk of fatigue due to circadian rhythm disruptions.

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6 Poor sleep quality, cognitive and psychomotor performance impairments, gastrointestinal distress, insomnia, and anxiety are also outcomes of circadian disruption. J.R. Belgan, C.M. Winget, and L.S. Rosenblatt, *The Desynchronisis Syndrome*, Annual scientific meeting: Aerospace Medical Association, Washington, D.C.: Pre-prints of scientific program, 1973.

7 D.I. Tepas and T.H. Monk, "Work Schedules," in G. Salvendy (Ed.), *Handbook of Human Factors*, New York: John Wiley & Sons, 1987, pp. 819-843.

8 K.E. Klein and H.M. Wegmann, *Significance of Circadian Rhythms in Aerospace Operations* (NATO AGARDograph, 247), Neuilly sur Seine, France: NATO AGARD, 1980.

9 S. Campbell, "The Basics of Biological Rhythms," in M.R. Pressman and W.C. Orr (Eds.), *Understanding Sleep: The Evaluation and Treatment of Sleep Disorders*, Washington, D.C.: American Psychological Association, 1997, pp. 35-56.

The occurrence pilot arrived at the Toronto Airport from Los Angeles at 2047 on January 16. It was estimated that it would take 1 hour 15 minutes for the pilot to clear customs, collect his baggage, and drive home, provided there were no delays. He would then likely require another 30 minutes to prepare for bed. His earliest bedtime would therefore be 2230. The pilot arrived at work the following morning at 0445, which would have required a wake-up at 0345 to prepare and drive the 30-minute trip to work.

Provided that he fell asleep immediately and did not wake up at all, which is unlikely due to the circadian rhythm disruptions noted above, the pilot would have slept for a maximum of 5 hours 15 minutes. The pilot also had an opportunity to sleep in his hotel room between the morning flights and the afternoon flights, which would have been interrupted by the one-hour lunch break he took outside the hotel. In addition to a shortened sleep period, the disruptions in circadian rhythms would likely have reduced the pilot's sleep quality. This lack of good quality sleep could have increased the pilot's risk of fatigue.

Fatigue directly affects decision making by changing how individuals assess risk. Fatigued individuals will change their perception of how risky a decision may be or will tolerate an increased level of risk.[10] Fatigue can also reduce the ability to problem solve a non-routine situation. Instead of approaching the situation flexibly, they increase their perseveration. Perseveration increases the likelihood that the normal routine will be maintained, and that can lead to a failure to revise the original plan.[11, 12]

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10 J.A. Horne, *Why We Sleep–The Functions of Sleep in Humans and Other Mammals*, Oxford, England: Oxford University Press, 1988, cited in Y. Harrison and J.A. Horne, "The Impact of Sleep Deprivation on Decision Making: A Review," *Journal of Experimental Psychology Applied*, 6, 2000, pp. 236-249.

11 F. Wimmer, R.F. Hoffman, R.A. Bonato and A.R. Moffit, "The Effects of Sleep Deprivation on Divergent Thinking and Attention Processes," *Journal of Sleep Research*, 1, 1992, pp. 223-230.

12 J.A. Horne, "Sleep Deprivation and Divergent Thinking Ability," *Sleep*, 11, 1988, pp. 528-536.

Studies have shown that, while stress may not decrease overall job performance, it can impair basic cognitive processes[13] such as working memory and attention. Individuals under stress do not retain as much information in memory while making decisions, nor are they able to attend to as many simultaneously presented pieces of information as unstressed individuals. Stress and fatigue combined can further exacerbate these working memory and attention decrements.[14, 15]

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13 S. Sonnentag and M. Frese, "Stress in Organizations," in W.C. Borman, D.R. Ilgen, and R.J. Klimoski (Eds.), *Handbook of Psychology*, volume 12: Industrial and Organizational Psychology, Hoboken, New Jersey: John Wiley & Sons, 2003, pp. 453-491.

14 G.R. Hockey, A.J. Maule, P.J. Vlough, and L. Bdzola, "Effects of Negative Mood States on Risk in Everyday Decision Making," *Cognition and Emotion*, 14, 2000, pp. 823-856.

15 M.M. Lorist, M. Klein, S. Nieuwenhuis, R. de Jong, G. Mulder, and T.F. Meijman, "Mental Fatigue and Task Control: Planning and Preparation," *Psychophysiology*, 37, 2000, pp. 614-625.

2.0 Analysis

2.1 Introduction

The pilot took off from Pelee Island in freezing precipitation with an aircraft that was ice-contaminated and over its maximum gross weight limit by at least 15 per cent. Although definitive information is not available to explain the pilot's decision making, this analysis will examine the operating environment and other factors that may have influenced his actions. Other safety-related issues were analysed, including the use of unrealistic passenger weight estimates and the capability of the Cessna Caravan to operate safely in icing conditions.

The severity of the impact made this accident non-survivable. There were no mechanical discrepancies found with the aircraft. All observed fractures throughout the aircraft structure were considered to have been the result of impact damage or salvage cuts; there was no indication of structural failure before impact.

2.2 Use of Standard Passenger Weights

2.2.1 General

Carrying the large fuel load meant that the weight of the passengers and cargo load would have to be reduced to stay within the aircraft's maximum allowable gross take-off weight. As it was, the total load of fuel, passengers, and cargo put the aircraft considerably over the maximum allowable gross take-off weight.

2.2.2 Validity of Standard Passenger Weights

Recent research conducted in Canada and the United States indicates that the average passenger is heavier than the currently used estimated weights. Based on this research, it is likely that many flights have operated and are operating at heavier weights than calculated and, in some instances, at weights in excess of the maximum allowable for the aircraft. If flight crews calculate aircraft weight using standard values for passenger weight that are not representative of the general population, the determination of total aircraft weight can be incorrect, resulting in an aircraft overweight condition. It can also result in inaccurate calculation of reference speeds. Both of these can have catastrophic consequences, particularly during critical phases of flight, primarily take-off and landing.

2.2.3 *Use of Standard Passenger Weights in Small Aircraft*

In the Pelee Island accident, the aircraft was calculated to be about 1270 pounds over the maximum allowable take-off weight. The difference between actual and standard weight of the passengers was about 570 pounds. For a small aircraft, such as the Cessna Caravan, using standard weights instead of actual weights can have serious aircraft performance implications.

In any statistical application, the larger the sample size, the more closely the sample mean will match the population mean. For large airliners, deviations between the calculated standard passenger weight and the actual weight are minimized by the larger sample size of passengers. For a small aircraft loaded to maximum gross weight, an underestimation in passenger weights could result in an overweight condition.

Many flights conducted in smaller aircraft operate at close to maximum gross weight on paper when, in fact, some of these flights may well be operating above maximum gross weight. Allowing the use of standard passenger weights in these aircraft exposes the industry to a high degree of risk. The use of actual passenger weights in small aircraft would provide a greater margin of safety.

2.3 *Ice on the Aircraft*

Along with the observed and calculated reduction in performance of the aircraft during and after the take-off, there are ample indications to conclude that the aircraft was contaminated with ice during the take-off run, and accumulated even more ice after departure.

- The weather at the time of the accident included mixed icing in cloud and freezing precipitation at the Pelee Island Airport.

- Several people on the island reported ice accumulation on their vehicles during the time passengers were getting on the aircraft. One person estimated the ice accumulation to be approximately ⅛ inch.

- It was pointed out to the pilot while the aircraft was on the ramp that there appeared to be ice contamination on the leading edge of the wing.

- The conditions were such that there would also have been ice on all top surfaces of the aircraft from the freezing precipitation. This ice contamination would have added to the weight of the aircraft. Furthermore, it would have been unaffected by using the de-icing equipment installed on the aircraft for use during flight in icing conditions.

The detrimental effects of the ice accumulation contributed to the eventual loss of the aircraft.

2.4 Aircraft De-icing Boot Activation

Limited experimental studies have shown that the "early and often" operation of de-icing boots is more effective in limiting intercycle ice accumulation than the procedure recommended for the Cessna Caravan, which is to wait for up to ¾ inch of ice accumulation before activating the de-icing boots. Such an accumulation will result in a significant performance loss, suggesting that the Cessna Caravan de-icing procedure is not the most effective in reducing the risks associated with in-flight icing.

There has been significant research into aircraft icing with respect to the Cessna Caravan airfoil section (NACA 23012), including "early and often" activation of the de-icing boots. The results of this research prompted further testing by Cessna and the FAA in 2005. The Board continues to monitor the progress of these studies and trials in light of the numerous icing accidents with the Cessna 208 aircraft. The findings and recommendations of these tests are pending.

2.5 Cessna 208 De-icing Boot Coverage

Experimental studies have shown that spanwise-step ice accretions result in significant performance loss. The effects were reported to be most severe on the NACA 23012 airfoil. The most critical chord-wise location for spanwise-step ice accretions was determined to be at approximately 12 per cent chord. The Cessna 208B de-icing boots extend to a maximum of only 5 per cent chord. Therefore, the most critical location is not covered by the de-icing boots and spanwise-step ice accretions could form there, adversely affecting aircraft performance.

2.6 Oversight by the Air Operator

Personnel from the Georgian Express Ltd. Toronto office travelled to Pelee Island on the first flight of the 2003-2004 season. Because crews knew that there was no de-icing equipment on the island, they would not depart for Pelee Island unless the weather was conducive to a successful round trip. However, if ice became an issue after they landed in Pelee Island, they had no convenient way to adequately inspect the aircraft or de-ice it.

The scheduled turnaround times for the Pelee Island service allowed only 10 minutes on the ground in both Windsor and Pelee Island. Records indicate that typical turnaround times were under 10 minutes, and in some cases, under 5 minutes. The required activities during this time included unloading the passengers and cargo, checking the weather and manifest, completing the weight and balance form, flight planning, completing an aircraft pre-flight inspection, and loading the cargo and passengers. It appears that both the company and the pilots treated the air service to Pelee Island as a single flight, Windsor to Windsor, with a brief stopover in Pelee Island, instead of treating each leg as separate flight with the same operational requirements. This could account for why the crews did not complete weight and balance computations and did not leave copies of their operational flight plans with the passenger agents.

The degree of oversight by the air operator was not adequate to detect the anomalies associated with the quick turnaround times.

2.7 *Regulatory Oversight*

Although operated as a charter, the Georgian Express Ltd. flights to Pelee Island were repetitive and had most of the characteristics of a scheduled operation. The company operated its flights between Windsor and Pelee Island in accordance with a schedule, there was a printed flight schedule available to the public, and passengers paid for their tickets. Under current TC definitions, repetitive charters are not considered scheduled operations. Therefore, such repetitive charter operations do not receive the same scrutiny normally given to a scheduled service. Because the air operator does not have to advise TC that it is conducting the service, it may be operating without the knowledge of the individuals charged with the oversight of commercial operations.

The Ontario Ministry of Transportation is not required to inform TC when a seasonal, repetitive charter commences operation. There is no mechanism in place that requires agencies involved in such an air service to advise TC.

Despite the abbreviated nature of the September 2001 audit, the next audit of Georgian Express Ltd. was not scheduled until September 2004, at the end of the 36-month window. It is not known what an audit of the company would have revealed; however, it should have been noted during an inspection of the Pelee Island operation that there was a lack of support facilities, specifically for dealing with aircraft surface contamination and the compressed nature of the flight schedule. The lack of support facilities and short turnaround times may have influenced the pilot's decision to proceed with the accident flight.

2.8 *Simulator Training Requirement*

Simulator training is an effective way to increase pilot skills and knowledge about an aircraft in general. This training is particularly useful for practising procedures that cannot be safely conducted in the aircraft. Without continued or recurrent simulator training, pilot skills and knowledge can degrade.

As described in Section 1.16 of this report, the existing wording in the CARs leaves room for interpretation regarding the requirement to conduct simulator training when renewing a lapsed PPC. Additionally, there seems to be no requirement to conduct recurrent simulator training for a pilot who maintains currency on type.

These apparent ambiguities in the CARs could result in a decrease in pilot flying proficiency due to a lack of training that can only be accomplished in a simulator.

2.9 Pilot Decision Making

From the information available, there is no indication that the accident pilot was a risk taker or that his decision making was negatively influenced by routine job stresses. A review of the records of his previous flights into Pelee Island show that it was not his practice to fly the aircraft in an overweight condition.

The pilot made a number of decisions that increased the risk to the safe operation of flight. He uploaded 1000 pounds of fuel before leaving Windsor when there was already ample fuel on board to complete the flights to and from Pelee Island, including alternate fuel. Although he normally uploaded more fuel than required as a precautionary measure after considering the passenger load for the return trip, in this instance, it exacerbated the eventual overweight condition of the accident flight. For the flight from Pelee Island to Windsor, he chose an alternate airport that did not satisfy the POH warning not to fly into an airport where freezing rain or drizzle conditions exist. There is no indication that he informed ATC of his change of alternate from Sarnia to Detroit. The pilot attempted the flight although he was aware of the ice contamination on the aircraft. All of the above decisions were inconsistent with the pilot’s normal approach to flight safety.

While it could not be established with certainty that the pilot was fatigued, given his past performance, it is likely that a combination of fatigue and stress reduced his working memory and narrowed his attention. Specifically, the scheduled short turnaround time, the large passenger load, the adverse weather conditions, the lack of de-icing equipment, and the need to complete the flight may have acted as stressors.

For the accident flight, there are indications that the pilot’s assessment of risk was likely degraded by some combination of stress and fatigue. The known effects of fatigue on risk assessment could account for his assessment that the flight risk was low or for his tolerance of increased risk to complete the short flight.

The pilot’s decision to fly overweight and without addressing the wing contamination pointed out by two individuals are other indications of his degraded assessment of risk. Retracting the flaps after take-off, contrary to the POH cautions not to raise the flaps when encountering icing conditions, is a further indication of his degraded performance.

Consistent with the known effects of fatigue-related perseveration, there is no indication that the pilot considered changing his original plan to complete the flight in spite of a heavier-than-normal passenger load and a direct report of contamination on the wing. He appeared to have narrowed his attention solely to completing the planned flight, regardless of several factors that indicated that the flight should not be completed.

2.10 The Accident Flight

The attitude of the aircraft at impact indicates that it had entered an aerodynamic stall. It was determined that the flaps were used for the take-off and were up at impact. Calculations show that, as soon as the flaps were retracted, the aircraft would be within the stall envelope due to the aircraft's weight and ice accumulation (see Table 3). The POH recommended procedure is to retract the flaps to 0° at 95 knots. The aircraft struck the ice in a nose-low, left-wing-down attitude. While rolling into a climbing right turn, the left wing would stall first. This would generate a nose drop and roll to the left, consistent with the attitude of the aircraft when it struck the ice. Although no one witnessed the final moments of the flight, it is reasonable to conclude that either the aircraft had not gained sufficient altitude to allow recovery from a stalled condition, or that the flight performance had degraded to the point that recovery was not possible.

3.0 Conclusions

3.1 Findings as to Causes and Contributing Factors

1. At take-off, the weight of the aircraft exceeded the maximum allowable gross take-off weight by at least 15 per cent, and the aircraft was contaminated with ice. Therefore, the aircraft was being flown significantly outside the limitations under which it was certified for safe flight.

2. The aircraft stalled, most likely when the flaps were retracted, at an altitude or under flight conditions that precluded recovery before it struck the ice surface of the lake.

3. On this flight, the pilot's lack of appreciation for the known hazards associated with the overweight condition of the aircraft, ice contamination, and the weather conditions was inconsistent with his previous practices. His decision to take off was likely adversely affected by some combination of stress and fatigue.

3.2 Findings as to Risk

1. Despite the abbreviated nature of the September 2001 audit, the next audit of Georgian Express Ltd. was not scheduled until September 2004, at the end of the 36-month window.

2. The internal communications at Transport Canada did not ensure that the principal operations inspector responsible for the air operator was aware of the Pelee Island operation.

3. The standard passenger weights available in the *Aeronautical Information Publication* at the time of the accident did not reflect the increased average weight of passengers and carry-on baggage resulting from changes in societal-wide lifestyles and in travelling trends.

4. The use of standard passenger weights presents greater risks for aircraft under 12 500 pounds than for larger aircraft due to the smaller sample size (nine passengers or less) and the greater percentage of overall aircraft weight represented by the passengers. The use of standard passenger weights could result in an overweight condition that adversely affects the safety of flight.

5. The Cessna Caravan de-icing boot covers up to a maximum of 5 per cent of the wing chord. Research on this wing has shown that ice accumulation beyond 5 per cent of the chord can result in degradation of aircraft performance.

6. At the Pelee Island Airport, the air operator did not provide the equipment that would allow an adequate inspection of the aircraft for ice during the pre-flight inspection and did not provide adequate equipment for aircraft de-icing.

7. Repetitive charter operators are not considered to be scheduled air operators under current Transport Canada regulations, and, therefore, even though the charter air operator may provide a service with many of the same features as a scheduled service, Transport Canada does not provide the same degree of oversight as it does for a scheduled air operator.

8. A review of the *Canadian Aviation Regulations* regarding simulator training requirements indicates that there is no requirement to conduct recurrent simulator training if currency and/or pilot proficiency checks do not lapse.

9. Commercial Air Service Standard 723.91(2) does not clearly indicate whether there is a requirement for simulator training following expiration of a pilot proficiency check.

10. Incorrect information on the passenger door placards, an incomplete safety features card, and the fact that the operating mechanisms and operating instructions for the emergency exits were not visible in darkness could have compromised passenger egress in the event of a survivable accident.

11. The dogs being carried on the aircraft were not restrained, creating a hazard for the flight and its occupants.

4.0 Safety Action

4.1 Action Taken

4.1.1 Georgian Express Ltd.

The company installed an aircraft de-icing machine on Pelee Island immediately following the accident.

The company now employs a second crew member on all passenger flights. This person is not assigned flight duties, but aids the pilot between flight activities. The company restated its policy to encourage all pilots to make sound and professional decisions regarding flight cancellations and re-emphasized its support for such decisions.

In an effort to reduce perceived mission pressure on aircraft captains, the chief pilot now reviews the weather each day to forecast delays or cancellations. The company operations manual was rewritten to reflect changes that Georgian Express Ltd. had initiated, as well as changes required as a result of the Transport Canada (TC) audit conducted after this occurrence.

Instead of having pilots deliver the passenger brief from memory, the company produced a written script for pilots to recite and sign as having given. The chief pilot is reviewing every flight plan to verify that the weight and balance program is being followed.

4.1.2 Transportation Safety Board of Canada

The defences against the risks associated with using standard weights are not adequate for aircraft carrying nine passengers or less. The use of actual passenger weights in small aircraft would provide a greater margin of safety. Therefore, on 07 October 2004, the Board recommended that:

> The Department of Transport require that actual passenger weights be used for aircraft involved in commercial or air taxi operations with a capacity of nine or fewer passengers. (A04-01)

The surveyed passenger weights in the United States and the investigation results indicate that the published standard weights no longer reflect average passenger weights. It was, therefore, likely that many flights conducted in Canada were operating at a heavier weight than calculated. On 07 October 2004, the Board recommended that, for all aircraft:

> The Department of Transport re-evaluate the standard weights for passengers and carry-on baggage and adjust them for all aircraft to reflect the current realities. (A04-02)

4.1.3 Transport Canada

TC responded to Recommendation A04-01 on 22 December 2004. In its response, TC indicated that it continues to review the standards and that one of the options under consideration is to require the use of actual passenger weights. In May 2005, TC conducted a formal risk assessment for the use of actual passenger weights in air taxi operations. The results of the risk assessment are currently under review. TC's response to this recommendation is assessed as "Satisfactory Intent." However, the present risks associated with using standard weights will remain until a new standard is put in place to ensure that actual weights are used for aircraft carrying nine passengers or less. The TSB is concerned that the length of time required to change/modify the standard could be excessive.

TC responded to Recommendation A04-02 on 22 December 2004, indicating that it had re-evaluated the standard weights for passengers and carry-on baggage and, effective 20 January 2005, adjusted them for all aircraft to reflect current realities. TC's response to the recommendation was rated "Fully Satisfactory."

TC amended the *Aeronautical Information Publication* (A.I.P. Canada) on 20 January 2005 to reflect re-evaluated standard weights for passengers and carry-on baggage. Operators whose approved weight and balance control program is based on the A.I.P. Canada weights are required to amend their programs to reflect these new weights (see Table 5).

Table 5. Amended A.I.P. Canada Standard Weights, 20 January 2005

Summer		Winter
200 lbs or 90.7 kg	MALES (12 yrs up)	206 lbs or 93.4 kg
165 lbs or 74.8 kg	FEMALES (12 yrs up)	171 lbs or 77.5 kg
75 lbs or 34 kg	CHILDREN (2-11 yrs)	75 lbs or 34 kg
30 lbs or 13.6 kg	INFANTS (0 to less than 2 yrs)*	30 lbs or 13.6 kg

* Add where infants exceed 10 per cent of adults.

The weights in Table 5 show increases of 18 pounds for men and 30 pounds for women over previously used standard weights. The weights for children and infants were unchanged.

4.1.4 Federal Aviation Administration

The Federal Aviation Administration (FAA) released Advisory Circular 120-27D, *Aircraft Weight and Balance Control*, on 11 August 2004. It is a comprehensive guide that provides air operators of large, medium, and small cabin aircraft with options for calculating passenger weights. In this circular, the passenger weights have also been increased to reflect current realities. This initiative is closely related to the TSB recommendations above. This occurrence was one of the accidents that precipitated the advisory circular.

The FAA issued Airworthiness Directive (AD) 2005-07-01, effective 29 March 2005, for the Cessna 208 and 208B aircraft. This AD is the result of several accidents and incidents involving the Cessna 208 and 208B operating in icing conditions. This occurrence was one of the accidents that precipitated the AD. The purpose of the AD was to ensure that pilots have enough information to prevent loss of control of the aircraft while in flight during icing conditions.

The AD requires that, before flight, in addition to a visual check, a tactile check of the wing leading edge, wing upper surface (up to two feet behind the de-icing boot at on-span location as a minimum), horizontal tail leading edge, and propeller blades is required if the outside air temperature (OAT) is below 5°C (41°F) combined with any one of the following:

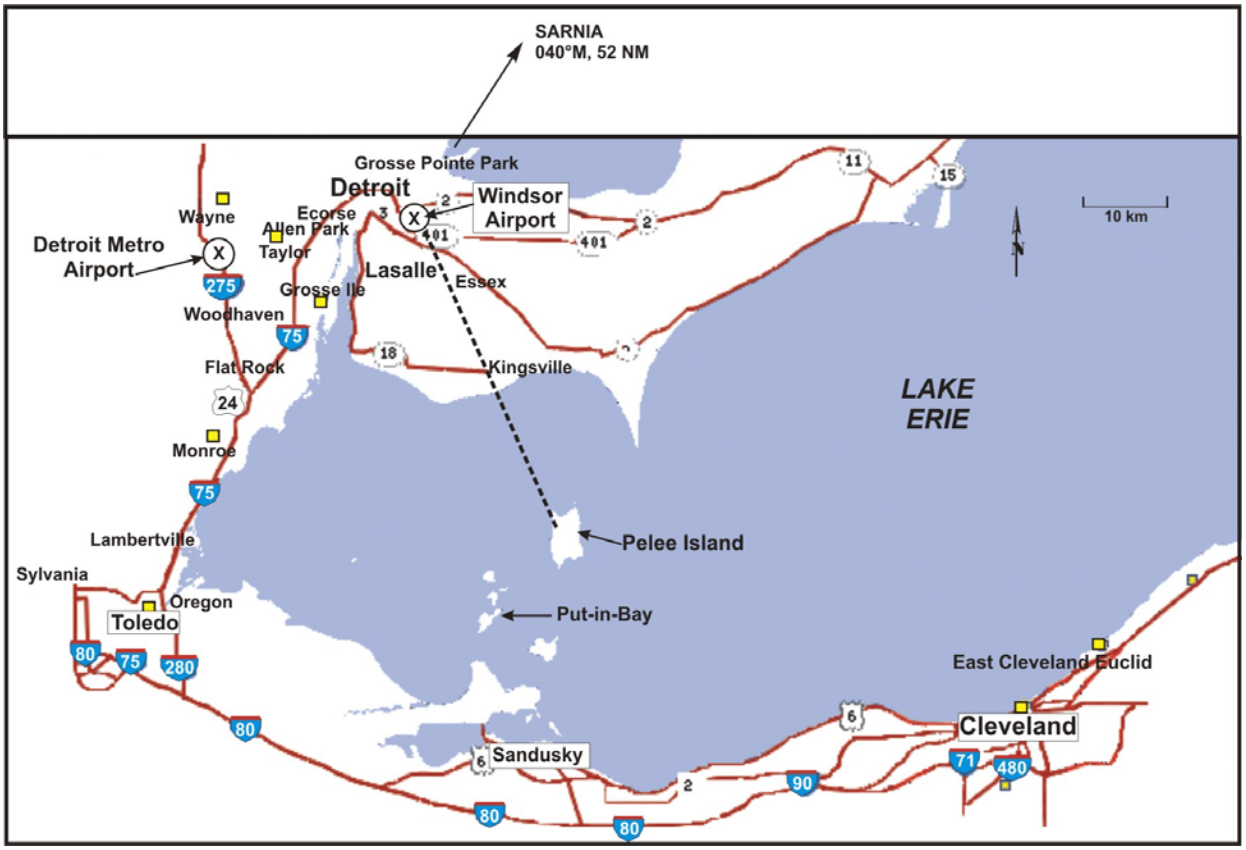
- visible moisture (rain, drizzle, sleet, snow, fog, etc.) is present;
- the aircraft was exposed to visible moisture (rain, drizzle, sleet, snow, fog, etc.) since the previous landing;
- the aircraft experienced in-flight ice accretion since the previous take-off;
- the difference between the dew point temperature and the OAT is 3°C or less; or
- water is present on the wing.

The preflight procedures in Section 4 of the basic pilot operating handbook have to be referenced.

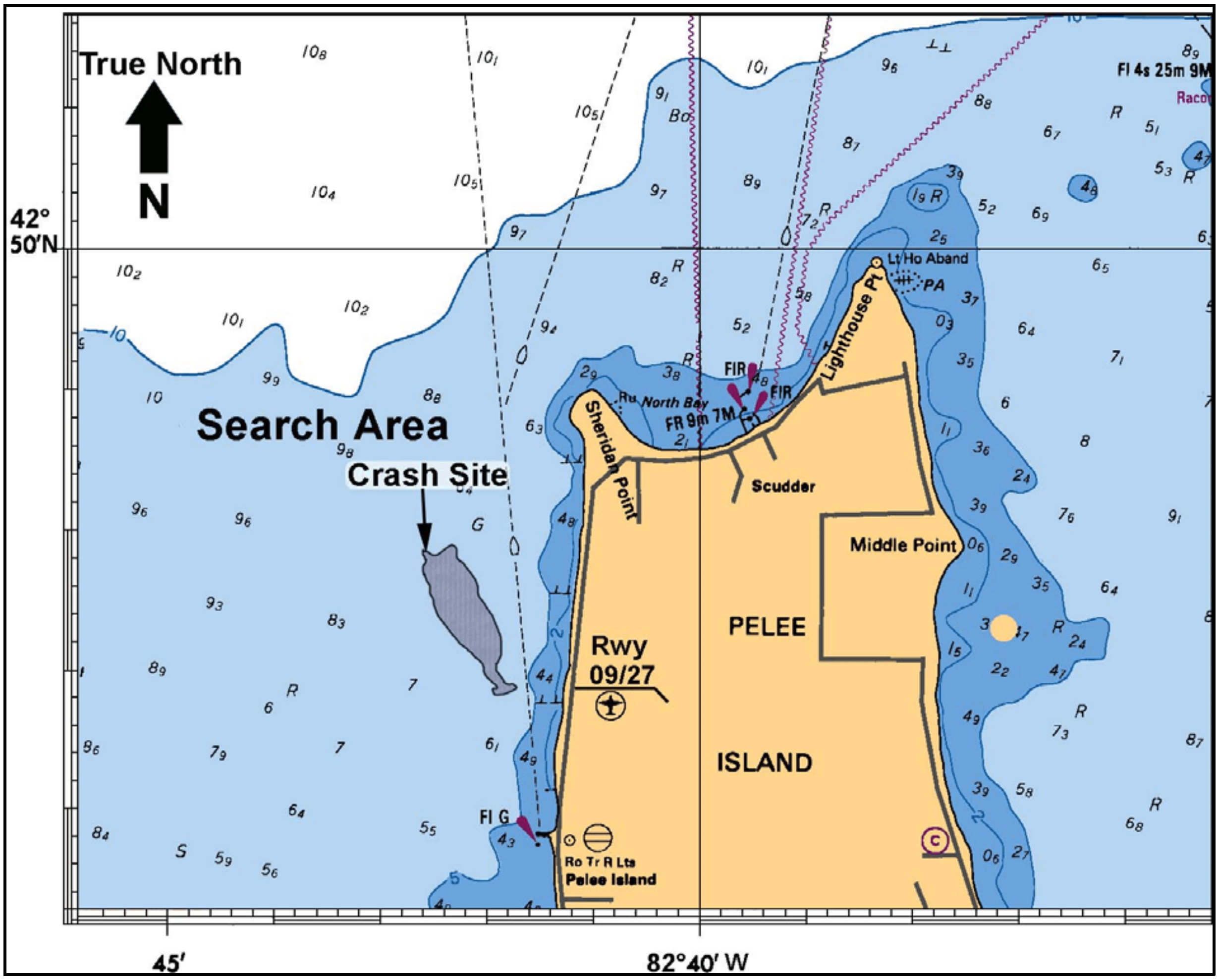
This AD applies equally to Cessna 208 aircraft in Canada, and Canadian owners are provided the information by mail or fax. There is no need for TC to issue a separate Canadian AD.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board authorized the release of this report on 17 January 2006.

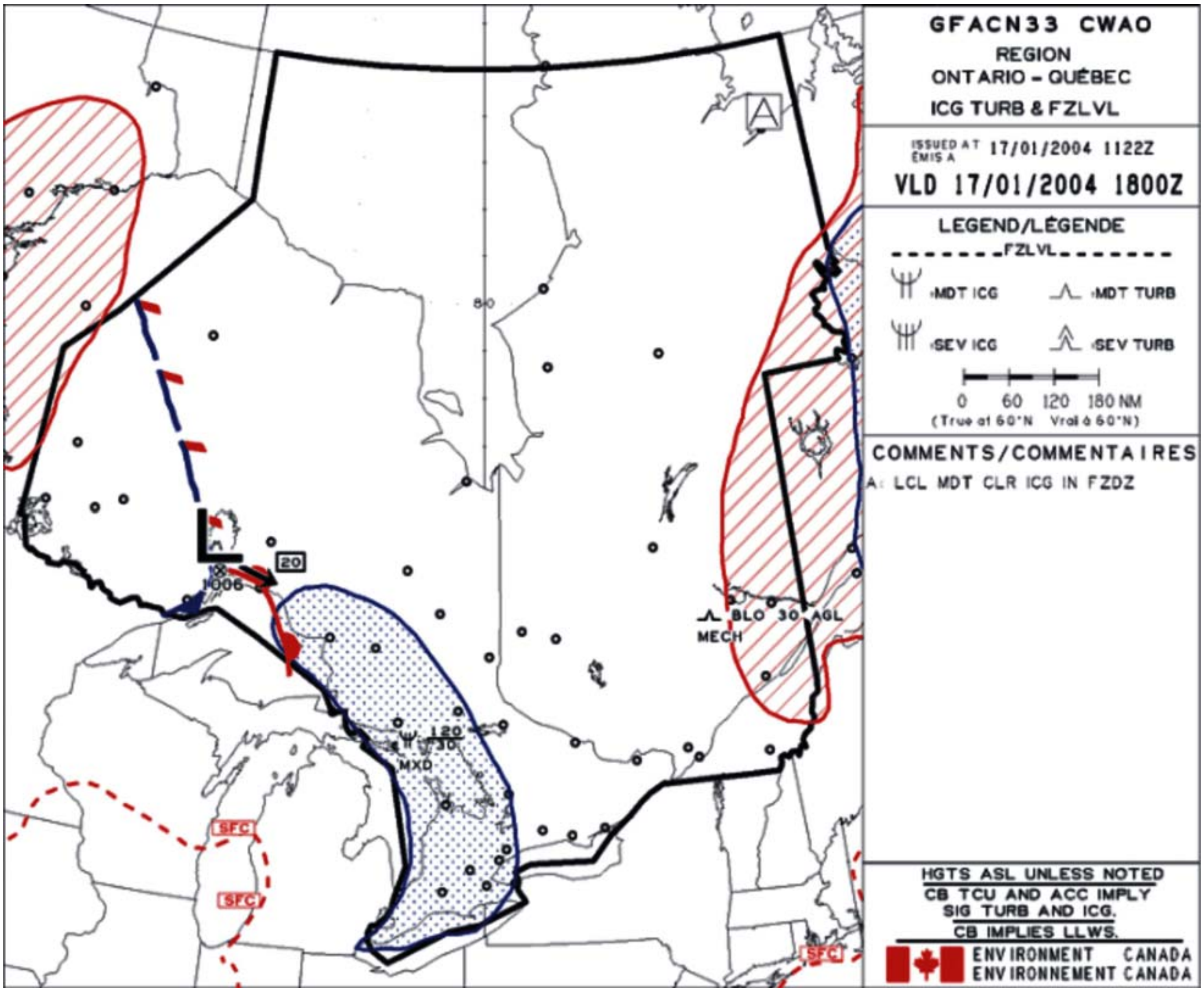
Appendix A – Map of the Crash Region



Appendix B – Map of Pelee Island



Appendix C – Graphic Area Forecast Chart



Appendix D – Wreckage Recovery

General

Photo 1. USCG ship *Neah Bay*

At the time of the accident, the lake was covered with ice from 2 to 12 inches thick. The water depth around Pelee Island was approximately 20 to 26 feet. When the first responder, a United States Coast Guard (USCG) helicopter, arrived at the crash site, the entire empennage was visible above the water. The empennage was observed to sink beneath the surface of the lake approximately four hours after the occurrence. The sinking coincided with the arrival on scene of the USCG ship *Neah Bay* (see Photo 1). Some pieces of debris from the aircraft, such as the cargo pod and engine cowling, were recovered from the surface of the ice.

At approximately 0830 eastern standard time on 19 January 2004, the Canadian Coast Guard Ship (CCGS) *Samuel Risley* arrived on scene. Its initial search included the area where surface debris was spotted. Surface debris that was not recovered by the USCG ship *Neah Bay* was retrieved and brought aboard the CCGS *Samuel Risley*.

In addition to the CCGS *Samuel Risley*'s crew, the following personnel were on board: a TSB regional investigator, the southwest regional chief coroner, an Ontario Provincial Police (OPP) detective to assist the coroner, an OPP investigating officer, six members from the OPP Underwater Search and Recovery Unit with a remotely operated vehicle (ROV) and surface supply diving equipment, and two OPP forensic identification officers.

The next several days were spent searching an area of approximately six million square feet using sonar, a magnetometer, and a video imaging camera. One of the limiting factors in locating the aircraft was that the crash coordinates were reported differently by the responding agencies. The aircraft was located on January 26. On the morning of January 27, divers entered the water and completed a video survey of the aircraft. It was decided to first drag the aircraft closer to the ship, then dive and resurvey the wreckage with a video camera.

The aircraft was rigged with one strap through the back doors and pulled closer to the CCGS *Samuel Risley*. A spreader bar was also used to spread the load evenly across the length of the fuselage by placing the straps at several fixed locations instead of a single lifting point. Using a chain saw, slabs measuring 10 feet by 10 feet were cut in the ice surface. These slabs were removed by the ship's crane, creating a hole approximately 30 feet by 40 feet. The ship's crane was used to lift the aircraft through the hole. The aircraft was recovered completely in one lift. It then took approximately two hours to lift the aircraft clear of the water and position it on stable ice. The aircraft was then loaded onto the ship.

On January 30, two more dives were completed to recover small debris from the bottom of the lake. At approximately 1800, the ship set sail for a docking facility in Windsor. The wreckage was first transported to a hangar facility for a preliminary inspection and then taken to the TSB Engineering Laboratory in Ottawa for detailed examination.

Operational Obstacles

The non-availability of accurate coordinates for the crash site proved to be a major challenge. There was confusion as to whether relayed position coordinates were in degrees, minutes and seconds or degrees and decimal minutes. There were also problems with the accuracy of the coordinates. Some of the coordinates received were accurate to three decimal places while others were accurate to one decimal place. This meant that the coordinates were accurate anywhere from one hundred feet to one mile. It took eight days to finally confirm the positions and get more accurate information about the initial response to the occurrence. Once the new information was received and the decision was made to resume the search at the new coordinates, it took little time to locate the aircraft.

Environmental Obstacles

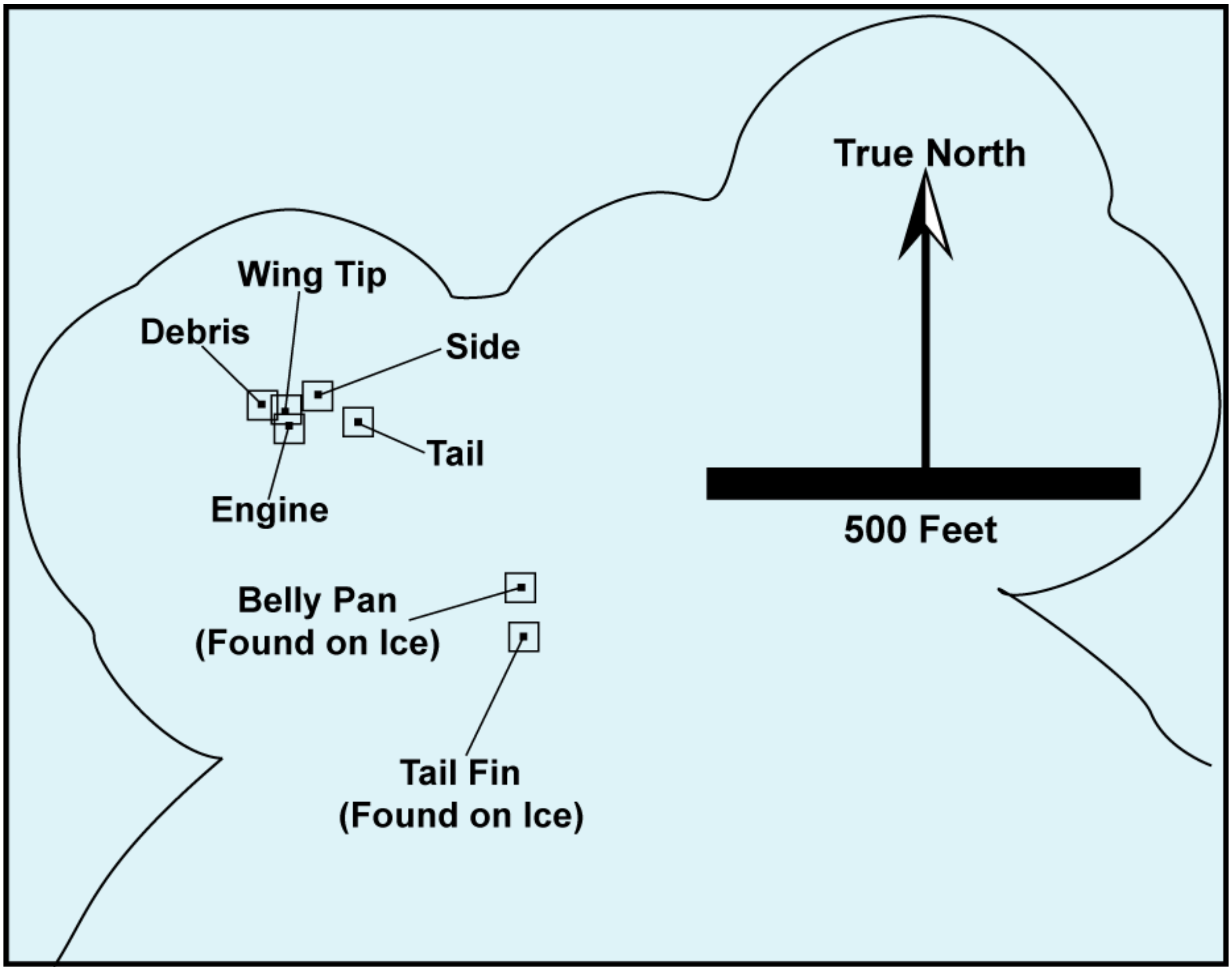
The harsh operating environment proved to be the most challenging obstacle during both the search and recovery. The ice prevented the use of a boat-drawn, side-scan sonar, and the ice hindered access by non–ice-breaking vessels. Additionally, once the aircraft was found, there was the problem of how to clear a hole in the ice large enough to pass the aircraft through. There were many areas where the ice was thick and safe to work on, but there were also areas of open water or ice leads created by shifting ice that had recently frozen over. This was often complicated by drifting snow that would cover the ice, hiding the thin areas.

Foul weather and extreme changes in temperature also hampered the search. During the 13-day search and recovery, the team dealt with temperatures that ranged from 0°C to -20°C, in both calm and gale force winds, and in both rain and snow. All these factors affected the ability of teams to work safely on the ice (see Photo 2).

Photo 2. CCGS *Samuel Risley*

The shallow water around Pelee Island presented further unique challenges. With only a few feet of water under the keel of the ship at any given time, the ship could only move if the sonar confirmed that an area was clear of obstacles.

Appendix E – Crash Site Debris Field



Appendix F – Passenger Door Placards

Photo 3. Exterior view of cabin passenger door

Photo 4. Interior view of upper hatch in the closed position

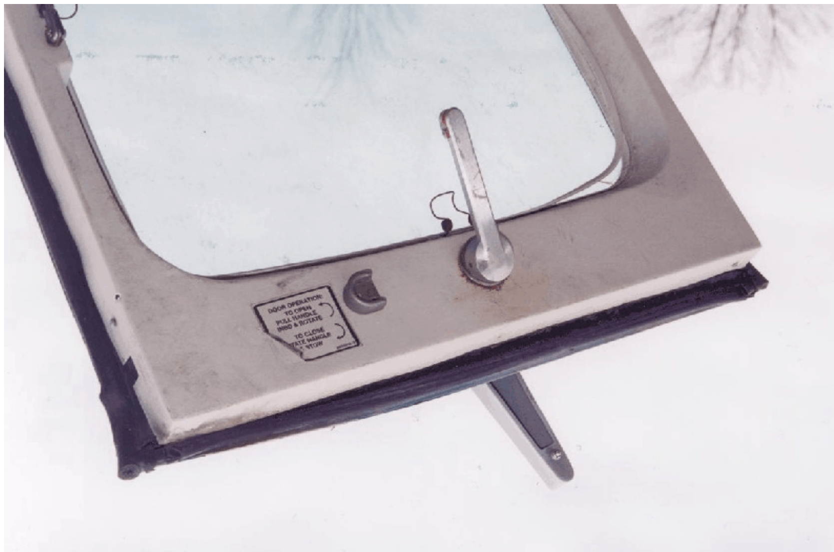


Photo 5. Interior view of the upper hatch in the open position

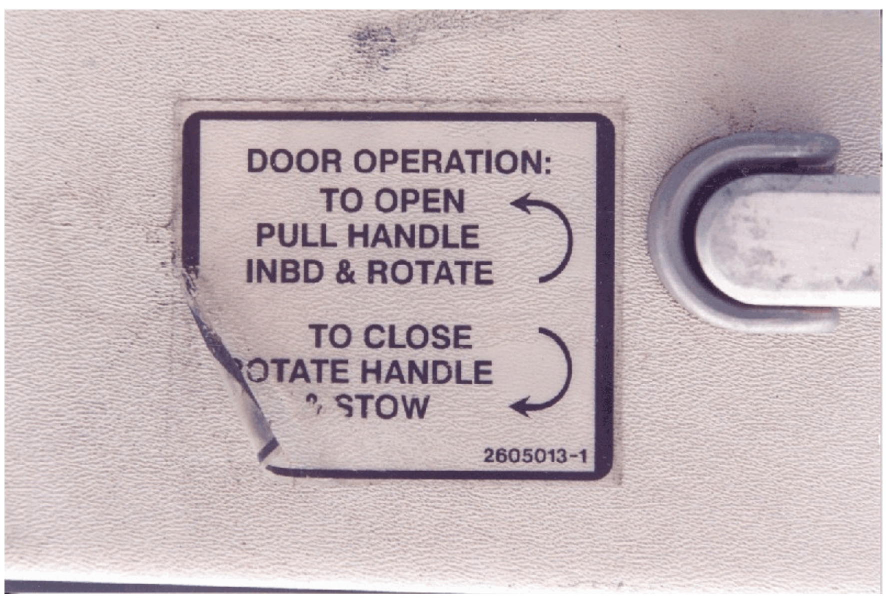


Photo 6. Close-up of placard showing direction of rotation opposite to actual handle movement

Appendix G – List of Supporting Reports

The following TSB Engineering Laboratory reports were completed:

LP 018/04 – Structures Group Report
LP 022/04 – Instruments Examination Report
LP 023/04 – Powerplants and Propeller Systems Report
LP 036/04 – Aircraft Performance Analysis Report
LP 046/04 – Position Coordinates Report

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

Appendix H – Glossary

ACIM	*Air Carrier Inspector Manual*
AD	Airworthiness Directive
agl	above ground level
AIAA	American Institute of Aeronautics and Astronautics
A.I.P. Canada	*Aeronautical Information Publication*
AOA	angle of attack
AOC	Air Operator Certificate
asl	above sea level
ATC	air traffic control
ATPL	airline transport pilot licence
ATS	air traffic services
CARs	*Canadian Aviation Regulations*
CASS	*Commercial Air Service Standards*
CBA	Commercial and Business Aviation
CCGS	Canadian Coast Guard Ship
C_{Lmax}	maximum lift coefficient
ELT	emergency locator transmitter
FAA	Federal Aviation Administration
FAR	*Federal Aviation Regulations*
FIC	Flight Information Centre
g	load factor
GFA	graphic area forecast
IFR	instrument flight rules
IMC	instrument meteorological conditions
KCAS	knots calibrated airspeed
kg	kilograms
KIAS	knots indicated airspeed
km	kilometres
lbs	pounds
METAR	aviation routine weather report
N	north
NASA	National Aeronautics and Space Administration
NDB	non-directional beacon
nm	nautical miles
NOTAM	Notice to Airmen
NTSB	National Transportation Safety Board
OAT	outside air temperature
OPP	Ontario Provincial Police
OSTC	Owen Sound Transportation Company
POH	pilot operating handbook

POI	principal operations inspector
PPC	pilot proficiency check
ROV	remotely operated vehicle
RWY	Runway
SAR	search and rescue
sm	statute miles
SOPs	standard operating procedures
TAF	terminal aerodrome forecast
TC	Transport Canada
TP	Transport Publication
TSB	Transportation Safety Board of Canada
UNICOM	private advisory station located at an uncontrolled aerodrome
USCG	United States Coast Guard
VFR	visual flight rules
VOR	very high frequency omni-directional range
W	west
°	degrees
°C	degrees Celsius
°F	degrees Fahrenheit
°M	degrees magnetic
°T	degrees true
ʹ	minutes